

VOLUME – IA
Part I & II
TECHNICAL CONDITIONS OF CONTRACT
(TCC)

NAME OF WORK:

Renovation, Modernization & Uprating of Kuttiyadi HEP from 3x25MW to 3x27.5 MW - Erection, Testing & Commissioning of new unit & Dismantling of existing unit incl civil works, material handling & site store erection as per SOW at KSEB Kuttiyadi HEP.

BHARAT HEAVY ELECTRICALS LIMITED



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VOLUME – I A (PART – I): Chapter-I

Project Information

Sl. No.	Title	Description
1.	Name of the Owner:	KERALA STATE ELECTRICITY BOARD. (KSEB)
2.	Address	KUTTIYADI Hydro Power Station Village: Koyilandi, District: KOZHIKODE (KERALA)
3.	Renovation, Modernization and Upgrading	3 x 27.5 MW
4.	Nearest Railway station	Kozhikode railway station (52 KM)
5.	Nearest Road	Kakkayam (1 KM)
6.	Nearest City	THAMARASSERY- 25 KM/ KOZHIKODE- 50 KM
7.	Nearest Airport	KOZHIKODE (50 KM), KOCHI (228 KM)
8.	Highest Temperature	36 deg C
9.	Lowest Temperature	20 deg C
10.	Elevation	91.75 Meter's (Turbine Centre line)

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

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VOLUME – I A (PART – I): Chapter- II

Scope of Work

1.2.1 BROAD SCOPE OF WORKS:

The scope of work under the contract shall include Dismantling of Old TG set including auxiliaries; renovate and reuse the fixed/embedded components; collection of all information/ dimension, taking measurements as required, assessing/ measurement of the condition and strength of various civil foundations and re-strengthen (if required) and reuse the foundations, unloading at store, loading, transportation, storing & preservation at site, loading & unloading of dismantled material from site to dumping yard, complete erection of all the components testing, commissioning and handing over operating plant to KSEB (customer) unit 1 to 3 along with civil, mechanical, electrical, control & instrumentation works as required including demonstration of performance guarantees for successful R & M with new TG of the units and hand over to the KSEB as an operating plant and the project shall include material & equipment and facilities within the defined battery limits.

The total scope of work is covered in two parts: Part 1 & Part 2.

The scope of work under this contract shall comprise of dismantling of the complete machine and safe storage of all the dismantled components and transportation of certain identified assemblies/ components from Kuttiyadi HEP to identified dumping ground by KSEB. All parts should be properly match marked before dismantling. The machine shall be handed over to sub-contractor after de-watering of machine by the KSEB.

- I. Total plant materials/ equipment's involved for material handling work under this tender will be approx. - 1798 MT. This quantity shall include new supply as well as old dismantled material.
- II. The total new material to be supplied from the BHEL manufacturing units for the project is approximately 910 MT for Erection, Testing and Commissioning. The contractor has to handle whatever actual materials are dispatched for the project irrespective of any variations and payments shall be released for the actual gross tonnage handled.
- III. The Contractor shall make all arrangements to deliver the equipment at site by trucks/ trailers, build his own stores (covered, uncovered, air-conditioned, if necessary) for the proper storage of equipment, maintain the stores and all related documents and records, transport the new/renewed equipment to site for erection purpose. All security arrangements also shall be made by the

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Contractor. Space only for stores and site office shall be made available, free of cost, to the Contractor by the KSEB/BHEL. Security arrangements means all necessary arrangement for security of equipment, tools and tackles etc. of the contractor at site.

- IV. Dismantling of all the items through the agreed dismantling procedure or mutually decided procedure between KSEB & BHEL without affecting day to day operation of running units of Power house. All the items so dismantled are to be tagged properly recorded with customer KSEB & Shifted to earmarked dumping yard after Handing Over to KSEB.
- V. The Contractor shall be responsible for proper and neat storage and also undertake conservation of all consignments including damaged boxes. During storage of equipment, the Contractor shall take into account deterioration and carry out the re-conservation of the complete equipment/parts/supplies as may be necessary as per the storage instructions of the Manufacturer of equipment/components. The Contractor shall also supply the consumables required for such re-conservation work and repair/replace parts required thereof for the proper functioning of the equipment after erection and commissioning.
- VI. The Contractor shall take the equipment from stores and transport the same to erection site. In case of dismantling & repair, the Contractor shall take the equipment/components from site to their repair shop (preferably most of the repair work shall be done at site only) and transport back the same to site after repair.
- VII. The Contractor shall unpack and do visual checking against physical damages to the equipment/cases, clean equipment before start of erection as well as before taking delivery in case of equipment/components required for repair. Damages/shortage, if any, shall be reported to the BHEL.
- VIII. The Contractor shall provide all necessary erection equipment and tools & tackles including material handling equipment, mobile cranes, fork lift machine, trailers, cranes, machine tools & repair kit, compressors and other equipment and instruments and consumables, all commissioning equipment and instruments, welding equipment, winches, alignment tools, precision levels, theodolite etc. which may be required for carrying out the erection and commissioning work efficiently. All instruments shall be properly calibrated before use. However, KSEB/BHEL's prior permission shall be required for removal of these erection and repair equipment/ materials from the site. The Contractor shall ensure that proper documentation is followed at entry gate of KSEB's premises for such items which shall be carried back by Contractor after completion of work. **The Contractor shall provide within 15 days from the date of effective date of Contract, his scheme for mobilization with Bar Chart indicating clearly the resources, manpower and machinery proposed to be deployed to ensure timely completion of work and quality of workmanship.**

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- IX. The Contractor shall provide all temporary ladders, scaffolding materials, platforms, supports and other necessary facilities required for dismantling, material handling, erection, testing and visual inspection of supplies at the point of installation and shall also provide necessary packing plates, wedges, shims, levelling screws etc. required for erection of equipment and structures.
- X. The Contractor shall provide erection consumables like oxygen and acetylene gas, welding rods, solder lugs, oil, grease, kerosene, cotton waste, etc. required for erection, installation and repair of equipment and steel structures.
- XI. The Contractor shall maintain in a neat manner the area placed at the Contractor's disposal.
- XII. The Contractor shall provide sufficient fencing, notice boards and lights to protect and warn others as may be considered necessary by the KSEB/BHEL. All materials used for providing these facilities shall be properties of the Contractor. A safety notice board containing warnings written in English, Hindi & Malayalam Languages shall be placed by the Contractor.
- XIII. The plant and equipment will be erected as per the instructions of the KSEB/BHEL and under the supervision of the supervisory personnel, to be deputed by the Contractor at site. The Contractor will also undertake rectification work on account of manufacturing defects, if any, required for proper erection and assembly which can be done at site only according to site condition.
- XIV. The Contractor will align, level, couple and securely fix all equipment, steel structures, appurtenances and accessories in accordance with drawings and/or instructions.
- XV. All precision survey instruments including leveling instruments will be arranged by the Contractor. The Contractor will carry out oil flushing and lubricants, grease, chemicals and as required till successful commissioning. Laying and termination of cables, bus bars, bus ducts and earthing will be done by the Contractor.
- XVI. Installation and connection of all piping's and fittings from the headers termination points to the equipment and inter-connection of all service lines within the design limit after the main headers/termination points will be Contractor's responsibility.
- XVII. The Contractor will check electrical connections to individual items. The Contractor will be responsible for checking the correctness of erection of mechanical equipment, auxiliary systems, electrical equipment, other equipment, etc. as per the specification and relevant drawings.
- XVIII. The Contractor will arrange all facilities at site to undertake Ultrasonic

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testing and stress relieving of butt welded pipe joints, as required.

- XIX. The Contractor will be responsible for the management of erection work with proper and adequate supervision for ensuring progress of erection work and quality of workmanship. The Contractor will deploy required number of supervisory, skilled, unskilled and auxiliary labor as required, for the erection work and comply with such reasonable instructions of the KSEB/BHEL in the interest of satisfactory progress and completion of the work according to the schedule.
- XX. Contractor is required to draw mutually agreed monthly erection programs in consultation with BHEL well in advance. Contractor shall ensure achievement of agreed program and shall also timely arrange additional resources considered necessary at no extra cost to BHEL.
- XXI. 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 non-conformities.
- XXII. The contractor shall submit daily, weekly and monthly progress reports, manpower reports, materials report, consumables (gases / electrodes) report, cranes availability report and other reports as per Performa considered necessary by the Engineer. The periodicity of the reports will be decided by BHEL Engineer at site.
- XXIII. The Contractor will be responsible for total commissioning of the Plant including mechanical run, commissioning and demonstration of Performance Guarantee Tests. The Contractor will organize the work in a manner that other work at site is not impeded and the workmen therein not endangered. Contractor will arrange temporary access at site, if required, for the erection work. Field efficiency test of (Turbine & Generator) shall be done on all the three units.
- XXIV. The Contractor will intimate the KSEB/BHEL/concerned Plant authorities in writing well in advance about the requirement of shut down of any of the existing units/facilities for inter-connection/ incorporation of additional facilities. The shutdown period will be mutually discussed and finalized. The work to be undertaken during the shutdown period will be planned meticulously by the Contractor to reduce the shutdown period to the minimum.
- XXV. The Contractor will return to the KSEB all crates, packing cases and packing

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materials and all returnable supplies belonging to the KSEB at a place designated by the KSEB at the erection site in the conditions these exist during and after erection work is completed.

- XXVI. The tests/checks to be conducted during erection by the Contractor will be as per the BHEL/matrix's instructions. The Contractor will attend to the rectification of erection defects, if any, expeditiously. The Contractor will arrange all testing instruments for such testing at site.
- XXVII. The Contractor will carry out final painting of the plant & equipment and pipelines, etc. erected as per the instructions of the KSEB/BHEL.
- XXVIII. Grouting of the equipment on the foundations with Shrink komp/ Ferro grout will be the responsibility of the Contractor.
- XXIX. The Contractor will indicate to the KSEB/BHEL well in advance the requirement of services such as electric power, water, EOT crane, etc. required during Dismantling/construction/erection period. The Contractor will arrange for the staying facilities of his working personnel. All safety, health and pollution control measures, as required to be adopted as per the Statutory Regulations and the Safety Codes for projects issued along with the tender documents otherwise required or implied by statutory regulations or practices, will be strictly followed by the Contractor during the execution of the Contract. The Contractor will set up a suitable safety organization of his own at site in this regard.
- XXX. A complete schedule of sequential erection of all the equipment, method of erection, safety aspects etc., is to be prepared by the contractor, well ahead of the start of the erection and it should be submitted for approval by BHEL. Erection of all the equipment shall be subject to inspection and clearance by BHEL / Customer at every stage. A log book shall be maintained for recording all the erection activities, procedures, checks and inspection details. This will bear the countersignature of BHEL /Customer's inspector at every stage. It is the responsibility of the contractor to maintain necessary records for the stage inspection, critical checks, etc. to meet the protocol for review.
- XXXI. The Contractor will comply with all Statutory Rules & Regulations with respect to the employment of labour at site including payment of minimum wages as per Govt. rules, deduction of employee's contribution to Provident Funds, depositing the same along with Contractor's contribution to the Provident Fund Commissioner, Employees State Insurance and other statutory deductions/ obligations.
- XXXII. At the end of the work the Contractor will remove all such temporary structures put up by him and hand over the site to the KSEB/BHEL in neat and tidy manner.

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1.2.2 DETAILED SCOPE OF WORK, EXISTING FACILITIES & BATTERY LIMIT

The scope of work for units 1 to 3 is as below (SCOPE OF WORK):

- (a) Dismantling of existing TG sets including associated auxiliaries, like cooling water system, dewatering & drainage system, Firefighting system, air conditioning system, ventilation system, drinking water system, compressed air system, and place these at a suitable storage space / yard (storage space will be provided by KSEB within 1 km of plant.
- (b) Renovate and reuse the Fixed/embedded components: distributor, liner, and foundation plates and anchorages etc.
- (c) Total plant materials/equipment's involved for material handling work under this tender will be approx. - 1798 MT. This quantity shall include new supply as well as old dismantled material.
- (d) All associated civil works pertaining to renovation and modernization of existing project will include but not be limited to Testing for suitability of the existing foundation, required minor modifications in the existing foundations (i.e. strengthening by re-barring/anchoring), Ventilation system foundation, additional rooms, cutouts/openings, dismantling of concrete and Dismantling & re-construction of brick work etc. including supply of all materials, labour, tools and plants.
- (e) Erection, testing, commissioning, start up and performance testing and handing over of Units 1 to 3, 27.5 MW each Hydro turbine-generator sets (TG sets). The TG sets includes Pelton turbine, Synchronous Generator along with associated Auxiliaries; Electricals including 11 kv Bus Duct, excitation equipment, Unit Auxiliary transformer and associated equipment; Control & Instrumentation and associated civil work. Contractor will ensure that the TG set will be completed with all materials and equipment whether specifically mentioned herein or not but required for satisfactory operation of the Units.
- (f) Design, Procurement, Supply, Receipt at Site, Erection, Painting & Finishing works etc. and Handing over to site Removable/ Re-erectable type Pre-Engineered, Pre- fabricated Steel Closed Storage Sheds- 1 nos. of size 30m X 15m x 6m including construction of civil foundation as per the technical specification.

1.2.3 DETAILED SCOPE OF MATERIAL HANDLING WORKS:

- a) The plant material shall be unloaded at power house with E.O.T cranes and shall be unloaded/loaded at BHEL stores /work site by contractor Mobile cranes/ Hydra. The E.O.T cranes shall be provided by BHEL/customer on free of cost for material handling/erection work. Arrangement of operator shall be responsibility of the contractor, if not provided by KSEB. In case EOT cranes are not available or under breakdown at Power house, contractor shall arrange his own Hydra/cranes /alternative arrangement which is acceptable

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to BHEL site engineer for material handling work loading / unloading of the plant materials /equipment and shall carry out the material handling work at project site.

- b) Keeping records and status of all materials as per BHEL practices. Verification of all the materials received at site. Prepare shortages/damage reports if any and assisting in insurance claim lodging.
- c) Transportation of materials from project store to the powerhouse service bay or the pre assembly area or any other work area of installation & vice-versa as per site requirement and the instructions of site engineer.
- d) Construction of temporary sheds/shelters for some of the special equipment's/ items as per the instruction of the site engineer.
- e) Providing sufficient illumination, firefighting equipment, warning signs in and around the place of work. Providing all necessary support/assistance for efficiency testing. Handing over of all the spares to customer at their stores. Handling and Transportation of scrap (packing wood and steel) from power house to KSEB scrap yard/stores/Dumping yard as per the instructions of BHEL engineer.
- f) Unloading and stacking of items in the service bay / work area with the help of EOT cranes/unloading arrangement as per the instruction of BHEL engineer. Proper Housekeeping and safe working.
- g) Dismantling of the existing equipment's and Erection, Testing, Commissioning, trial operation and Handing over of all new equipment's covered in this tender (See table below).

The broad facilities/equipment to be dismantled (common as well as unit specific) are given in Table below:

Sl. No.	Name of the Equipment/Facility
1	Turbine and associated equipment including Turbine shaft, runner, guide bearing, nozzle assembly, deflector assembly etc of all three units.
2	Governing System including Oil pressure system, Governor panels etc. of all three units.
3	Generator and associated equipment including stator, rotor, generator shaft, Thrust bearing, guide bearings, Generator Air Coolers of all three units.
4	Excitation System including Pilot Exciter, Main Exciter, Slip rings, Excitation panels etc. of all six units.
5	Cooling water system (common) including, pump- motor sets, pipe, valves, filters, etc. for all three units.
6	Dewatering & drainage system including pipes, valves, and pump-motor sets etc. Common for all three units.
7	2 nos. LP compressors including compressed air piping, valves etc. common for all the three units.
8	Unit Auxiliary transformer and other associated facilities of all three units.

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9	11 KV switchboards, Unit Auxiliary board panels, Control panels, Protection panels etc. of all six units.
10	Bus ducts, Power, Control and other cables within battery limit of all three units.
11	HT, LT, Control and instrumentation cables of all three units and also of common auxiliary systems.
12	Miscellaneous items used in all the three Units.

NOTE: - 01 No of 14T Hydra to be provided close to storage sheds of BHEL/KSEB.

Also operation and maintenance during entire contract period is the responsibility of contractor. It is the property of the contractor and shall be dismantled and taken back after completion of work.

- h) Shifting and re-stacking of materials if required to facilitate the erection works.
- i) Re-conciliation of materials with BHEL and KSEB. Documentation and records (Films/ Movies/ Photographs) from embedment to evacuation.
- j) All the dismantled components that are not envisaged to be used back in the unit are required to be stored/preserved properly till the completion of work. All nuts bolts studs & dowels shall be cleaned, applied grease and kept in polythene packs with proper tagging/ bin cards. Responsibility for arrangement of wooden boxes as required shall be of the contractor at his own cost.
- k) All consumables like old dhoties, markeen cloth, kerosene oil, petrol, diesel, jute, grease and other preservatives shall be arranged by the contractor at his own cost.
- l) All measurements like levels & clearances shall be recorded at each stage of dismantling of machines as per directions of BHEL Engineer. For design/ manufacturing purpose, if BHEL requires the measurement of Structure/existing components extra, contractor has to perform on the instruction of BHEL. Necessary measuring instruments for this are to be made available by the contractor.
- m) All consumables required for grinding, welding, gas cutter etc. required shall be arranged by the sub- contractor at his own cost for completion of dismantling and erection work. All material required for platform shall be arranged by the sub-contractor at his own cost. Welding generators, grinders, cutters etc. shall be arranged by the sub-contractor at his own cost.
- n) Erection devices, special T&P etc. as available with KSEB shall be supplied free of cost. However special spanners, slings, required for the job but not available with KSEB in usable conditions shall be arranged by the contractor at his own cost. In case of any damage during dismantling to devices, T&P etc. provided by KSEB free of cost to the sub-contractor, sub-contractor will

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have to bear the replacement/ repair cost.

- o) Chain pulley blocks, jacks, pull lift machines, D-shackles and general T&P shall be arranged by the sub- contractor at his own cost with due test certificates.
- p) There is only one rotor erection pit in power house. The ways and means of cutting and dismantling of other rotors (while the assembly of one rotor in rotor erection pit is underway) within transportable limit of power house shall be responsibility of the Contractor. Necessary procedure for the same shall be submitted by the Contractor to BHEL for information/acceptance.
- q) All dismantled equipment shall be stored on the wooden planks and preserved properly. All safety rules in respect of handling of equipment of material is also to be observed. If any other part required to be dismantled for complete & successful dismantling of M/c the same shall be done by the contractor within the scope of this work.
- r) Any component if damaged during dismantling due to negligence of contractor shall be replaced by the contractor at the time of assembly at his own cost. Such components should be of best quality manufactured as per the BHEL drawing.

1.2.4 DETAILED SCOPE OF DISMANTLING WORK (TURBINE, GENERATOR & OTHER MECHANICAL EQUIPMENT)

The following existing facilities will be dismantled:

- Unit 1 to 3 Turbine Generator set including the associated equipment up to Generator transformer adjacent to power house towards tail race side and auxiliary transformer located at upstream of power house.
- All facilities associated with the above including cables, cable structures, maintenance platforms etc. Transport/shift and place all the dismantled equipment to the storage space ear marked for the purpose.
- Lifting devices and special tools required for dismantling shall be provided by BHEL/KSEB as per availability. Healthiness is to be assessed by the Contractor. Necessary device if available will be provided 'As is where Basis'. Dismantling of stator shall be done in erection pit/ Service bay only. Generator/Transformer/cable etc., will be dismantled and properly recorded with KSEB and to be stored/placed in space provided by BHEL/KSEB normally within 1KM of power house.
- There is only one rotor erection pit in power house. The ways and means of dismantling of other rotors (while the assembly of one rotor in rotor erection pit is underway) within transportable limit of power house shall be

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responsibility of the Contractor. Necessary procedure for the same shall be submitted by the Contractor to BHEL for information/acceptance.

- Before dismantling of unit is carried out, Dummy cone (BHEL supplied item) to be welded with penstock in power house. Same dummy cone to be used for other units before dismantling of units is carried.
- Power/ control/ Instrumentation common cable in dismantled unit to be isolated, tagged and tapped.
- Further details of major components to be dismantled are given below for information:

1.2.4.1	Water Turbine	
	No. of Units	3 (three)
	Maker's name and Country	FUJI ELECTRIC .LTD., Japan
	Type	Vertical Shaft 4 jet Impulse turbine (Pelton)
	Output	37000 hp
	Maximum Gross head	666.2928m
	Average net head	643.128m
	Discharge at rated output	4.87 m ³ /sec
	Discharge at maximum net head	4.939 m ³ /sec
	Speed	600 rpm
	No. of jets per runner	4
	Runaway speed at Max gross head	1100 rpm
	Diameter of runner	1700 mm
	No of Buckets per runner	23
	Diameter of jet	5 inch
	Diameter of Turbine Shaft	45.72 cm
	Direction of rotation	Clockwise from top
	Turbine Bearing	White metal casted on to ring like bearing shell of steel plate
	Type	Oil Immersed, self lubricated
1.2.4.2	Governor	
	Type	Oil Pressure cabinet actuator type with electrically driven

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		governors
	Oil Pressure	20 to 22 kg/cm ²
	Quantity of Oil	3870 kg at 21kg/cm ²
	Type of speed sensing Device	Permanent Magnet Generator (PMG)
	Type and make of Tachometer	Pendulum Type and PMG techno
	Type and make of Pressure Gauges	Pressure 22 kg/cm ²
1.2.4.2.1	Pump	
	No. & Type of Pump	2 Nos. Gear Type Oil Pumps of 100 lpm
1.2.4.2.2	AC Oil Pump Motor	
	Type	ORK 582-4, Three Phase Squirrel Cage Induction motor
	Output	7.5 KW
	Voltage	415V
	Speed	1450 rpm
	Frequency	50Hz
1.2.4.2.3	Oil Pressure Pump	
	Type	Horizontal Shaft gear Pump
	Speed	1450rpm
1.2.4.2.4	DC Motor oil Pump	
	Type	Series
	Output	10 hp
	Speed	600 rpm
1.2.4.2.3	Permanent Magnet Generator	
	Make	Fuji Electric Co. Ltd., japan
	Voltage / current/rating	110V/ 3.68 Amp/ CMR
	Phase / Speed/no of poles	3/ 600 rpm/ 10
1.2.4.3	Actuator	
	Method of Drive of Actuator	Leaf spring pendulum type actuator of double acting system
	Motor make	Fuji Electric Co. Ltd., japan
	Type/ rating/ frequency	SPRY 55/3-10/ Continuous/ 50Hz

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1.2.4.4	MAIN INLET VALVE	
	Type	Double sealing Type Rotary Valve
	Operation: Closing/Opening	By oil pressure/ By water Pressure
	Weight of MIV	22.20 Tonnes
1.2.4.5	GENERATOR	
	Make & Year	Fuji Electric Co. Ltd., japan, 1966
	Type No.	SPF 565/44-10
	Number of units	3
	Rated capacity	25 MW (28MVA at 0.9 pf)
	Rated speed/ No of poles	600 rpm/ 10 poles
	Generation voltage/ current	11 kV/ 1470Amps
	Stator core material	Stainless steel
	Cooling	Water cooling
	No. of surface air coolers	6
	Outside Diameter	5000 mm
	Generator barrel dia	6300 mm
	Generator barrel height	3050 mm
	Rotor Outer dia	2400 mm
	Shaft dia	450 mm
	Length of shaft	5900 mm
	Dia/ Type of coupling	740 mm/ bolted coupling
	Type of winding/ no of slots / no of conductor in each slot	Wave/ 164/2
	Stator weight	39 Tonnes
	Rotor + shaft weight	60 Tonnes
	Lifting Device	0.5 Tonnes
	Rotor+ exciter	61 Tonnes
	Braking System	Automatic and hydraulically operated
1.2.4.6	Excitation system	
1.2.4.6.1	DC generator	
	Make	Fuji Electric Co. Ltd., japan
	Type	DC Shunt Stabilized exciter
	Voltage/ current	180V/ 520A

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	Rated speed/ Insulation	600 rpm/ Class B
1.2.4.6.2	Field Circuit Breaker	
	Make	Fuji Electric Co. Ltd., japan
	Voltage/ current	600 V/ 600A
1.2.4.6.3	Motor driven Rheostat (70E)	
	Make	Fuji Electric Co. Ltd., japan
	Voltage/ current	220V/ 7.2A
1.2.4.6.4	Motor driven Rheostat (90R)	
	Make	Fuji Electric Co. Ltd., japan
	Voltage/ current	110V/ 0.5A
1.2.4.7	Station Auxiliary External Transformer	
	No. of units	1
	Make	AEG, Germany
	Capacity	500 Kva
	No of phases	3
	Cooling	ONAN
	Primary Voltage/ Current	11Kv/ 26.25A
	Secondary Voltage/ Current	433 V / 666.7 A
	Connection	Star- delta
	Weight	2400 kg
1.2.4.8	UNIT AUXILIARY TRANSFORMER	
	No of Units	3
	Make	AEG, Germany
	Capacity	500 KVA
	No of phases	3
	Primary Voltage/ Current	11Kv/ 26.25A
	Secondary Voltage/ Current	433 V / 666.7 A
	Connection	Delta- star
	Weight	2400 kg
1.2.4.9	11kV Segregated Phase Bus Duct	
	Conductor	Copper (channel)
	Outer width/ Thickness	40mmx80mm/ 6mm
1.2.4.10	Cooling Water System	

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1.2.4.10.1	Cooling water Pump (3 nos.)	
	Make	Fuji Electric Co. Ltd., japan
	Power	37kW
	Voltage/ phase/ frequency	440V/ 3/ 50Hz
	Lift head/ speed	25m/ 1500 rpm
1.2.4.10.2	Portable drainage Pump (1 no.)	
	Type	Portable Horizontal type
	Power	2.2kW
	Voltage/ phase/ frequency	440V/ 3/ 50Hz
	Head/discharge/ speed	0.7m/ 0.5 m ³ /sec/1420 rpm
1.2.4.10.3	Emergency Cooling water Pump	
	Type	Vertical sump Pump
	Power	90kW
	Voltage/ phase/ frequency	440V/ 3/ 50Hz
	Head/discharge/ speed	50 m/ 6 m ³ /sec/ 1500 rpm
1.2.4.11.1	Air Compressors No.1	
1	Compressor	
	Make	Elgi Equipments Ltd.
	Pressure/ capacity	30kg/cm ² / 18 m ³ /hr
	Input Power/ Tank Capacity	5.7 kW/ 0.25m ³
2	Motor	
	Make	Kirloskar Electric Co.
	Type	3 Phase Induction motor
	Rating	5.5 kW, 415V, 11A
3	Receiver	
	Make	Elgi Equipments Ltd.
	Capacity/ working Pressure	2 liter/ 30kg /cm ²
1.2.4.11.2	Air Compressors No.2	
1	Compressor	
	Make	Mikuni Kiai Kogyo Co. Ltd.
	Pressure/ capacity	24kg/cm ²
2	Motor	
	Make	Fuji Electric Co.
	Type	3 Phase Induction motor

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	Rating	3.7 kW, 400V, 7.3 A
3	Receiver	
	Make	Mikuni Kiai Kogyo Co. Ltd.
	Capacity/ working Pressure	0.2 m ³ / 29kg /cm ²
1.2.4.12	415V Switchgear	
	Make	Schneider Electric
	Amps	800 A
	Size	4800 x 1200 x 2400
1.2.4.13	Battery & Battery Charger	
1.2.4.13.1	Battery 1	
	Type	Lead Acid
	Rating / No of cells	375 AH,100V / 55
1.2.4.13.2	Battery Charger	
	Make	AEG, Germany
	Rating	123 V DC, 65 A
1.2.4.13.3	Battery 2	
	Type	Lead Acid
	Rating	225 AH, 48V/ 24 Nos.
1.2.4.14	Air Conditioning Units (8 No.)	
	Make	Voltas
	Type/ Capacity	Split type inverter/ 2.0 T
1.2.4.15	Control Room	
	Carrier/ communication Panel	4 nos.
	Metering and Protection Panel	16 nos.
	Control Desk	2 no.

1.2.5 EXISTING FACILITIES TO BE REFURBISHED AND UTILISED:

Fixed/embedded components of Units 1 to 3 e.g. distributor, pit liner, and foundation plates and anchorages are to be refurbished and reused. The required renovation details are enumerated in the Table.

Sl.No	Name of the equipment	Details of Renovation
1.	Distributor	Cleaning of distributor will be done, eroded portion will be examined by ultrasonic method, weld filled to bring back the original profile and protection coating will be applied.
2.	Turbine	Cleaning of Turbine Housing will be done, eroded portion

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	Housing	will be examined by ultrasonic method, weld filled to bring back the original profile and protection coating will be applied.

1.2.6 DETAILED SCOPE OF NEW PLANT & EQUIPMENT FOR ERECTION, TESTING & COMMISSIONING:

The broad scope of new equipment/facility is as follows.

Sl. No.	Name of Equipment / Facility	Unit	Qty
A	TURBINE, GENERATOR & ASSOCIATED EQUIPMENT		
1.	Main Inlet Valve	Sets	3
2.	Pelton Turbine (Suitable for producing 27.5 MW at Generator terminals at rated head and discharge) complete with all associated equipment and auxiliaries	Sets	3
3.	Nozzle injector assembly, Needle servomotor, Deflector servomotor & knives etc... (4 jets / unit) - complete with all accessories and controls	Sets	3
4.	Digital type Electro-hydraulic turbine governors with all accessories and controls - complete	Sets	3
5.	Vertical Shaft Generator 27.5MW+10% COL – complete with all accessories and controls (including generator shaft)	Sets	3
6.	Static Excitation System complete with Auxiliaries	Sets	3
7.	11kV Segregated Bus ducts with all accessories	Sets	3
8.	Unit Control, Protection & Metering System	Sets	3
9.	Generator Transformer Control, Protection & Metering System	Sets	3
10.	Power transformer (12.5MVA) control, protection and metering system	Sets	2
11.	Common annunciation panel (for all 6 units and 110kV feeders)	Set	1
12.	LAVT panel and NGT cubicle	Sets	3
13.	Synchronizing panel complete- with all accessories and controls	Set	1
14.	Temperature scanners with at least 32 channels	Sets	3
15.	Unit Automation Panel with all accessories and controls	Sets	3
16.	Automation Panel for Common Services with all accessories and controls	Set	1
17.	Computerized Control System (SCADA) covering entire power house (3+3 machines and switch yard) with all accessories	Set	1
18.	Operator work station with independent and large video server using LED backlit LCD screen, with screen size not less than 68" (diagonally) with dedicated PC, control and graphical unit.	Set	1

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19.	Dry type indoor 500 kVA Unit Auxiliary Transformer with all accessories and controls	Sets	3
20.	LT switchgear for unit auxiliaries & common services with all controls and interlocks	Set	1
21.	Auxiliary supply & metering panels	Set	1
22.	415V AC Unit Auxiliary Board	Sets	3
23.	415V AC Station Service Board	Set	1
24.	110V DC Main & Sub Distribution Boards	Sets	3
25.	110V DC Emergency Distribution Board	Set	1
26.	Uninterrupted Power Supply System (1+1 standby), 30kVA, 240VAC, Single phase, 50Hz with a common plante / tubular battery set	Set	1
27.	Powerhouse Lightning Protection System	Set	1
28.	Renewing station lighting including changing of cables and controls	Set	1
29.	Station Grounding System	Set	1
30.	Cooling Water System (3 motor driven pump sets with all accessories and controls)	Set	1
31.	Oil Handling System (LVDH) for governors	Sets	3
32.	Portable oil filtering unit for bearing oil	Set	1
33.	LP Compressed Air System (for air brakes, dust collectors etc...)	Set	1
34.	Brake Dust Extraction System for Generator	Sets	3
35.	CO2 Fire Protection System for Generator	Sets	3
36.	Portable Fire Extinguishers (Foam, DCP, CO2, fire balls, fire buckets, Clean Agent type & ABC type)	Set	1
37.	Air Conditioning & Ventilation System including control room modification	Set	1
38.	Feeder Vertical panels having Feeder Control, Protection, Metering & instrumentation system	Nil	Nil
39.	Bus protection panel	Nil	NIL
40.	Power, Control and Instrumentation Cables including SCADA compatible cable, Cable trays & Cable accessories complete for powerhouse.	Set	1
41.	Battery charger with 110V twin charger suitable for 400AH battery including all connections	Set	1
42.	Vibration Monitoring system for Lower guide Bearing, Upper guide Bearing and Turbine Guide Bearing including bracket vibration in both x and y directions	Set	3
43.	Shaft current monitoring system	Set	3
44.	HP oil and jack system	Set	3
45.	Creep detectors with all accessories and controls	Set	3
46.	Moisture detectors	Set	3
47.	Anti Condensation Heaters	Set	3
48.	Mechanical overspeed device with all accessories and controls	Set	3

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49	Portable partial discharge monitor	Set	1
B	Electrical Equipment: Detailed in this chapter in SECTION IIA		
C	Control & Instrumentation: Detailed in this chapter in SECTION IIB		
D	Civil Works: Detailed in this chapter in SECTION IIC		
E	MISCELLANEOUS		

1.2.7 BATTERY LIMITS:

On the power house upstream side, the battery limit will be up to penstock outlet in power house of each unit. On the downstream side, the battery limit will be up to Turbine discharge chamber.

FACILITIES ALREADY INSTALLED FOR THE PROPOSED UNIT

Penstock, Distributor, Power House, EOT Crane (1 Nos each of capacity 65/5 Ton) and Tailrace are constructed/installed and to be utilized for the proposed Units 1 to 3.

BRIEF OF EQUIPMENT

1. TURBINE SYSTEM

a. Distributor

Existing distributor has to be refurbished

b. Turbine casing

Existing turbine Housing has to be refurbished

c. Nozzle Servomotor and Deflector Servomotor assembly

There are four internal nozzle servomotor / deflector servomotor assembly in one unit. Each set consists of Nozzle Inlet/Spider, Nozzle tip and nozzle tip liner (SS), jet deflector, needle and needle stem, nozzle servomotor, deflector servomotor etc. Before erection, complete nozzle and deflector assembly are to be tested in S/bay. Weight of each nozzle assembly is approximately 9.17 tonnes.

Deflector operating mechanism: It shall consist of servomotor connecting rod, lever, inter connecting links etc.

Oil headers for nozzle servomotor assembly and deflector servomotor assembly: Supplying oil for opening and closing of nozzle servomotors and deflector servomotors oil headers are provided.

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d.Runner & shaft assembly

The Pelton type runner assembly having 23 buckets with OD 1700 mm appx and height 400 mm is weighting approximately 16 tonnes.

The turbine shaft nominal dia appx 450 mm with flanges at both ends is bolted to runner at turbine end with shear bush and fitted bolt. Upper flange of turbine shaft is bolted with fitted bolt to generator shaft bottom flange. Total length of shaft is approx. 2630 mm and approx. weight is 5.38 tonnes.

The shaft is provided with a collar to support the runner and shaft assembly on the turbine guide bearing housing when uncoupled from generator end.

e.Turbine guide bearing

Turbine Guide bearing shall be of self-oil lubricating shell type with cooling arrangement. The bearing shall be located above the turbine runner.

The bearing shall permit sufficient vertical movement of the runner and shaft to allow for adjustment of the generator thrust bearing.

f.Feedback mechanism

It comprises of wire rope mechanism and LVDT to transmit signal of the movement of nozzle servo motor (opening/closing) to the hydro mechanical cabinet (HMC) of governor

g.Metering instruments

Pressure and temperature measuring instruments are installed on this metering panel to measure the pressures of different points like distributor, sealing air & water pressures, servomotor closing & opening pressures etc. The pipelines shall be hydraulically tested to required pressure.

h.Oil, water, air pipelines

Laying and clamping /supporting of oil pipe lines, water pipe lines and compressed air pipe lines are would be shown indicative in respective drawings. Laying of these pies to be decided to suit site condition. Pipes shall in general be supplied in straight lengths and to be bent at site as per requirement. For medium and large size pipes, regular bends may not be supplied and therefore bends shall have to be fabricated at site within the quoted rates. The pipes are to be welded at site as per drawing. All welds are to be tested as per drawing requirements. All pipes are to be hydraulically

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tested at site after welding. Cleaning of pipe acid pickling to be carried out as per drawing requirement.

i. Other Miscellaneous Mechanical assembly

Other miscellaneous mechanical assembly like, hatch covers, platform and ladders etc. are envisaged.

j. Main Inlet Valve (Spherical Valve):

Main Inlet Valve: 850 mm nominal diameter spherical type including inlet pipe, outlet pipe with dismantling joint, Service seal(main seal) on U/S and Maintenance seal on D/S side is piston type, two levers, two servomotors, Bypass valve, Air release/Decompression valve and anti-vacuum valve, drain valve, flow measurement device etc. The upstream and downstream cast machined bodies are bolted together. The valve door shall be of casting with trunnions on both sides bolted. Weight closure is envisaged.

Inlet pipe of MIV: The inlet pipe (56 mm thick) is in one piece of diameter 1200 mm at upstream side and is welded to penstock and at downstream side flanged to MIV. Welding shall be subjected to NDT as per drawings.

Outlet Pipe with dismantling joint: The outlet pipe (56 mm thick) with dismantling joint is in one piece of diameter 1200 mm. At upstream side it is flanged to MIV and at downstream side flanged to distributor.

k. Digital Governor & Oil Pressure System for Governor, Oil Pressure system for MIV, Oil Pressure System for Penstock Valve

2. GENERATOR SYSTEM

a. General:

The generator is of vertical shaft suspended type construction with closed air circuit ventilation and suitable for coupling to a Pelton turbine. Static excitation system is provided for energizing the field winding of rotor. This supply is fed through slip rings located above the generator rotor. The generator thrust cum guide bearing is positioned above the rotor in upper bracket and a lower guide bearing below the rotor in lower bracket. The bearings are of self-lubricating type and immersed in oil bath in which plug-in type oil coolers are provided.

Air operated brakes are mounted on lower bracket. These are also used for lifting the rotor for maintenance purposes.

For trapping and subsequent evacuation of the brake dust generated during braking operation, brake dust collection equipment has also been provided.

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Generator lower guide bearing is positioned below the rotor. The bearing is self-lubricating type, immersed in oil bath with plug in coolers provided for cooling of oil. The upper bracket (top bracket) will be bolted on the stator frame.

Air coolers are directly mounted on the outer steel casing of stator. CO2 type fire extinguishing system is provided. For monitoring the vibrations on the bearings of the machine, an on-line (continuous) monitoring system has been provided. Creep running of the machine is detected through a creep detector which is in governor scope. Air gap monitor and shaft current monitor are also provided. Portable partial discharge equipment is also provided.

b.Stator:

The stator frame shall be split in sections consistent with transport limitations and shall have bolted and doweled joints with seal welding. Wound stator in 4 segment shall be supplied to be jointed at site. For installation of wound stator over the existing/new sole plate, sandwich plates are to be welded after taking the measurement.

Also for bottom bracket sole plate, the existing rib over the sole plate to be cut and sandwich plate to be welded after taking measurement. Also machining of above sandwich plate shall be in the scope of contractor

c.Rotor:

The rotor shall be built at site. Rotor construction shall be designed to suit the assembly at site (stacking, pressing, curing of lamination insulation, installation and mounting of rotor poles).

The poles shall be fastened to the rotor rim by means of simple or double dovetails or T-heads and secured in place by means of tapered keys.

d.Collector:

The collector shall be installed on the top of the generator above the upper guide bearing and shall transmit the excitation current to the pole coils via connection bars fitted in the upper shaft. It shall include two slip-rings i.e. one per polarity, brushes and brush holder.

e.Generator Shaft coupling:

The shaft shall be made of forged carbon steel properly heat-treated and provided with coupling flanges at top and bottom for connecting to the rotor, and to the turbine shaft respectively

f.Bearings:

The generator will be provided with thrust bearing arranged in upper bracket, upper guide bearing arranged with central part of upper bracket and lower bearing arranged on lower bracket.

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g.Brakes and jacks:

The generators shall be equipped with a combined braking and jacking system. Piping in the brake and jack system shall be of stainless steel seamless type.

h.Fire protection

An automatic CO2 fire protection system with distributing mains and two ring headers, one at the top of the stator overhang and other at the bottom within the generator housing, spray nozzles, thermostatic temperature detectors, smoke sensors, aspirator type smoke detector, control equipment etc. as required for fire detection/protection and extinguishing the fire within the generator shall be installed.

CO2 supply at the desired pressure shall be made available from the fire CO2 bank system outside the generator barrel up to fire control panel. Necessary controlling valves and piping for further connection shall be installed. Suitable arrangement shall be made for testing the system.

i.Brake dust collection system

Suitable exhausting arrangements for sucking and collection of brake dust, will be provided during braking operation of the machine, consisting of extraction unit, hoppers around brake assembly for trapping dust and flexible hoses for connecting hoppers to the extraction unit. The extraction unit will have a motor driven exhaust fan to be fitted with an easily removable sheet steel bin for collecting heavy dust. The lighter particles of the dust will be collected by suitable fabric based filter.

j.Cooling water system

The unit will be self-ventilating by its own circulation action. The generator will be totally enclosed. Pit seals will be provided for separation of the generator air-cooling system from the turbine pit. The air-water heat exchangers (stator air coolers) will be mounted on the stator frame, each provided with shut -off valves at inlet and outlet. Each cooler will be readily removable without disturbing the others when the machine is not in operation.

3. Safety / Monitoring Devices

a.Vibration monitoring system

Continuous vibration monitoring system complete with proximity probes, input/output module, control/processor unit, relays, junction boxes, cabling and associated accessories will be supplied for on-line monitoring of vibration in the generating units. It will comprise:

b.Anti-Condensation Heating

In order to avoid water condensation during long non-operative period of the machine, heating elements will be installed inside the generator barrel. These

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elements will be rated for three-phase 415 V A.C., 50 Hz; and their terminals will be connected to an easily accessible terminal box. The heating will be controlled automatically by adjustable hygrostat, setting range about 50-100% relative humidity. The anti-condensing heating will also be provided with manual ON/OFF switch and corresponding indication lamps in the local control panel. Provision will also be made for adjustable thermostat for automatic control of the heaters.

4. Miscellaneous system

a. Excitation System and Digital Voltage Regulator

The excitation system and DVR will consist of: -One (1) set of dry type excitation Transformer, Full wave fully controlled rectifier system with thyristor bridge arrangement for 100% redundancy, Digital voltage regulators with all limiters & power system stabilizer, Power supply units, Field flashing equipment, including transformers, DC field circuit breakers, Discharge resistors, Digital control and metering equipment, Excitation cable connecting the rotor to DC field breaker, Any other items not specified above but are necessary to complete the system for satisfactory operation.

b. Cooling Water System

Three new sets of cooling water system (one for each unit) will be envisaged. One cooling water pump for each unit. The source of the cooling water is tail race. The existing embedded cooling water pipelines will be cleaned and reused after renovation. Isolation valve, strainer/ filter in suction line of each set of pump set will be provided. Non return valve, strainers, differential pressure gauge across the strainer, pressure gauge, motorized valves etc. will be provided in discharge line of individual pump sets. The discharge of all pumps will be connected through a common header and an isolation valve will be provided between two consecutive units. Through the common header cooling water is fed to individual unit such as generator air cooler, generator thrust bearing cooler, upper guide bearing, lower guide bearing, turbine guide bearing, provision for shaft seal cooling, transformer oil coolers, Air conditioning system etc. Suitable capacity of pump, size of valves, pipeline, instruments etc will be designed to meet the above water requirement. After cooling, return cooling water will be directly discharged through a common header into tail race.

c. Compressed Air system

LP Compressor 1000x1500x1200 mm-2 nos, Air receiver 1500x1500x2000 mm-1 no, complete pipes, valves will be replaced by new one. Automatic as well as manual operation control of LP compressors will be provided. All necessary instrumentation like pressure gauge and temperature gauge etc will be provided. Temperature sensor, pressure switch and auxiliary relays etc as per requirement will be provided.

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d. FIRE PROTECTION SYSTEM

Portable fire extinguisher such foam type, DCP type CO2 type, fire balls, fire buckets, clean agent type and ABC type to placed/ mounted at respective locations in the power house.

1.2.8 ELECTRICS

Scope of contractor will also include following:

Dismantling of existing panels (incl cables), Storage, erection and commissioning of electrical systems as per BOQ. Minor civil works required for fixing of electrical equipment/ panels/ cables, bus duct opening, support and reinforcement of existing foundation etc.

The Contractor will be responsible for complete satisfactorily working of system with guaranteed parameters.

Miscellaneous Activities

Following miscellaneous works will also be included in the scope of Contractor:

- Obtaining certificate from Chief Electrical Inspectorate of the state for installation and energizing the complete electrical system and equipment covered under the package.
- Any modification or additional requirements by Statutory Authorities will have to be carried out without time and cost implication to the BHEL.
- Necessary clearance for the charging of equipment's from electrical inspector is to be obtained by the contractor. Arranging any other statutory approval, if required.

a. ERECTION, TESTING COMMISSIONING:

The scope of Contractor will include erection & commissioning of all electrical equipment required for the power plant units and auxiliaries covered under their scope for R&M of units 1 to 3 with new TG of Kuttiyadi Power House at Kakkayam.

The major equipment covered under scope will be as follows:

- Static Excitation System complete with Auxiliaries
- 11kV Segregated Bus ducts with all accessories

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- Unit Control, Protection & Metering System (generator control panel, turbine control panel etc...) - complete
- Generator Transformer Control, Protection & Metering System - complete
- Power transformer (12.5MVA) control, protection and metering system - complete
- Common annunciation panel (for all 6 Units and 110kV feeders)
- LAVT panel and NGT cubicle
- Synchronizing panel complete- with all accessories and controls
- Temperature scanners with at least 32 channels
- Unit Automation Panel with all accessories and controls
- Automation Panel for Common Services with all accessories and controls
- Computerized Control System (SCADA) covering entire power house (3+3 machines and switch yard) with all accessories
- Operator work station with independent and large video server using LED backlit LCD screen, with screen size not less than 68" (diagonally) with dedicated PC, control and graphical unit.
- Dry type indoor 500 kVA Unit Auxiliary Transformer with all accessories and controls
- LT switchgear for unit auxiliaries & common services with all controls and interlocks
- Auxiliary supply & metering panels
- 415V AC Unit Auxiliary Board
- 415V AC Station Service Board
- 110V DC Main & Sub Distribution Boards
- 110V DC Emergency Distribution Board
- Uninterrupted Power Supply System (1+1 standby), 30kVA, 240VAC, Single phase, 50Hz with a common plant / tubular battery set
- Powerhouse Lightning Protection System
- Renewing station lighting including changing of cables and controls
- Station Grounding System
- Feeder Vertical panels having Feeder Control, Protection, Metering & instrumentation system (including import-export trivector meters with AMR facility)
- Bus protection panel
- Power, Control and Instrumentation Cables including SCADA compatible cable, Cable trays & Cable accessories complete for powerhouse & those required for switchyard
- Battery charger with 110V twin charger suitable for 400AH battery including all connections
- Vibration Monitoring system for Lower guide Bearing, Upper guide Bearing and Turbine Guide Bearing including bracket vibration in both x and y directions
- Shaft current monitoring system
- Creep detectors with all accessories and controls

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- Moisture detectors
- Anti Condensation Heaters
- Mechanical over-speed device with all accessories and controls
- Portable partial discharge monitor
- Local Push Button stations for drive motors, Junction boxes etc.
- HT & LT Power and control cables, instrumentation and special cables as per requirement and accessories including their termination at both ends. All kind of cables of power house equipment as well as switchyard equipment is in the scope of Contractor.
- Cable supporting structures, GI cable trays (ladder type and perforated type), cable racks, other associated accessories and fire sealing materials for laying, termination and sealing of cables are supplied by supplier. Cable trestles, if needed within the battery limit for supporting contractor's cables, will be in the contractor's scope. Contractor will lay separate trays for laying different type of cables like power, control and screened cables.
- Complete earthing system for all the equipment/systems - equipment earthing and electronic earthing as per actual requirement. Earthing connection of all new equipment to existing network.
- Welding sockets (415V), Power receptacles, 240 V sockets, 240V Industrial type sockets etc. are included in the scope of the contractor.
- 110 kV Switchyard (Material handling only)
- Illumination within battery limit including DC emergency lighting.
- Lightening Protection for area under extension of 110 kV Switchyard In addition to above.

Following are also the scope of Contractor:

- Supply of hand gloves and shock treatment charts in English, Hindi and Malayalam.
- All the test required for successful commissioning of the system (Transformer, CT/PT) is to be done by vendor after arranging necessary instruments/equipment's like SFRA, DGA, PPM, BDV, Tan-delta test etc as per the guidelines issued by concerned supplier. Agencies to carry out these test are to be deployed among the approved list of the supplier (to be provided in due course of time). These tests are to be repeated till charging clearance from the supplier.
- Electrical Protection System: The protection required for the various electrical equipment e.g generator, generator transformer, 110/11 kV, 500 KVA Station transformer, unit aux. transformers, station auxiliary transformer, auxiliary motor etc. All the relays including generator protection relays will be microprocessor based numeric type irrespective of their use with communication facilities.
- Common electrical system to erected, tested and commissioned with the first unit for which RMU is carried out.
- Arrangement of temporary work yards, material depots and access as

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- required, as well as removal from site of all erection equipment, packing materials etc.
- Any item not mentioned in the specification, but considered by the Contractor necessary for satisfactory operation and maintenance of the plant will be included by the Contractor in his scope of installation.

b. DISMANTLING

The scope of the Contractor will also include the following:

- Dismantling of all equipment within battery limit. Contractor has to remove all the old/existing equipment along with cables. All the unused existing equipment will be removed, packed and placed in a proper place within 1 km as decided by the purchaser. Following major existing equipment will be dismantled.
- Excitation System including Pilot Exciter, Main Exciter, Slip rings, Excitation panels etc.
- 11kV Bus ducts, Power, Control and other cables
- 11 KV switchboards, Unit Auxiliary board panels, Control panels, Protection panels
- All electrical panels including 11 kV Switchboards, Unit Aux. Board, Station Aux. Boards and control cables pertaining to Units # 1 to 3
- All station switchboards
- Battery banks, battery chargers and DCDBs
- HT, LT and Control cables
- Cable trays, supporting structures, cable racks etc
- Generator control & relay panel, generator metering panel, generator transformer control, relay & metering panels.
- CTs, PTs, LAs etc.
- All steel structures required under battery limit to complete the job.
- **Cabling (Cables, Cable supporting materials, trays etc)**
- All HT/LT power, control cables and cable accessories supporting structures, cable installation, cable terminations with necessary junction boxes and fire sealing are under the scope of Contractor for all areas and also including all HT cables includes cables from station transformer to 11kV switchboard and 11 kV switchboard to Station Auxiliary Transformer.
- All control and protection cables required for connection to relays, meters, signaling alarm, control, monitoring etc. at main station building will be provided. They have to be laid, glanded and terminated at both ends by the Contractor. Existing cables will be removed and placed in proper condition in a place identified by the purchaser's store.
- In addition to the above equipment dismantling and storage of other equipment / structures etc as required to complete the job is in the scope of Contractor.

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c. BATTERY LIMITS AND TERMINATION POINTS

Generator Transformer Side

Power evacuation up to generator transformer will be included in Contractor's scope. Control cable including cable termination at both ends wherever signals are required to be tapped/transmitted including control cable termination in yard equipment is in contractor scope.

Auxiliary Side

Existing DG set

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SECTION IIB: CONTROL & INSTRUMENTATION:

a)GENERAL

This specification is intended to define the basic requirements of instrumentation & control system for R&M with New TG for the Unit- 1 to 3 along with their auxiliaries as specified in the contract document. The basic philosophy of C&I system will cover entire 3 units in totality and will be based on the state-of-the-art microprocessor based control system. The C&I system will ensure safe, efficient and smooth operation of the plant and equipment with minimum intervention of the operating personnel during normal working of the plant, load fluctuation/shut-down and start-up of the unit.

b)SCOPE OF WORK

The scope of work will include transportation to site, storage, erection, testing and commissioning of all instrumentation and control equipment, cables, pipes, auxiliaries and erection hardware necessary for completion and handing over of instrumentation and control work for the unit after integrated final commissioning.

The Contractor shall do all erection and commissioning of the complete Control and Instrumentation system including Distributed Control System (DCS) or Programmable Logic Control (PLC) based system, Primary and Secondary Instruments, Panels, Control Desks, Alarm Annunciation System, Electric Power Supply System, Actuators, Instrumentation Cables and Process Connection impulse tubing, Actuators/MOV (Motor Operated Valve).

The scope of work will also include all civil works, like chipping, digging, concreting including filling material etc. associated with erection of instruments and associated equipment. Installation of all HT/LT power, control cables and cable accessories supporting structures, cable installation, cable terminations with necessary junction boxes and fire sealing are under the scope of Contractor for all areas covered in the scope including all HT cables. All control and protection cables required for connection to relays, meters, signaling alarm, control, monitoring etc. at main station building will be provided, laid glanded and terminated at both ends by the Contractor. Existing Panels, cables will be removed and placed in proper condition in a place identified by the purchaser's store. All existing Impulse tubes, conduits will be replaced by new SS impulse tubes and conduit. Erection, testing and commissioning of the total equipment for successful commissioning/completion of the project are in scope of contractor.

Measurement and control equipment will be complete in all respect and any equipment / accessories not explicitly indicated in this specification, but considered essential for proper functioning of equipment and process will be included in the Contractor's scope of

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work. The instrumentation system will cover for New TGs and its auxiliaries. A proven dedicated 1:1 hot redundant centralized Distributed Control System (DCS)/ PLC based system for each unit will be envisaged with this package. Redundant Electro Hydraulic Turbine Control system with redundant actuator will be envisaged for each turbine. Electro – Hydraulic control unit will be envisaged for Servo Rotary Valves. The instrumentation equipment for all units of Hydel power plant with their auxiliary facilities as covered in the specification and also as felt necessary by the BHEL shall be completed by Contractor for the completeness of the job. Fully wired panels, cabinets, desks, racks, transmitter cabinets and junction boxes. All signal, control & Power cables will be FRLS armoured types or manufacturer standards cables required for instrumentation work. All field instruments (4-20mA) will be replaced by new SMART type 2 wire transmitters. All local field mounted instruments for New TGs will be newly envisaged. Turbine Vibration monitoring system and measurements with sensor and converter box will be provided for New TGs as per manufacturer standards. Erection, calibration, testing and commissioning of the total equipment included in this specification. All tools and tackles, special testing equipment and consumables required for erection and commissioning activities will be arranged by the contractor.

1.2.9 CIVIL WORKS

CIVIL SCOPE OF WORKS

General

The project comprises of Renovation, Modernization & Uprating works of the existing Kuttiyadi Hydro Electric Project from (3x25 MW) to (3x27.5 MW). Following works are to be executed

A.Associated Civil Works pertaining to renovation and modernization of existing project

B.Supply and installation of Storage shed of size 30m X 15m x 6m including foundation works

Broad Scope of work

- a) All associated civil works pertaining to renovation and modernization of existing project will include but not be limited to Testing for suitability of the existing foundation, required minor modifications in the existing foundations (i.e. strengthening by re-barring/anchoring), Ventilation system foundation, additional rooms, cutouts/openings, dismantling of concrete and Dismantling & re-construction of brick work etc. including supply of all materials, labour, tools and plants.
- b) Design, Procurement, Supply, Receipt at Site, Erection, Painting & Finishing works etc and Handing over to site Removable/ Re-erectable type Pre-Engineered, Pre- fabricated Steel Closed Storage

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Sheds- 1 nos. of size 30m X 15m x 6m including construction of civil foundation as per the technical specification.

Note:

- The above provided list is indicative only for the bidder's guideline. Any other work not mentioned above, but required for completion of the package in total, deemed to have been included in the bidder's scope under this contract. Such work will be executed under this contract by bidder as per the direction of Engineer in charge.
- The complete works shall be carried out as per scope. If any work covered in the scope of contract cannot be executed using items available in BOQ, additional / extra items shall be made and rates for such items shall be worked out as per clause 2.15.7 of GCC. However, contractor shall be bound to execute all the works under the scope of the contract and decision whether an extra item is applicable or not, shall be taken by BHEL Engineer, which shall be binding on the contractor.
- Reinforcement steel, structural steel for civil & structural works, embedment's/ inserts as required, for the works in general shall be supplied by the bidder and payment shall be made as per corresponding item in BOQ. If BHEL provides Structural Steel from scraps (if available) for inserts, payment shall be made as per corresponding item in BOQ.
- The excavated earth has to be heaped in the desired location and the same should be utilized for further filling works. No additional lead shall be given.
- 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, 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.
- 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.
- 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.

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- 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.
- The unit rates quoted for various items of B.O.Q shall include all the stipulations mentioned in technical specifications and nothing extra over B.O.Q rates shall be payable.
- Drawings showing enough details for the construction as per the specification shall be furnished to the contractor in a phased manner.
- In case the description/specifications as per BOQ are found to be incomplete, Indian Standard Codes (IS Codes) specifications shall be followed. Quantities mentioned in the BOQ cum Rate Schedules, are approximate only and liable for variation due to change of scope of work / variation in schedule of quantities, changes in design etc. The tenderers shall undertake to execute actual quantities as per advice of BHEL Engineer and accordingly the final contract price shall be worked out on the basis of quantities actually executed at site and payments will also be regulated for the same. The quantities indicated against each item may vary to any extent and no compensation will be payable in variation of Individual quantity.
- Any activity which is necessarily required for satisfactory execution of any item of BOQ in line with technical specifications shall be deemed to be included in BOQ item even if it is not described in the item description and no extra payment shall be made against such activity.
- Furnishing samples of all materials required by the BHEL Engineers for testing / inspection and approval, for use in the works. The samples may be retained by the BHEL Engineer for final incorporation in the works.
- Furnishing test reports for the products used or intended to be used, if called for the specifications or if so desired by the BHEL Engineer. Contractor shall furnish the manufacturers test certificate for the steel & cement procured by them. Apart from this all the field test shall be arranged by contractor for concrete, bricks, coarse & fine aggregate, Gravels /Boulders etc. either at site or nearby Field Quality Lab. approved by BHEL if so desired by BHEL's Engineer. All the expenses in these regards shall be borne by contractor. Contractor shall procure Reinforcement Steel, Structural Steel & Cement from reputed manufacturer & approval for the same shall be obtained from BHEL well in advance before ordering for the materials.
- The bidder should fully apprise himself of the prevailing conditions at the proposed site, climatic conditions including monsoon pattern,

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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.

- The Contractor will carry out all checks and tests as directed by the Purchaser / Consultant and submit the results thereof. Acceptance of works will be subjected to achieving required quality as laid down in code of Bureau of Indian Standards.

METHOD OF MEASUREMENT

Mode of measurement shall be as per relevant IS 1200 in conjunction of IS code 3385. 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

For Detailed scope of work

a) CIVIL WORK : Refer

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Chapter 2 (Section-C: SPECIFIC TECHNICAL REQUIREMENTS FOR CIVIL & STRUCTURAL WORKS (SPECIFICATION NO: PE-TS-471-600-C001))

Chapter 3 (Section-D: CIVIL, STRUCTURAL & ARCHITECTURAL WORKS (SPECIFICATION NO. PE-TS-471-600-C001))

b) STORE SHED Erection : Refer

TECHNICAL CONDITIONS OF CONTRACT (TCC) PART-II

Chapter-4 (Section-E - SPECIFIC TECHNICAL REQUIREMENTS FOR STORAGE SHED)

MISCELLANEOUS

- I. The equipment and piping shall be erected in conformity with the provisions of standards/ specifications and as may be directed by BHEL. The method of welding (Arc, gas, TIG, MIG/MAG or other method) may be indicated in the detailed drawing/ schedules. BHEL engineer will have option of changing the method of welding as per site requirements.
- II. On the discretion of BHEL site engineer, which is depending upon the site requirement, some of the material may be directly unloaded in the powerhouse/work site with EOT Cranes or own crane or suitable alternative own arrangement of contractor. Contractor shall

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keep record of the same. For such works contractor shall be paid under material-handling work of packages.

- III. EOT cranes shall be provided free of hire charges and on sharing basis with KSEB. The contractor will have to provide additional qualified operator for operating the EOT cranes round the clock if required or as per requirement.
- IV. Penstock, distributor, Power House, EOT Crane (1 Nos of capacity 65/10.2 Ton), and Tailrace are constructed/installed and to be utilized for the proposed Units 1 to 3.
- V. Construction drawings and documents shall be provided at site to the contractor for erection of work. The Contractor shall be provided with construction power at 400V, 3-phase for the purpose of the erection/construction under the Contract only at single one point and is chargeable. The Contractor shall make his own arrangements to lay and maintain necessary supply lines for temporary power from a single point. The Contractor shall make his own further distribution arrangement. All temporary wiring must comply with Indian Electricity Rules and Act and will be subject to the customer's inspection and approval before connection to supply and later. Non-availability of power from the customer shall not be an excuse for delay in completion of erection/construction.
- VI. On the discretion of BHEL site engineer, **Construction power to other BHEL contractors/vendors shall be provided by contractor on chargeable basis. The charge towards electricity consumption by other contractors shall be decided by BHEL site in-charge.** However, electricity bill raised by power supplier is to be paid by contractor. The bill may include fixed charges, minimum consumption charges, taxes, duties etc.
- VII. Display of danger board signs in Hindi, Malayalam and English languages near switches is to be ensured by the Contractor. The Contractor will supply and install all distribution cables, wires and switches, etc. of rated capacity for the work starting from the source of power at his own cost. He will employ Electricians having valid Electrical License for carrying out the installations as well as for the maintenance works.
- VIII. Bidder shall also install DG set of suitable capacity for backup power in case of power failure as per site requirement for construction power.
- IX. **Installation, maintenance and operation of Hydra/ Mobile Crane shall be in scope of contractor. Hydra/ Mobile crane of suitable capacity to be deployed by the contractor**
- X. **Heaviest consignment to be handled is approx. 40T/or may be higher. The contractor shall deploy of the suitable capacity**

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crane on his own as and when required to complete the work (within the quoted rates). No crane shall be provided by BHEL in storage yard/dumping yard for any purpose.

- XI. Dismantling of stator shall be done in erection pit/ service bay/ dumping yard as per customer requirement. Generator/Transformer/cable etc. will be dismantled by the contractor. Dismantled materials will be properly recorded with KSEB and to be stored in PH space provided by BHEL/KSEB and within 1Km of power house (storage space provided by BHEL/KSEB).
- XII. There is only one rotor erection pit in power house. The ways and means of cutting and dismantling of other rotors (while the assembly of one rotor in rotor erection pit is underway) within transportable limit of power house shall be responsibility of the Contractor. Necessary procedure for the same shall be submitted by the Contractor to owner for information/acceptance.
- XIII. Stator and rotor assembly of each unit to be done parallel in service bay by the contractor.
- XIV. In the workshop of KSEB there are equipment's/machine like drilling machine, lathe etc. Contractor shall deploy qualified operator as and when required within the quoted price.
- XV. Chain pulley blocks, jacks, pull lift machines, D-shackles and general T&P shall be arranged by the sub- contractor at his own cost with due test certificates.
- XVI. Details of Major equipment along with weights & Dimensions, supplied by BHEL & its vendor under this scope are given in (Volume-IA, Part-I, Chapter-IV). However, changes on account of change in design may occur, for which no compensation will be payable and contractor shall complete the entire work as detailed in the tender specifications within finally accepted rates/ prices. As per instructions of BHEL site engineer and or due to space constraint at service bay/power house /work site/stores, some of the assemblies, devices like the Stator/rotor lifting devices, hydraulic test device, other T&Ps may require multiple handling and multiple stacking for shifting from power house/work site to BHEL stores and stores to power house /work site. This shall be responsibility of contractor and for this no additional payments shall be made to contractor.
- XVII. The welding electrodes required for site welding/renovation of major components of turbine like Turbine casing, distributor, Inlet /outlet pipes of MIV/IDV, some high pressure piping and any other special consumables **which are supplied by manufacturing units** along with plant material shall be issued to contractor for subject work free of cost. Contractor shall maintain proper records for all those consumables and submit the signed copy of consumption certificate

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(along with respective RA bills) from the respective package Incharge nominated by Engineer Incharge. **However general purpose electrodes for systems like piping of generator, Turbine and its auxiliaries bus ducts and other auxiliary pipelines etc. Electrodes /filler wires shall be the responsibilities of contractor. Contractor shall arrange BHEL approved general purpose electrodes.**

- XVIII. Field efficiency test of (Turbine & Generator) shall be done on all the three units.
- XIX. **PAINTING:** - All the plant equipment's /items shall be painted with required coat of red oxide primer & required coat of synthetic enamel paint, color as per drawings and site requirement. Paint shall be supplied by BHEL supplying units. The quantity to be supplied by manufacturing units is fixed. Contractor has to follow the painting procedure strictly, any deficiency in quantity of paints due to wrong procedure shall be borne by the contractor.
- XX. The contractor shall have to deploy adequate experienced/qualified engineers and supervisors for material handing work, dismantling work and erection, commissioning, pre-commissioning, testing/checking work, trial run and attending pending points of the units, minimum man-months deployment required shall not be less than the following:-

Sl No	Type of Manpower	Quantity (Nos)	Minimum Man-months
1	Engineer (Degree holders)	02	48
2	Supervisor (Diploma holders)	04	96
3	Welding Supervisor / NDT level-II (Qualified)	01	28
4	Safety supervisor (Qualified)	01	28

The above figures for deployment of engineers and supervisors for material handing work and erection, commissioning, pre-commissioning, testing/checking works are tentative only and if need for any additional manpower over and above the mentioned figures are required as per site requirement, the same shall be arranged by the contractor at no extra cost to BHEL. If the contractor fails to deploy the minimum man-months of each above category manpower at appropriate time at Kuttiyadi HEP site as per site requirement then deduction shall be made from his bills at the rate of Rs.50,000/- per man month for Engineer (at Sr No 1) and Rs. 25,000/- per man month for supervisors (at Sr No 2,3,4). If any of the above category is not utilized fully, it shall be converted in to

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other category keeping in view the rates at the discretion of BHEL.

Utilization report of all above man-months shall be maintained and submitted the signed copy of utilization report certificate (along with respective RA bill) from the respective package In charge nominated by Engineer In charge.

XXI. The contractor under this contract shall also provide services of skilled/semiskilled/unskilled persons for total contract period free of cost exclusively for use by BHEL. This manpower will be required for following services:

- Skilled workers for office, colony, stores.
- Semi-Skilled workers for office, colony, stores.
- Un-Skilled workers for office, colony, stores.

Persons so deployed shall have to work in extended hours whenever required. Workmen provided as per the above provisions shall be fully trained and experienced in the nature of work for which they are deployed.

In case contractor fails to provide above-mentioned manpower as desired by BHEL, the latter shall have the right to hire such services from other agencies at the risk and cost of the contractor. During extended contract period, contractor shall continue to provide the above categories of workers for BHEL use. Utilization report of all above man-months shall be maintained and submitted the signed copy of utilization report certificate by the contractor (along with respective RA bill) from the respective package Incharge nominated by Engineer Incharge.

“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.

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VOLUME – I A (PART – I): Chapter- III Time Schedule

1.3 TIME SCHEDULE

MOBILIZATION, TIME SCHEDULE, CONTRACT PERIOD AND GRACE PERIOD

1.3.1 INITIAL MOBILIZATION:

After receipt of LOA, Contractor shall discuss with Project Manager / Construction Manager/Engineer Incharge of BHEL regarding initial mobilization. Contractor shall mobilize necessary resources (considering the immediate requirement of the site and agreed by Engineer Incharge) within 15 days of issue of letter of award or as per the directive of Project Manager / Construction Manager. Such resources shall be progressively augmented to match the schedule of milestones and commissioning.

1.3.2 MOBILIZATION FOR DISMANTLING, ERECTION, TESTING AND COMMISSIONING ETC.

The activities for Dismantling, erection, testing etc shall be started as per directions of Construction Manager of BHEL. Contractor shall mobilize further resources as per requirement to commence the work of erection, testing etc as per scope of work, and progressively augment the resources to match schedule of the project.

1.3.3 COMMENCEMENT OF CONTRACT PERIOD AND TENTATIVE SCHEDULE

Planned/actual Start of Site store erection work activity at site shall be considered as “start of contract period” whichever is earlier. The date of commencement of contract period shall be the mutually agreed date between the bidder and BHEL site engineer to start the site store erection work. In case of discrepancy, the decision of BHEL site engineer is final. Site mobilization will not be considered as start of contract period. The contractor has to subsequently augment his resources in such a manner that following major milestones of erection & commissioning are achieved on specified schedules:

	SN	MAJOR MILESTONE	START/ COMPLETION
	1	Site Mobilization	15 days from Award of LOA or as decided by BHEL.
	2	Start of contract period (Zero date)	Start of Site store erection work at site as decided by Project Manager of BHEL.
	3	Start Dismantling of unit 3	90 days from zero date

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M1	4	Complete Dismantling of Unit 3.	120 days from zero date
M2	5	Completion of Unit axis alignment of Unit 3.	300 days from zero date
	6	Completion of Trial Run of Unit 3.	330 days from zero date
M3	7	Complete Dismantling of Unit 2.	360 days from zero date
M4	8	Completion of Unit axis alignment of Unit 2.	540 days from zero date
	9	Completion of Trial Run of Unit 2.	570 days from zero date
M5	10	Completion of Dismantling of Unit 1.	600 days from zero date
M6	11	Completion of Unit axis alignment of Unit 1	780 days from zero date
	12	Completion of Trial Run of Unit 1.	810 days from zero date
	13	Completion of all facilities at site including completion of punch point and site closing.	870 days from zero date

Note: Above schedule of activities is tentative and may change as per site/customer requirement.

1.3.4 PENALTY FOR SLIPPAGE IN MILESTONES

The construction programme/work schedule approved by customer which includes milestone dates for the completion of various important component parts and installation of equipment. The same will be shared to the contractor. These milestones are indicators for the timely completion of the project. Any slippage / slackness occurred in the milestones shall be compensated for attaining the final completion date. If any delay / slackness occurs in achieving each milestone stipulated in the milestones for reasons attributable to contractor, a penalty at the rate of 1% of value of works remaining to be completed for that milestone for each day of slippage shall be levied. If the contractor completes the whole project in the agreed time of completion, the penalty so levied shall be paid back without interest after issuance of Completion Certificate.

The maximum amount of penalty to be levied so shall be limited to 5% of the contract amount. The penalty if levied will be recovered from the part bill. In case the liquidated damages are to be charged, the amount of penalty already levied shall be set apart from the amount of liquidated damages. The penalty is to be charged only during the period of completion.

1.3.5 CONTRACT PERIOD

The contract period for completion of entire work under scope shall be 29 MONTHS from the "START OF CONTRACT PERIOD" as specified earlier.

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The period from the commencement of preparatory work for dismantling/erection till the actual "start of contract period" shall not be reckoned for the above purpose.

1.3.6 PERFORMANCE GUARANTEE FOR WORKMANSHIP

Even though the work will be carried out under the supervision of BHEL Engineers the Contractor will be responsible for the quality of the workmanship and shall guarantee the work done for a period of 36 (Thirty Six) months from the date of commencement of guarantee period as defined in Technical Conditions of Contract, for good workmanship and shall rectify free of cost all defects due to faulty erection detected during the guarantee period. In the event of the Contractor failing to repair the defective works within the time specified by the Engineer, BHEL may proceed to undertake the repairs of such defective works at the Contractor's risk and cost, without prejudice to any other rights and recover the same from the Security Deposit.

The start date of the defect liability period is the date of taking over of the project by the Agreement Authority" 36 months shall be the defects liability period.

All the equipments and systems replaced and all other equipments and parts used by the contractor for the renovation of various equipments and systems shall be under defects liability period for a period of 36 months.

In the case of generating units, the defects liability period shall be 36months from the date of commissioning and handing over of each generating unit to KSEBL.

The date of handing over shall be the date of completion of 72 hours' continuous run of each generating unit after completion of its renovation.

In the case of other equipment and common auxiliary systems, the defects liability period shall be 36 months from the date of commissioning and handing over of each equipment/ common auxiliary system to KSEBL.

During the defects liability period the contractor shall replace/repair/ rectify the defects of all the replaced equipment free of cost.

If the defective equipment has to be shifted to the contractors works for such repairs the to and fro freight charges and all other incidental expenses including insurance shall be borne by the contractor.

The contractor shall be liable to rectify the defects noted in the workmanship of modernisation and renovation of units during the defects liability period i.e. 36 months from the date of handing over each units to the KSEBL.

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1.3.7 CONSEQUENCE OF DELAY

- 1.3.7.1 In case of delay in completion is attributable to the contractor, LD shall be imposed on contractor as per GCC clause 2.7.9.
- 1.3.7.2 Risk and cost shall be applicable as per GCC clause 2.7 RIGHTS OF BHEL.
- 1.3.7.3 In case of prolonged delay and if customer imposes risk and cost on BHEL, BHEL shall impose the risk and cost on contractor and recover proportionate amount for risk and cost amount applied by customer on BHEL for number of days' delay attributable to contractor.

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VOLUME – I A (PART – I): Chapter – IV Tentative weight Schedule

1.4 Tentative Package wise Weight Schedule

Tentative weight schedule/ Details have been given below

A	Weight of supplied items	Nos	Unit weight in KG	Total weight in KG
1	EHGC	3	900	2700
2	HMC	3	2800	8400
3	PP set for GOV	3	2400	7200
4	Accumulator for GOV	3	2000	6000
5	N2 tank for Gov	3	1000	3000
6	Oil Sump Tank	3	2400	7200
7	Piston Accumulator for MIV	3	2000	6000
8	N2 tank for MIV	3	1000	3000
9	HCP for MIV	3	1000	3000
10	ECP for MIV	3	400	1200
11	Lub Oil purifier	3	2250	2250
12	Oil storage Tank	2	1200	2400
13	Turbine (incl auxiliaries)	3	46240	138720
14	MIV (incl Auxiliaries)	3	17500	52500
15	BUS Duct (incl LAVT, NG, Structure etc.)	3	22666	67998
16	Generator (incl auxiliaries)	3	143000	429000
17	Misc Packages of HE	3	14800	44400
18	Unit Aux Transformer	4	3400	13600
19	Excitation transformer	4	1500	6000
20	DC system	1	5500	5500
21	LT switchgear system	1	11800	11800
22	Cables (power, control & Inst) & cable tray and accessories	1	55475	55475
23	Earthing & Lighting protection	1	1200	1200
24	OFC	1	3300	3300
25	UnIt & Protection control	3	6300	18900
26	Line control	1	4500	4500
27	Common control	1	4500	4500
28	Misc. Packages	1	40	40

Note:- The above weights of items are tentative only and is liable for variation. These are given for only a general idea to vendor. Payment will be made on the lump sum /unit rate/items-wise accepted by BHEL. No claim of subcontractor shall be entertained in case of mismatch of above weights and actual supplied from MUs.

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VOLUME – I A (PART – I): Chapter – V Rate Schedule/BOQ

1.5 RATE SCHEDULE/BOQ

KUTTIYADI HEP (3X27.5 MW) DISMANTLING, ETC & Material handling work:

1.5.1 Contractor shall fully understand equipment description and scope of work before quoting. The scope of work and responsibility of the contractor as mentioned under these specifications shall be covered within the quoted rates.

1.5.2 The tenderer shall quote the rates as per the rate schedule only. No cutting/ erasing / over writing shall be done.

RATE SCHEDULE CUM BOQ

	SL. NO	DESCRIPTION OF WORKS	QTY	% ALLOCATION ON TOTAL CONTACT VALUE
PART-1 HTG (67%)	1	TOTAL PRICE FOR ERECTION, TESTING, COMMISSIONING AND HANDING OVER THE ENTIRE WORK OF 3X27.5 MW KUTTIYADI HEP. APPROXIMATELY 910 MT SUPPLIED MATERIAL	1 set	51.50%
	2	TOTAL PRICE FOR DISMANTLING OF UNITS (AS PER SCOPE OF WORK OF THIS TENDER)	1 set	6.50%
	3 (A)	TOTAL PRICE FOR ENTIRE WORK AS DEFINED IN THIS TENDER SPECIFICATION IN RESPECT OF RECEIPT, UNLOADING, ITS VERIFICATION PROPER STORAGE PRESERVATION OF PLANT MATERIALS AT PROJECT STORE/POWER HOUSE /WORK SITE AND TRANSPORTATION TO POWER HOUSE/WORK SITE FROM STORE & VICE VERSA AND UNLOADING:HANDED OVER FOR ERECTION.: ALSO MATERIAL HANDLING OF DISMANTLED ITEMS AND HANDING OVER TO CUSTOMER IN THE SCRAP YARD. (AS PER SCOPE OF WORK OF THIS	910 MT	9%

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		TENDER) (TOTAL WEIGHT APPROX.: - 910 MT)		
	3 (B)	TRANSPORTATION OF OLD DISMANTLED ITEMS INCL. LOADING AT POWERHOUSE/OTHER WORK SITE, UNLOADING AND STACKING AT DISPOSAL YARD OF CUSTOMER AT A DISTANCE OF APPROX. 1 KM. (TOTAL WEIGHT APPROX.: - 888 MT)	888MT	
PART-2 CIVIL (26%)	4	TOTAL PRICE OF CIVIL WORKS OF UNITS 1 TO 3 (AS PER SCOPE OF WORK OF THIS TENDER)	1 Set	26%
PART-3 STORE (7%)	5	DESIGN, MANUFACTURING, SUPPLY, RECEIPT AT SITE, ERECTION, PAINTING, FINISHING ETC. AND HANDING OVER OF REMOVABLE/RE-ERECTABLE TYPE PRE-ENGINEERED, PREFABRICATED STEEL STORAGE SHEDS	1 Set	7%

NOTES:

- a. In case any activity though specifically not covered in above BOQ/price schedule but the same is covered under scope of work as per contractual specification etc, no extra claim on this account shall be entertained.
- b. The quantities indicated in scope of works are indicative and are liable to vary depending upon the site requirement. The contractor has to handle/erect/commission/complete all the items indicated by BHEL for achieving completion of work as per the scope. Total payment made to contractor for items shall be on the basis of actual quantity handled/executed as per certification of BHEL.

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VOLUME – I A (PART – I): Chapter – VI **Terms of payment**

1.6 TERMS OF PAYMENT

- 1.6.1 The 'Engineer' will certify regarding the actual work executed in the measurement books and bills, which shall be accepted by the contractor in measurement book.
- 1.6.2 Contractor shall submit bills for the work completed under the specification, once in a month detailing work done during the month. The format for billing shall be approved by BHEL before raising invoices.
- 1.6.3 Shortage / damage reports to be submitted on BHEL standard materials management forms. No payment shall be released till the contractor submits these reports and are verified by the Engineer.
- 1.6.4 PRICE VARIATION COMPENSATION- PVC as per Clause no 2.17 of GCC, is applicable for this contract.
- 1.6.5 RETENTION AMOUNT AND PAYMENTS:- Retention amount shall be withheld from each RA bill as per provision of clause 2.22 of GCC regarding retention amount and payments
- 1.6.6 Subject to any deduction which BHEL may be authorized to make under the contract, the contractor on the certificate of the Engineer at site be entitled for payment as explained hereunder.
- 1.6.6.1 Interest bearing recoverable advance: Not Applicable.
- 1.6.6.2 PROGRESSIVE PAYMENT SHALL BE RELEASED ON PRORATA BASIS

1.6.7 PART 1 ITEM 1 OF THE RATE SCHEDULE

- i.** 80% of contract rate of item No. 1 of rate schedule shall be payable as detailed in Annexure -A (enclosed) on completion of erection.
- ii.** 10% of contract rate of item No. 1 of rate schedule shall be payable as detailed in Annexure -A (enclosed) on commissioning of each unit.
- iii.** 5% contract rate of item No. 1 of rate schedule shall be payable on completion of PG test of each unit.
- iv.** 5% of contract rate of item No. 1 of rate schedule shall be payable as detailed in Annexure -A (enclosed) on completion pending points, contractual obligations and material reconciliation.

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NOTE: Further break-up and/or minor changes in the Annexure A referred above, if required depending upon the site conditions, can be done at site entirely at the discretion of BHEL site.

1.6.8 PART 1 ITEM 2 OF THE RATE SCHEDULE

- i.** 90% of contract rate of item No. 2 of rate schedule shall be payable as detailed in Annexure -B (enclosed) on satisfactory completion dismantling of components.
- ii.** 10% contract rate of item No. 2 of rate schedule shall be payable as detailed in Annexure -B (enclosed) completion of contractual obligation.

NOTE: Further break-up and/or minor changes in the Annexure B referred above, if required depending upon the site conditions, can be done at site entirely at the discretion of BHEL site.

1.6.9 PART 1 ITEM 3A OF THE RATE SCHEDULE

- i.** 30 % of the rate shall be payable on prorata basis after the materials are safely unloaded by using their (vendor) Cranes, shifted to stores and updating in store material register / store stocks registers as per BHEL practices such as GR/LWB/loading advice/box packing slip subject to furnishing of following information along with the bills as per above clause.
 - Proof of claim lodged with Railways/Transporters in respect of shortage/open delivery.
 - Material Management forms duly filled/Records generated in stocks (Stock registers and computers) and certified by BHEL Engineer.
- ii.** 15% of the rate shall be payable on prorata basis after verification, stacking /re-stacking safekeeping, in line with documents and records as per BHEL standards is ensured. Opening of cases/ repacking, wherever necessary (with contractors own T&P and labour).
- iii.** 25 % of the rate shall be payable on prorata basis after Updation of verification details in material stock registers, submission of reports as per specified formats for shortage/open delivery, lodging of police report if required, documents for insurance claims etc and preparation of material receipt certificates in prescribed formats where ever applicable.
- iv.** 27% of the rate shall be payable on pro-rata basis on completion of identification of material in ready to lift for issue to BHEL/Erection agency (Power house/Work site area and vice versa) and updation of issue details in stores records.
- v.** 3% of rate shall be payable on Fulfillment of contractual obligations on pro-rata basis as mentioned below:
 - a.1% of rate shall be payable on Removal of grass/weed/upkeep in the store area.
 - b.1% of rate shall be payable on Preservation of the material.
 - c.1% of completion of material reconciliation.

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1.6.10 PART 1 ITEM 3B OF THE RATE SCHEDULE

- i.** 80% of rate shall be payable on pro rata basis on shifting and unloading including stacking of dismantled material in designated scrap yard area. Document in support of tonnage of dismantled material to be submitted along with the monthly RAB.
- ii.** 15% of rate shall be payable on pro-rata basis on completion of identification and keeping record of dismantled material.
- iii.** 5% of rate shall be payable on completion of area cleaning.

Note: -

- 1. If non-availability of EOT Cranes at power house, the contractor shall use his own crane or make alternative arrangement at his own cost which is acceptable to BHEL site engineer for material handling work. No additional payment shall be made.
- 2. In case the specified activities under all the above categories (i to iv) are not performed, the admissible payment against the performed activities shall be regulated as per the specified break- up only.

1.6.11 PART 2 ITEM 4 OF THE RATE SCHEDULE

- i.** Progressive payment @ 90% of the value of work executed till the date of measurement shall be made based on actual measurements & verification by BHEL through running account bill as per the rates of break-up for civil package as detailed in Annexure -C (enclosed).
- ii.** Balance 10 % shall be paid on completion of pending points and contractual obligations as per the rates of break-up for civil package as detailed in Annexure -C (enclosed).

- The 'Engineer' will certify regarding the actual work executed in the measurement books and bills, which shall be accepted by the contractor in measurement book.

NOTE: Further break-up and/or minor changes in the Annexure C referred above, if required depending upon the site conditions, can be done at site entirely at the discretion of BHEL site.

1.6.12 PART 3 ITEM 5 OF THE RATE SCHEDULE

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.

- i.** 100 % payment on execution of work and on certification by engineer-in – charge for item rate works under A1 to A17. 100 % of the accepted item rate in the Rate Schedule for store as detailed in Annexure -D (enclosed) shall be paid as certified by BHEL Engineer. All admissible deductions shall be made from this 100% value. Retention amount shall be applicable as per GCC.
- ii.** 75% of payment towards rate schedule item B1 in Annexure -D (enclosed) is payable after receipt of materials at site. Balance 25% payment towards rate schedule item B1 in Annexure -D (enclosed) is payable after completion of entire works of shed in totality.

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- iii.** 50% of payment towards rate schedule item B2 in Annexure -D (enclosed) is payable after completion of side & roof sheeting works. Balance 50% payment towards rate schedule item B2 in Annexure -D (enclosed) is payable after completion of entire works of shed in totality.
- Mode of measurement shall be as per relevant IS 1200. 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.
 - 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.
 - The 'Engineer' will certify regarding the actual work executed in the measurement books and bills, which shall be accepted by the contractor in measurement book.

NOTE: Further break-up and/or minor changes in the Annexure D referred above, if required depending upon the site conditions, can be done at site entirely at the discretion of BHEL site.

1.6.13 GST compliant tax invoice is mandatory for releasing of payment. GST amount shall be released separately on submission of proof as per Cl. TAXES AND OTHER DUTIES. E-Invoice as applicable is mandatory for releasing the payment.

1.6.14 Running Account Bills for Storage Shed shall be submitted separately.

1.6.15 Payment for the first running bill will be released only on production of the following.

- i. PF Regn. No.
- ii. Labour License No.
- iii. Workmen Insurance Policy No.
- iv. Wage sheet along with every bill duly certified by the contractor to be submitted.
- v. Unqualified Acceptance for Detailed L.O.I.
- vi. Initial 50% Security Deposit.
- vii. Rs 100 /- Stamp Paper for Preparation of Contract agreement.

1.6.16 Contractor shall submit CHECK LIST TO BE SUBMITTED WITH EACH RUNNING BILL (attached with this tender) with each running bill along with the documents mentioned there.

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VOLUME – I A (PART – I): Chapter-VII **Taxes and other Duties**

1.7.1 Goods and service Tax (GST) & Cess

1.7.1.1 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.

1.7.1.2 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

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

BHEL GSTN - 32AAACB4146P1ZO

NAME - BHARAT HEAVY ELECTRICALS LIMITED

ADDRESS - BHEL SITE OFFICE,

KSEB RMU OF KUTTIYADI HEP,

KAKKAYAM, KAKKAYAM,

Kozhikode, Kerala, 673615

1.9.1.4 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.

1.9.1.5 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.

1.9.1.6 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.

1.9.1.7 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.

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

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1.9.1.9 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.

1.9.1.10 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.

1.9.2 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.

1.9.3 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.

1.9.4 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.

1.9.5 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.

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VOLUME – I A (PART – I): Chapter-VIII Facilities Matrix in the scope of contractor/BHEL

1.6 Facilities Matrix in the scope of contractor/BHEL:

BHEL/KSEB shall provide limited open space for site office and store free of rental charge. It is the responsibility of the contractor to construct temporary sheds for his own use and to dismantle and clear the site after completion of work or as and when required, as a part of his scope of work as per the instructions of BHEL Engineer.

BHEL/KSEB shall provide space for labour colony. Charges for the same if any shall be decided in consultation with BHEL/KSEB. Contractor shall have to build his own colony/ quarters for his workmen/ staff OR can take houses on rental basis in nearby places. Contractor shall be responsible for providing all necessary facilities to staff and workmen like construction of residential accommodation with electricity & water inside the rooms, proper sanitation, transport, medical facilities etc. at his own cost as required under various labour laws and statutory rules and regulations. Electricity & water connection are to be obtained from the statutory body for labour colony & residential purpose. Running charges are to be born- by contractor.

Contractor has to arrange their own DG sets (backup power source), 1 no. of 125 kVA (rating is only indicative, however bidder has to examine the capacity as per requirement) for Power House area for execution of complete scope of work including construction power for power house, switchyard, other work sites, stores and BHEL office etc. within the awarded rates.

The contractor shall have to arrange the water for construction purpose by himself for powerhouse within the awarded rates. Any further distribution will also be the responsibility of the Contractor as a part of his work.

Provision of distribution lines for electric power from the central points/DG sets to the required places of use (like power house & other construction sites, BHEL office, stores etc) with proper distribution boards observing the safety rules laid down by the electrical authorities of the state shall be done by the contractor, supplying all the materials like cables, distribution board, switch boards, TPN, CBS, ELCBS/ MCCBS/ Copper/ Brass clamps, copper conductor, change over switches pipes etc. at his own cost. If any failure is caused in supply of the power and water, it is the responsibility of the contractor to make alternate arrangements at his cost. The contractor shall adjust his working shifts / hours accordingly and deploy additional manpower if necessary so as to achieve the targets.

On the discretion of BHEL site engineer, **Construction power to other BHEL contractors/vendors shall be provided by contractor on chargeable basis. The charge towards electricity consumption by other contractors shall be decided by BHEL site in-charge.** However electricity bill raised by power

TECHNICAL CONDITIONS OF CONTRACT (TCC)

supplier is to be paid by contractor. The bill may include fixed charges, minimum consumption charges, taxes, duties etc.

No compensation for idle labour or extension of time for completion of work will be given to contractor unless provided for elsewhere in the tender.

Adequate lighting arrangement such as flood lights, hand lamps and area lighting shall be arranged by the contractor at the site of his work areas within finally accepted rates.

On completion of work or as and when required by BHEL, all the temporary buildings, structures, pipe lines, cables etc. shall be dismantled and levelled and debris shall be removed as per instruction of BHEL by the contractor at his cost. In the event of his failure to do so, the Engineer will get it done and expenses incurred shall be recovered from the contractor along with prevailing overheads. The decision of BHEL Engineer in this regard shall be final.

PART I: ESTABLISHMENT/FACILITY

Sl.No	Description	Scope / to be taken care by		Remarks
		BHEL/ KSEB	Bidder	
1.1.0	ESTABLISHMENT			
1.1.1	FOR CONSTRUCTION PURPOSE:			
A	Open space for office	Yes		Free of rental charge
B	Open space for storage	Yes		Free of rental charge
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	
1.1.2	FOR LIVING PURPOSES OF THE BIDDER			
A	Open space	Yes		Charges for the same if any shall be decided in consultation with KSEB/BHEL
B	Living accommodation		Yes	

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1.2.0	ELECTRICITY			
1.2.1	POWER FOR CONSTRUCTION PURPOSE			415V (+/- 10%) Power supply at one point shall be made available to the Contractor on chargeable basis for Works only as per availability. The Contractor shall lay cables as per his requirement from this point. Complete network beyond the one point supply (Provided by Employer) as stated above shall be responsibility of Contractor. Although, 415V (+/- 10%) power supply shall be provided by Employer on chargeable basis, however, Contractor shall deploy adequate backup power by DG sets on his own cost so that construction schedule is not hampered on account non-availability of power. Exact location for installation of DG Sets will be decided by the contractor in consultation with the customer, whose decision shall be final and binding on the contractor.
1.2.1.1	Payment of electricity consumption		Yes	
1.2.1.2	Maintenance of lighting, distribution boards of power at suitable working areas		Yes	
1.2.1.3	Providing of the consumables such as sockets, switches, MCCB, bulbs etc.		Yes	
1.2.2	POWER FOR BHEL STORES			
1.2.2.1	Responsibilities of obtaining connection		Yes	
1.2.2.2	Charges for obtaining connection		Yes	

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1.2.2.3	Payment of electricity consumption at BHEL Store(s)		Yes	Electricity bill raised by power supplier is to be paid by bidder . The bill may include fixed charges, minimum consumption charges, taxes, duties etc
1.2.2.4	Payment of electricity consumption at BHEL Office in BHEL Store(s)	Yes		
1.2.2.5	Maintenance of lighting, distribution boards of power at suitable working areas		Yes	
1.2.2.6	Providing of the consumables such as sockets, switches, MCCB, bulbs etc .		Yes	
1.2.3	POWER for the office, stores, etc of the bidder			
1.2.3.1	Responsibilities of obtaining connection		Yes	
1.2.3.2	Charges for obtaining connection		Yes	
1.2.3.3	Payment of electricity consumption		Yes	
1.2.3.4	Distribution from single point including supply of materials and service		Yes	
1.2.3.5	Demobilization of the facilities after completion of works		Yes	
1.3.0	WATER SUPPLY			
1.3.1	For construction purposes at Power House:		Yes	
1.3.1.1	Making the water available at single point		Yes	
1.3.1.2	Further distribution as per the requirement of work		Yes	
1.3.2	Water supply for bidder's office, stores, etc		Yes	
1.3.2.1	Making the water available at single point		Yes	
1.3.2.2	Further distribution as per the requirement of work		Yes	

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1.3.3	Water supply for BHEL office, and stores, etc			
1.3.3.1	Water supply for BHEL office, near power house.		Yes	
1.3.3.2	Water availability at BHEL Store		Yes	
1.4.0	LIGHTING/ ILLUMINATION			
1.4.1	For construction work (supply and execution of all the necessary materials such as lamps, extension boards, hand lamps, cable etc): 1. At construction site 2. At preassembly area 3. At storage area		Yes	
1.4.2	Lighting for the living purposes of the bidder at the colony / quarters		Yes	
1.5.0	COMMUNICATION FACILITIES FOR SITE OPERATIONS OF THE BIDDER		Yes	
1.6.0	COMPRESSED AIR SUPPLY			
1.6.1	Supply of Compressor and all other equipment's (including pipes, valves, storage systems etc) required for supply of compressed air at site		Yes	
1.6.2	Installation of the above system, operation, and maintenance of the same.		Yes	
1.6.3	Supply of the all the consumables for the above system during the contract period		Yes	

PART II ERECTION FACILITIES

Sl.No	Description	Scope / to be taken care by		Remarks
		BHEL/ KSEB	Bidder	
2.1.0	Engineering works for E&M construction	Yes		
	Engineering works for Civil work		Yes	In consultation with BHEL

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2.1.1	Providing the erection drawings for all the equipment's covered under this scope	Yes		
2.1.2	Drawings for construction Methods	Yes	Yes	In consultation with BHEL
2.1.3	As-built drawings – where ever deviations observed and executed and also based on the decisions taken at site-example – routing of small bore pipes	Yes	Yes	As Built drawing to be prepared by BHEL. Bidder to help BHEL in making as built drawings
2.1.4	Shipping lists etc for reference and planning the activities	Yes		
2.1.5	Preparation of site erection schedules and other input requirements	Yes	Yes	Bidder to prepare in consultation with BHEL
2.1.6	Review of performance and revision of site erection schedules in order to achieve the end dates and other commitments	Yes	Yes	To be jointly done on regular basis
2.1.7	Weekly erection schedules based on SI No 2.1.5		Yes	
2.1.8	Daily erection / work plan based on SI No 2.1.7		Yes	
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	
2.1.10	Preparation of preassembly bay		Yes	

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VOLUME – I A (PART – I): Chapter – IX T&Ps and MMEs to be deployed by Contractor

A TOOL & PLANTS (T&Ps)- INDICATIVE LIST OF T & Ps			
Sl. No.	EQUIPMENT	Quantity	Deployment Period
1	General purpose Hand tools	As per requirement	As per requirement
2	Drilling Machines 1/4", 1/2", 3/4", 1" & 1.5"	As per requirement	As per requirement
3	Welding Machines	As per requirement	As per requirement
4	Gas cutting set	As per requirement	As per requirement
5	Trucks 50T/ Trucks 20T	As per requirement	As per requirement
6	Lorries /Trailer of adequate capacity	As per requirement	As per requirement
7	Hydra -14T	As per requirement	As per requirement
8	Hydraulic Crane - 55T	As per requirement	As per requirement
9	Torque Wrenches up to 2000 NM.	As per requirement	As per requirement
10	Fork lift – 3T	As per requirement	As per requirement
11	Impact Wrench (Pneumatic) up to 2400 NM	As per requirement	As per requirement
12	Chain pulley block of various capacities (2T, 5T, 10T,20T)	As per requirement	As per requirement
13	Turn Buckle (2T, 5T, 10T etc)	As per requirement	As per requirement
14	Hydraulic / Mechanical Jacks of various capacities (5-10-20-100T)	As per requirement	As per requirement
15	Air Arc Gouging Arrangement	As per requirement	As per requirement
16	Hydraulic pump (hand operated)	As per requirement	As per requirement
17	125 KVA DG set (rating is only indicative, however bidder has to examine the capacity as per site requirement)	As per requirement	As per requirement
18	MIG Welding machine set	As per requirement	As per requirement
19	Concrete Vibrators	As per requirement	As per requirement

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20	Jack Hammer With Compressor	As per requirement	As per requirement
21	Dumpers	As per requirement	As per requirement
22	Water tanker	As per requirement	As per requirement
23	Dewatering pump	As per requirement	As per requirement
24	Winches	As per requirement	As per requirement
25	Concrete mixer M/c of suitable capacity/Transit Mixture	As per requirement	As per requirement
26	Precision tools (S No a-d below) (Quantity & Deployment period) - As per requirement. a.0.02 accuracy block level / Dumpy level with accessories / Theodolite work station. b.Inside micrometer / Outside micrometer of range -0-25, 25/50, 50-75, 75-100, 100-150. c. Vernier calipers range 150, 300 / Telescopic gauge / Slip gauge / Feeler gauges. d.Dial gauge with magnetic stand.		
NOTES	1. The above list is only indicative and these T&Ps may not be required for entire contract period but contractor will ensure that these T & Ps are provided as per need. Contractor will assess actual quantity and period of requirement based on his experience. Contractor has to mobilize / maintain adequate numbers of T& P for meeting the work schedule and intermediate milestones as notified by BHEL Engineer. 2. If any one of T&P mentioned above is not needed for proper execution of scope of work, provided contractor has not utilized BHEL free issued T&P for completing such work, no recovery from contractor shall be applicable. 3. Any additional item required in addition to above mentioned T&P for proper execution of scope of work, contractor has to arrange such T&P within quoted rate on the instruction of BHEL in writing in a reasonable period within two weeks from the written instruction from BHEL.		
	4. In case deployment of T&P w.r.t requirement, is delayed or deployed for a shorter period or abnormal down time of T&P or in case T&P w.r.t requirement was not deployed by the contractor as per instruction of BHEL and BHEL had to deploy either its own T&P or from outside, the recovery shall be done from the contractor as under: a.In case BHEL had to deploy its own T&P, hire charges of T&P applicable for outside agencies as per extant guidelines for "Hire Charges on issue of Capital Tools & Plants" shall be recovered. b.In case BHEL had to deploy the T&P from outside, actual hiring cost plus applicable overheads shall be recovered. 5. Other terms and conditions regarding T&Ps / MMEs please also		

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	refer clause for T&Ps & MMEs in SCC. 6. All the tools and plants required for this scope of work are to be arranged by the contractor within the quoted rates. The list is suggestive in nature. Any additional T&Ps required to be arranged by the contractor. 7. If work gets delayed due to non-availability of T&Ps, BHEL reserves the right to get the work done at the risk and cost of contractor without prejudice to rights of BHEL as in GCC.

B	MONITORING AND MEASURING EQUIPMENTS (MMEs)- INDICATIVE LIST OF MMEs TO BE PROVIDED BY CONTRACTOR AS PER REQUIREMENT AT SITE		
SL NO	EQUIPMENT	Quantity	Deployment Period
1	General purpose Hand tools-	As per requirement	As per requirement
2	Digital/Analog Multi-meter AC & DC-	As per requirement	As per requirement
3	Megger 0-1000-2000-5000V	As per requirement	As per requirement
4	Primary current injection kit – 1000A	As per requirement	As per requirement
5	Tong Testers DC-30/60/300A, AC-50/100/500/1000A	As per requirement	As per requirement
6	Digital Multimeter 4&half digit	As per requirement	As per requirement
7	Phase sequence indicator 110-450V	As per requirement	As per requirement
8	Frequency meter 0-100 HZ (0-110-230-415 V)	As per requirement	As per requirement
9	Single phase variac 0-220 V, 15A	As per requirement	As per requirement
10	Three phase variac 0-415,25A	As per requirement	As per requirement
11	Digital micro Ohm meter	As per requirement	As per requirement
12	A.C. H.V. Test Kit – 50/60KV	As per requirement	As per requirement
13	Dead weight Tester for calibration of pressure gauge.	As per requirement	As per requirement
14	Precision Thermometer	As per requirement	As per requirement
15	Sound level meter 150 db.	As per requirement	As per requirement
16	Digital Handhold Temperature meter	As per requirement	As per requirement
17	Digital Recorder	As per requirement	As per requirement
18	Total station	As per requirement	As per requirement
19	Auto Level	As per requirement	As per requirement

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20	Measuring tape	As per requirement	As per requirement
21	Plumb bobs	As per requirement	As per requirement
Notes: 1. The above list is only indicative and these MMEs may not be required for entire contract period but contractor will ensure that these T&Ps are provided as per need. Contractor will assess actual quantity and period of requirement based on his experience. 2. If any one of T&P mentioned above is not needed for proper execution of scope of work, provided contractor has not utilized BHEL free issued T&P for completing such work, no recovery from contractor shall be applicable. 3. Any additional item required in addition to above mentioned T&P for proper execution of scope of work, contractor has to arrange such T&P within quoted rate on the instruction of BHEL in writing in a reasonable period within two weeks from the written instruction from BHEL. 4. In case deployment of T&P w.r.t requirement, is delayed or deployed for a shorter period or abnormal down time of T&P or in case T&P w.r.t requirement was not deployed by the contractor as per instruction of BHEL and BHEL had to deploy either its own T&P or from outside, the recovery shall be done from the contractor as under: 4.1 In case BHEL had to deploy its own T&P, hire charges of T&P applicable for outside agencies as per extant guidelines for "Hire Charges on issue of Capital Tools & Plants" shall be recovered. 4.2 In case BHEL had to deploy the T&P from outside, actual hiring cost plus applicable overheads shall be recovered. 5. Other terms and conditions regarding T&Ps / MMEs please also refer clause for T&P& MMEs in SCC. 6. All the MMEs required for this scope of work are to be arranged by the contractor within the quoted rates. The list is suggestive in nature. Any additional MMEs required to be arranged by the contractor. If work gets delayed due to non-availability of MMEs, BHEL reserves the right to get the work done at the risk and cost of contractor without prejudice to rights of BHEL as in GCC.			

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VOLUME – I A (PART – I): Chapter-X LIST OF T&P BEING PROVIDED BY BHEL FOR USE OF CONTRACTOR FREE OF HIRE CHARGES ON SHARING BASIS

S.NO.	EQUIPMENT	CAPACITY	QTY
1.	EOT CRANE (Power House)	61/10.2 MT	01

NOTE: The above mentioned suitable capacity crane without slings & lifting tackles will be provided by BHEL on sharing basis. The operation and maintenance of cranes shall be the responsibility of contractor. The fuel/power shall be also given by contractor.

- 1 EOT cranes will be provided by BHEL free of hire charges & on sharing basis for subject work with exclusions as advised. Routine maintenance shall be taken care by the contractor under this scope of work. However, contractor will not be entitled for any compensation due to non-availability of EOT crane.
- 2 The contractor will have to provide qualified operator adequate in numbers for operating the mobile and EOT cranes round the clock if required or as per requirement.
- 3 All other terms & conditions shall be as per SCC clause no. 4.2.1 & 4.2.2

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VOLUME – I A (PART – I): Chapter-XI ANNEXURES

ANNEXURE A								
BILLING BREAK UP FOR SUB- CONTRACTOR FOR RENOVATION & INSTALLATION WORK OF 3x27.5 MW KUTTIYADI HEP								
Sl. No.	EXISTING FACILITY FOR RENOVATION/ REFURBISHMENT		UNIT NO.			Comm an	TOTAL % = (F1)	Total in Rs. = (A1xF1)/100
			I	II	III			
1	Refurbishment of embedded parts (incl Distributor, pipes, sole plates etc)		1.5	1.5	1.5		4.5	
SL No.	PACKAGE FOR INSTALLATION		UNIT NO.				TOTAL % = (F1)	Total in Rs. = (A1xF1) / 100
			I (%)	II (%)	III (%)			
2	Main Inlet Valve – Spherical valve type with all accessories and controls							
2.1	Erection of Spherical valve on foundation		0.6	0.6	0.6		1.8	
2.2	Assembly of inlet and outlet piece		0.4	0.4	0.4		1.2	
2.3	Placing and assembly of Servomotors on foundation		0.4	0.4	0.4		1.2	
2.4	Air, Water & Oil Pipe line for MIV.		0.4	0.4	0.4		1.2	
3	Vertical Shaft Pelton Turbine compatible for housing in existing manifold / distributor piping							
3.1	Shaft and runner assembly		1.5	1.5	1.5		4.5	
3.2	Assembly turbine Guide bearing including pad scraping.		2.0	2.0	2.0		6.0	
3.3	Air, Water & Oil Pipe line for Turbine		1.60	1.60	1.60		4.80	
3.4	Instrumentation and box up		1.40	1.40	1.40		4.20	
4	Nozzle injector assembly, Needle servomotor and Deflector servomotor assembly							
4.1	Nozzle servomotors, deflector servomotors assembly		0.6	0.6	0.6		1.80	
4.2	Dry stroking and time adjustment of Nozzle Servomotors and Deflector Servomotors		0.6	0.6	0.6		1.80	
5	Digital type Electro-hydraulic turbine governors with all accessories and controls							
5.1	Installation of HMC and Needle control panel		0.4	0.4	0.4		1.2	
5.2	OPU with sump tank and associated pipings for Governor and MIVs.		0.2	0.2	0.2		0.6	
6	Vertical Shaft Generator- complete with all accessories and controls (including generator shaft)							
6.1	Stator assembly, joint winding, HV etc.		2	2	2		6	
6.2	Stator shifting to pit and its Centering, levelling etc.		0.6	0.6	0.6		1.8	
6.3	Rotor rim building in service bay.		1.4	1.4	1.4		4.2	
6.4	Mounting of Rotor Poles, HV test etc.		0.4	0.4	0.4		1.2	
6.5	Lowering of Rotor in Pit.		0.7	0.7	0.7		2.10	
6.6	Bottom bracket assembly in service bay.		0.2	0.2	0.2		0.60	
6.7	Blue matching of bearing pads and thrust bearing components.		0.2	0.2	0.2		0.60	

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6.8	Assembly/Installation of Brake & Jack system, Brake dust collector, HS lubrication system.		0.2	0.2	0.2		0.60	
6.9	Assembly of Top bracket arms & Centre piece in service bay.		0.15	0.15	0.15		0.45	
6.10	Assembly of thrust bearing in top bracket		0.15	0.15	0.15		0.45	
6.11	Lowering of Top bracket in Pit.		0.15	0.15	0.15		0.45	
6.12	Assembly of thrust collar in Generator shaft		0.15	0.15	0.15		0.45	
6.13	Installation of stator air coolers and its associated pipings		0.15	0.15	0.15		0.45	
6.14	Fire protection system of generator.		0.15	0.15	0.15		0.45	
6.15	Generator instrumentation, gauge panel including calibration.		0.15	0.15	0.15		0.45	
6.16	Complete Unit Axis Alignment		0.20	0.20	0.20		0.60	
6.17	Extension shaft, slip ring, brush gear, CCL, carbon dust collector etc.		0.08	0.08	0.08		0.24	
6.18	Box up of bearings, oil filling in bearings, installation of air baffles, guide etc.		0.08	0.08	0.08		0.24	
7	Static Excitation System complete with Auxiliaries		0.50	0.50	0.50		1.50	
8	11kV Segregated Bus ducts with all accessories		0.30	0.30	0.30		0.9	
9	Unit Control, Protection & Metering System (generator control panel, turbine control panel etc...)		0.80	0.80	0.80		2.40	
10	Generator Transformer Control, Protection & Metering System		0.40	0.40	0.40		1.2	
11	Power transformer (12.5MVA) control, protection and metering system		0.30	0.30			0.6	
12	Common annunciation panel (for all 6 Units and 110kV feeders)					0.3	0.3	
SL No.	PACKAGE FOR INSTALLATION	UNIT NO.			Comm an	TOTAL % = (F1)	Total in Rs. = (A1xF1)/100	
		I (%)	II (%)	III (%)				
13	LAVT panel and NGT cubicle	0.3	0.3	0.3		0.9		
14	Synchronizing panel complete- with all accessories and controls				0.2	0.2		
15	Temperature scanners with at least 32 channels	0.2	0.2	0.2		0.6		
16	Unit Automation Panel with all accessories and controls	0.6	0.6	0.6		1.8		
17	Automation Panel for Common Services with all accessories and controls				0.3	0.3		
18	Computerized Control System (SCADA) covering entire power house (3+3 machines and switch yard) with all accessories				0.3	0.3		
19.	Operator work station with independent and large video server				0.6	0.6		
20.	Dry type indoor 500 kVA Unit Auxiliary Transformer with all accessories and controls	0.6	0.6	0.6		1.8		
21.	LT switchgear for unit auxiliaries & common services with all controls and interlocks	0.2	0.2	0.2		0.6		
22.	Auxiliary supply & metering panels				0.6	0.6		
23.	415V AC Unit Auxiliary Board	0.5	0.5	0.5		1.5		
24.	415V AC Station Service Board				0.5	0.5		
25.	110V DC Main & Sub Distribution Boards	0.2	0.2	0.2		0.6		

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26.	110V DC Emergency Distribution Board					0.4	0.4	
27.	Uninterrupted Power Supply System (1+1 standby),30kVA, 240VAC, Single phase, 50Hz with a common plante / tubular battery set					0.2	0.2	
28.	Powerhouse Lightning Protection System					0.5	0.5	
29.	Renewing station lighting including changing of cables and controls					0.5	0.5	
30	Station Grounding System					0.2	0.2	
31	Cooling Water System (3 motor driven pump sets with all accessories and controls)					0.6	0.6	
32	Oil Handling System (LVDH) for governors		0.6	0.6	0.6		1.8	
33	Portable oil filtering unit for bearing oil					0.2	0.2	
34	LP Compressed Air System					0.7	0.7	
35	Brake Dust Extraction System for Generator		0.3	0.3	0.3		0.9	
36	CO2 Fire Protection System for Generator		0.6	0.6	0.6		1.8	
37	Portable Fire Extinguishers (Foam, DCP, CO2, fire balls, fire buckets, Clean Agent type & ABC type)					3.0	3.0	
38	Feeder Vertical panels having Feeder Control, Protection, Metering & instrumentation system					2.4	2.4	
39	Bus protection panel					0.6	0.6	
40	Power, Control and Instrumentation Cables including SCADA compatible cable, Cable trays & Cable accessories complete for powerhouse & those required for switchyard					7.5	7.5	
41	Battery charger with 110V twin charger suitable for 400AH battery including all connections					0.42	0.42	
42	Vibration Monitoring system		0.3	0.3	0.3		0.9	
43	Shaft current monitoring system		0.25	0.25	0.25		0.75	
44	HP oil and jack system		0.30	0.30	0.30		0.9	
45	Creep detectors with all accessories and controls		0.2	0.2	0.2		0.6	
46	Moisture detectors		0.2	0.2	0.2		0.6	
47	Anti Condensation Heaters		0.2	0.2	0.2		0.6	
48	Mechanical overspeed device with all accessories and controls		0.2	0.2	0.2		0.6	
GRAND TOTAL FOR RENOVATION & INSTALLATION WORK OF 3 X 27.5 MW KUTTIYADI HEP							100	

Note - : $A1 = 0.515 \times A$; Where 'A' = Total Lumpsum Value Quoted'

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ANNEXURE- B

BILLING BREAK UP FOR SUB- CONTRACTOR FOR DISMANTLING OF UNITS 1,2 & 3 OF 3x27.5 MW KUTTIYADI HEP

Sl. No.	PACKAGES TO BE DISMANTLING and TRANSPORTED TO SCRAP YARD	UNIT NO.			COMMON	TOTAL % = (F2)	Total in Rs. = (A2XF 2)/100
		I	II	III			
1	Turbine and associated equipment including Turbine shaft, runner, guide bearing incl housing	5	5	5		15	
2	Nozzle servomotors, deflector servomotors assembly	3	3	3		9	
3	Generator and associated equipment including stator, rotor, generator shaft, Thrust bearing, guide bearings, Generator Air Coolers and brackets	7	7	7		21	
4	Excitation System including Pilot Exciter, Main Exciter, Slip rings, Excitation panels etc.	3	3	3		9	
5	Cooling water system (common as well as unit specific) including, pump- motor sets, pipe, valves, filters, etc	3	3	3		9	
6	11kV Bus ducts, Power, Control and other cables	4	4	4		12	
7	11 KV switchboards, Unit Auxiliary board panels, Control panels, Protection panels	4	4	4		12	
8	Governing system incl piping	3	3	3		9	
9	All the residual items not covered above				4	4	
GRAND TOTAL FOR DISMANTLING OF UNIT 1,2 & 3						100.00	

Note : $A_2 = 0.065 \times A$; Where 'A' = Total Lumpsum Value Quoted'

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ANNEXURE C

BILLING BREAK UP FOR SUB- CONTRACTOR FOR CIVIL WORKS OF 3x27.5 MW KUTTIYADI HEP						
Sl No.	ITEM DESCRIPTION	UNIT	Quantity	Factor (F)	RATE (Rs.) = FACTOR (F)*C1/ (100000 (Rounded off to two places after decimal)	AMOUNT (Rs) =(Rate X Qty)
	100 EARTH WORK					
	Earth work: Earth work In excavation, backfilling and disposal including necessary men/women, materials, equipment, loading, transportation, unloading, dewatering etc as per specification, drawing and as directed by engineer- in-charge for the following:					
101	Earth work in excavation in all types of soil including ash which can be excavated by any means including setting out, levelling, dewatering (but excluding special type of dewatering viz. well point method), shoring & strutting (wherever required), dressing the sides & bottom, all lifts, ramming/compacting the excavated bottom, stacking, disposal of surplus excavated materials within a lead upto 1Km, spreading/levelling of disposed materials etc all complete for following depths below ground level.					
A	Depth from ground level but not exceeding 2 m	CUM	165	0.841	-	-
B	Depth exceeding 2 m but not exceeding 4 m	CUM	25	1.050	-	-
103	Earth work in excavation in soft rock (rock without any recovery of excavated materials in the form of hard stone/boulder) including weathered rock which can be excavated by means of crow bar, pick axe, pneumatic rock breaker attachment with excavator machine etc but does not require chiselling or blasting including setting out, levelling, dewatering (wherever required), shoring & strutting (wherever required), dressing the sides & bottom, all lifts, ramming/compacting the excavated bottom, stacking, disposal of surplus excavated materials within a lead upto 1 Km, spreading / levelling of disposed materials etc all complete for following depths below ground level.					
A	Depth from ground level but not exceeding 2 m	CUM	140	2.780	-	-
B	Depth exceeding 2 m but not exceeding 4 m	CUM	15	4.241	-	-
106	Earth work in excavation upto any depth below ground level in hard rock requiring chiselling including wedging, line drilling, pre shearing etc as required for grading, setting out, levelling, dewatering (wherever required), dressing the sides & bottom, all lifts, stacking/disposal of surplus excavated material within a lead upto 1 Km, spreading / levelling of disposed materials etc all complete as per specification, drawing and as directed by the engineer-in-charge.					
A	Depth from ground level but not exceeding 2 m	CUM	15	7.291	-	-
B	Depth exceeding 2 m but not exceeding 4 m	CUM	15	8.752	-	-

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c	Depth exceeding 4 m but not exceeding 6 m	CUM	10	10.213	-	-
107	Earthwork in Back filling upto any depth below ground level around foundations, plinths, trenches, drains etc to proper grade and level in layers not exceeding 250 mm thickness using/with selected materials from compulsorily excavated earth available within a lead upto 1 Km and compacted as specified including re-excavation of stacked earth, watering, ramming/compaction by manual/mechanical means, dressing etc all complete.for the following.					
a	Each layer compacted so as to achieve at least 90% maximum dry density as per IS-2720 (Part-VII)	CUM	211	0.706	-	-
b	Each layer compacted so as to achieve at least 95% maximum dry density as per IS-2720 (Part-VII)	CUM	10	0.720	-	-
108	Earthwork in Back filling upto any depth below ground level around foundations, plinths, trenches, drains etc to proper grade and level in layers not exceeding 250 mm thickness using/with selected materials directly from excavation within a lead upto 1Km and compacted as specified including re-excavation of stacked earth, watering, ramming/compaction by manual/mechanical means, dressing etc all complete.for the following:					
a	Each layer compacted so as to achieve at least 90% maximum dry density as per IS-2720 (Part-VII)	CUM	5	0.256	-	-
b	Each layer compacted so as to achieve at least 95% maximum dry density as per IS-2720 (Part-VII)	CUM	10	0.272	-	-
109	Extra over ST No. 101 and 103 to 108 for carriage of material/earth for every 500m or part thereof beyond an initial lead of 1km.	CUM	144	0.065	-	-
110	Earth work in backfilling upto any depth below ground level around foundations, plinths, trenches, drains etc to proper grade and level in layers not exceeding 250 mm thickness so as to achieve required compaction with approved borrowed soil (borrowed soil to be arranged by the bidder) and compacted as specified including supplying boorowed soil, royalty/seignorage fee (if any), sorting, spreading, breaking clods, watering, ramming/compaction by manual/mechanical means, dressing, finishing to required lines, grades and slopes, tesing, all lead and lifts etc all complete as per specification, drawing and as directed by the engineer for the following:	CUM	10	8.486	-	-
111	Supplying and filling sand upto any depth under floors, around foundations, plinths etc. in layers not exceeding 250 mm thickness and compacted so as to achieve at least 80% relative density as per IS-2720 (Part-XIV) including spreading, watering, ramming/compaction by manual / mechanical means, dressing, royalty (if any) etc. all complete.	CUM	12	20.390	-	-
	200 CONCRETE WORKS					

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	CONCRETE WORK: Providing and placing concrete work including cost of labour, materials (unless otherwise specified in BOQ/contract specification) and equipment for handling, transportation, batching, mixing, placing, vibrating and curing (excluding cost of centering, shuttering and reinforcement) with mechanised equipments like batching plant, transit mixer, concrete pump etc. complete as per drawing, specifications and as per direction of engineer in charge for the following:					
201	Concrete of grade M7.5 (1 part cement, 4 part sand, 8 parts of 40 mm graded aggregate by volume) as mass filling course, lean concrete, levelling course, mud mat under and around foundations/ floors, at any depth below finished floor level etc.	CUM	11	37.565	-	-
202	Concrete of grade M10 (1 part cement, 3 part sand, 6 parts of 40 mm graded aggregate by volume) as lean concrete, levelling course, mud mat under and around foundations/floors at any depth below finished floor level etc.	CUM	10	39.419	-	
203	Concrete of grade M15 (1 part cement, 2 part sand, 4 parts of 40 mm graded aggregate by volume) as lean concrete, levelling course, mud mat under and around foundations/floors at any depth below finished floor level etc.	CUM	13	43.128	-	
204	Concrete of grade M20 (1 part cement, 1.5 part sand, 3 parts of 20 mm graded aggregate by volume) under floors, paving, plinth protection, pipe encasing etc complete.	CUM	20	43.570	-	
A205	Providing and laying Design Mix cement concrete (except on existing RCC) conforming to IS:456 & IS 10262-2009 for reinforced concrete works with coarse sand and graded hard stone aggregate of 20mm nominal size in foundations/substructure, grade slab, paving, drains, under floors etc at all level below finished floor level, any shape, position or thickness etc complete including use of plasticizer/ superplasticizer conforming to IS:9103 (latest) to achieve required slump in concrete all complete as per specification & drawing for the following.					
a	M 25 Grade	CUM	58	46.486	-	-
b	M 30 Grade	CUM	10	47.551	-	-
B205	Providing and laying Design Mix cement concrete on existing RCC conforming to IS:456 & IS 10262-2009 for reinforced concrete works with coarse sand and graded hard stone aggregate of 20mm nominal size in foundations/substructure, TG foundation, discharge chamber, grade slab, paving, drains, under floors etc at all level below finished floor level, any shape, position or thickness etc complete including use of plasticizer/ superplasticizer conforming to IS:9103 (latest) to achieve required slump in concrete and including straightening of existing reinforcement, suitable chemical treatment for bonding of old and new concrete, etc all complete as per specification & drawing for the following.					
a	M 25 Grade	CUM	20	58.647	-	-

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b	M 30 Grade	CUM	10	59.764	-	-
c	M 35 Grade	CUM	10	60.734	-	-
206	Providing and laying Design Mix cement concrete of grade conforming to IS:456 & IS 10262-2009 for reinforced concrete works with coarse sand and graded hard stone aggregate of 20mm nominal size in superstructure at all level above finished floor level, any shape, position or thickness etc complete including use of plasticizer/ superplasticizer conforming to IS:9103 (latest) to achieve required slump in concrete all complete as per specification & drawing for the following.					
a	M25 Grade	CUM	23	46.761	-	-
b	M 30 Grade	CUM	5	47.826	-	-
c	M 35 Grade	CUM	3	49.074	-	-
A206	Providing and placing in position Micro-concrete, which shall be epoxy based prepacked chloride free, non-shrink, free flow, self compacting, ready to use after mixing water in specified proportion obtained from approved manufacturer including proper wet curing, suitable chemical treatment for bonding with old concrete etc all complete as per specification and directions of Engineer-in-charge.					
a	M 35 Grade	CUM	5	345.838	-	-
211	Providing and encasing of structural steel member with concrete using nominal aggregate size of 12.5mm down. Encased member shall be wrapped with welded wire mesh/chicken wire mesh with proper lap etc. complete as per specification for the following grades. (Payment of welded wire mesh, chicken wire mesh shall be made separately)					
b	M 25	CUM	2	45.533	-	-
c	M 30	CUM	1	46.348	-	-
213	Providing and laying Design Mix cement concrete as per IS:456 & IS 10262-2009 for reinforced concrete works using graded aggregate for Concrete in precast works like roof slabs/trench covers, fins, lintels, chajas, beams, columns, wall panels, facias etc.at all levels in all kinds of work including formwork/moulds, curing, rendering the top exposed surface with cement sand mortar (1:3), handling, storing, transpoting, all leads, erection without damage, setting in position with cement sand mortar (1:3), filling the gaps between adjacent precast units with M30 grade concrete or cement sand mortar (1:3) and including making of holes for bolts for fixing, welding etc.complete with graded aggregate (20/12.5/10 mm) and as per specification and drawing for following grades.					
a	M 25 grade	CUM	3	64.860	-	-
b	M 30 grade	CUM	3	66.134	-	-

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A214	Providing and laying Design Mix cement concrete as per IS:456, IS 3370 & IS 10262-2009 for reinforced concrete works using graded aggregate for Concrete in water retaining/conveying structures including straightening of existing reinforcement, suitable chemical treatment for bonding of old and new concrete, addition of suitable plastisizer cum waterproofing cement additives conforming to IS 9103 latest to achieve a slump more than 125 mm in concrete as per manufacturers recommendation and conforming to limits of permeability as per IS 2545 and specification with 20 mm nominal size graded aggregate for following grades. Watertightness is to be ensured including structural grouting if required.					
b	M 30 grade	CUM	5	68.330	-	-
A215	Dismantling complete concrete work for all types of structures at all levels including stacking of servicable material to a lead of 500 m and disposal of unservicable material upto a lead of 2 km, cutting of reinforcement, labour, equipment, safety precautions etc all complete as per drawings, specification and instructions of engineer in charge.					
a	Plain cement concrete of all grades	CUM	25	7.639	-	-
b	Reinforced cement concrete of all grades	CUM	25	11.662	-	-
B215	Dismantling part concrete work for all types of structures at all levels using approved tools and dismantling scheme(causing least vibrations and no damage to remaining/adjoining structures and having least noise) including stacking of servicable material to a lead of 500 m and disposal of unservicable material, straightenng/bending/cutting of reinforcement, labour, equipment, scaffolding and supporting platforms, removal of loose concrete, cleaning of reinforcement, safety precautions, including preparation of and getting customer/BHEL approval of dismantling scheme & procedure etc all complete as per drawings, specification and instructions of engineer in charge. (Measurement shall be done for the volume of dismantled concrete only)					
a	Plain cement concrete of all grades	CUM	3	54.415	-	-
b	Reinforced cement concrete of all grades	CUM	40	68.018	-	-
A216	Chipping of concrete in reinforced concrete work, cutting pockets, making openings at all levels and according to shapes, disposal of waste materials as directed by engineer including equipment, safety precautions, making good the broken surface etc all complete as per specification, drawing, instructions of engineer in charge but excluding cutting of reinforcement .	CUDM	1000	0.685	-	-
217	Extra over and above St No 216 for cutting of reinforcement, all sizes and types including labour, equipment, return of cut reinforcement to store etc all complete as per specification, drawings and instructions of engineer in charge. Measurement shall be on the cross sectional area of reinforcement cut.	SQCM	10	0.037	-	-

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218	Cutting Reinforced concrete with mechanised tools like Core drilling machine etc. for cutting pockets, holes, cores in slab, beam, column or foundation as per direction of engineer in charge.	CUDM	1000	1.551	-	-
A219	Cutting of existing concrete/RCC slab/RCC wall (total thickness upto 500mm including floor finish & deck sheet if any) using power tools HILTI/ BOSCH make or equivalent with low noise and dust including cutting reinforcements, removing the rubbish, making good the broken edges/surface with cement mortar, painting, finishing to match with existing finishing, scaffolding/ supporting at all level, all complete and as directed by Engineer (measurements shall be taken as per cutting surface area).	SQM	85	32.543	-	-
300 FORM WORKS						
	FORMWORK: Providing, fixing and removing formwork at all elevations for all structures, as per specifications and including all labour, material, scaffoldings and centering etc. complete as per drawing, specifications and as per direction of engineer in charge for the following:					
A301	Fairface form work with good quality water proof ply wood of minimum 12mm thickness and smooth surface below finished ground floor level for foundations/substructures, TG foundation, discharge chamber, footings, base of columns, walls, columns, pilasters, beams, mass concrete, trenches etc.including chamfering of edges as per drawing, specification and instruction of engineer in charge..	SQM	274	3.908	-	-
302	Fairface form work with good quality water proof ply wood of minimum 12mm thickness and smooth surface above finished ground floor level for columns, beams, suspended floors, roofs, lintels, cantilevers, staircases, landings, balconies, etc. including chamfering of edges as per drawing.for all heights as per specification, drawing and instruction of engineer in charge.	SQM	319	4.833	-	-
304	Providing, fixing and removing formwork in block-outs/pockets and openings (below 0.1 sqm plan area) at all elevations including cutting, formation of all shapes and all other operations required for making the required shape and size all complete as per specification, drawing and instruction of engineer in charge.					
a	Upto 150 mm depth	EACH	20	1.848	-	-
b	Pockets of depths more than 150mm and upto 300 mm depth	EACH	20	3.222	-	-
c	Pockets of depths more than 300mm and upto 600 mm depth	EACH	20	5.920	-	-
d	Pockets of depths more than 600mm and upto 1000 mm depth	EACH	5	9.443	-	-
e	Pockets of depths more than 1000mm and upto 1500 mm depth	EACH	5	13.765	-	-
A305	Extra over item no.301 and 302 for curved form work for foundations/substructures, TG foundation, discharge chamber, footings, beams, walls, trenches, domes, arches etc as per specification.					

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a	Extra for Curve Shuttering for Item No. 301	SQM	5	0.782	-	-
	400 REINFORCEMENT					
	REINFORCEMENT WORK : Reinforcement work including all labour, material (unless otherwise specified in BOQ/contract specification), equipment, transportation, handling etc at all level as per specification, drawings and as directed by engineer - in - charge for the following:.					
402	Providing, straightening, cutting, bending, placing in position at all level, binding in position of steel reinforcements of TMT steel of grade Fe-500D or 500EQR confirming to IS:1786 including cost of reinforcement steel, binding wire, labour, scaffolding, transportation to & from stores etc complete all as per specifications, drawings and as directed by Engineer.	MT	12	488.352	-	-
405	Providing & fixing of Rebar in existing concrete surface by inserting reinforcement bar with Epoxy based suitable bonding compound of Hilti or equivalent make (HIT-RE-500 of Hilti or equivalent make) for interconnection of new R.C. structure with existing R.C. structure. Depth of drilled hole should be suitable to develop maximum recommended strength as per approved manufacturer's recommendation. This item includes supply of all materials including bonding chemicals, T&P required to execute the work, cost of all labour, transportation of chemical, staging to reach work place etc. all complete as directed by Engineer - in - Charge. Random Pull out non destructive test as directed by engineer shall be conducted to ensure strength of bond and same is included in this item. Reinforcement bar shall be paid separately under item no. 402, 403, 404 as applicable.					
a	12mm Reinforcement bar	EACH	50	3.0685	-	-
b	16mm Reinforcement bar	EACH	50	4.786	-	-
c	20mm Reinforcement bar	EACH	50	6.701	-	-
d	25mm Reinforcement bar	EACH	50	7.706	-	-
e	28mm Reinforcement bar	EACH	50	8.862	-	-
	500 WATER PROOFING WORKS					
	Roof Treatment works: Roof treatment works including all labour, material (unless otherwise specified in BOQ/contract specification), equipment, transportation, handling, curing, sampling, testing etc at all level as per specification, drawings and as directed by engineer - in - charge for the following:					
502	Providing and laying underbed grading plaster with cement mortar 1:4 (1 cement : 4 sand) and average thickness of 15 mm including preparation of surface, batching, mixing, leveling etc. all complete.	SQM	58	0.890	-	-

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506	Providing and applying PU based water proofing treatment with one coat of polyurethane or any other equivalent material based primer with an application rate of minimum 6 sq.m per litre and two successive liquid coatings of high solids content urethane pre-polymers or equivalent material based finish coats as per relevant IS/ASTM standards to form an elastomeric membrane with overall dry film thickness 1.5 mm subject to minimum 500 gm/sqm/coat application rate. Item includes surface preparation, polyscrim cloth /fabric, polymerised mortar base preparation, etc all complete as per specifications and directions of engineer in charge.	SQM	58	9.553	-	-
507	Providing and laying wearing course consisting of 25mm thick plain cement concrete of grade M15 (1:2:4) with graded aggregate of 12.5mm size cast in panels of maximum size 1.2mx1.2m and reinforced with 0.56 mm dia. galvanised chicken wire mesh and sealing of joints (in grooves of 6mm X 6mm) using silicon /elastomeric compound etc all complete.	SQM	58	6.609	-	-
510	Providing and laying cement concrete chequered flooring tiles of 22 mm thickness and size 300x300 mm conforming to IS 13801 with 8 mm thick 1:4 cement mortar over the top most layer of roofing treatment in pathway or entire area with fine joints including sealing of joints (silicon/elastomeric sealant) and providing expansion gap in both directions filled up with (silicon/elastomeric) joint sealant, ~~including underbed(as per drawings) filled up with (silicon/elastomeric) joint sealant etc all complete.~~ (Water proofing paid elsewhere)(including cost of cement for tiles making)	SQM	24	4.914	-	-
511	Providing and applying two coats of bitumen grade 85/25 as per IS 702 (@ 1.7kg/sqm)with 1% antistripping compound conforming to IS 6241 in foundation, wall, column etc on concrete surfaces exposed to soil / ash including surface preparation etc. all complete.	SQM	224	1.336	-	-
515	Providing and applying IP net coating system(min 200 micron thickness) to exposed concrete surfaces of approved make and as per manufacturer's recommendation.	SQM	2	2.015	-	-
	600 JOINTS AND FILLERS: Joints & fillers including all labour, material, equipment, transportation, handling etc at all level as per specification, drawings and as directed by engineer - in - charge.					
601	Supplying & installation of bitumen impregnated fibre board conforming to IS 1838 as joint filler at joints in concrete including nailing, coating of both faces with coal tar pitch/bitumin etc. all complete.					
a	12 mm wide joints.	SQM	2	3.797	-	-
b	20 mm wide joints.	SQM	2	4.729	-	-
c	25 mm wide joints	SQM	2	7.094	-	-
d	50 mm wide joints	SQM	2	14.133	-	-
603	Providing and applying polysulphide based sealant conforming to IS:12118 in joints in concrete including cleaning of joints, raking out					

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	groove, application of primer, scaffolding etc. all complete for following size grooves:					
a	25mmX25mm	RM	2	4.064	-	-
b	50mmX25mm	RM	2	7.723	-	-
604	Supplying and filling in position hot applied bitumin sealing compund (Grade A) confirming to IS 1834 including cleaning, mixing, heating, pouring/injecting sealing compound in gaps in joints including application of primer etc. all complete.					
a	10mm X 40mm	RM	2	0.443	-	-
b	12mm X 25mm	RM	2	0.364	-	-
c	20mmX25mm	RM	2	0.479	-	-
606	Providing and installing PVC joint sealing strips of minimum 3mm thickness and minimum width 100 mm at the construction, expansion and isolation joints from reputed manufacturers 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, without any longitudinal joint; and shall be procured and installed in largest practicable lengths having a minimum number of transverse joints with jointing procedure as per the manufacturer's recommendations including the material and tools required for jointing, testing, protection, etc all complete. The joints in rubber seals shall be vulcanished as needed.	RM	2	1.603	-	-
607	Providing and installing strong and tough alkathene sheet or equivalent of about 1 mm in thickness in isolation joints and shall be fixed by an approved adhesive compound on the cleaned surface of the already set concrete as per the manufacturer's recommendations, to cover it fully including the material and tools required for jointing, testing, protection, etc all complete.	SQM	2	0.570	-	-
609	Providing and sealing of joints with premium grade silicon sealant (Silpruf of GE silicon or approved equivalent) including cleaning of joints, raking out groove, joint filler tapes, application of primer, curing, scaffolding etc. all complete as per manufacturer's recommendation for following size groove:					
a	25mmX25mm	RM	2	2.065	-	-
b	50mmX25mm	RM	2	3.778	-	-
610	Providing and fixing PVC water stops in joints conforming to IS 12200 & IS 15058 all complete for the following: (Bulb or Kicker type)					
d	230 mm wide and 6 mm thick	RM	2	1.658	-	-
612	Providing and applying approved fire retardant sealant in joints/openings including cleaning of joints/openings, raking out groove, application of primer, scaffolding etc. all complete.					
a	25mmX25mm	RM	2	2.684	-	-
b	50mmX25mm	RM	2	5.206	-	-
	700 MS EMBEDMENTS					
	MS EMBEDMENTS: Embedments including all labour, material (unless otherwise specified in BOQ/contract specification), equipment, transportation, handling etc. at all level as per specification, drawings and as directed by					

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	engineer - in - charge for the following:					
701	Supply, fabricating and fixing of mild steel embedments, inserts, pipe sleeves, angle pieces, rungs of various diameters, plates of dimensions as required etc. including welding, bolting, cutting, drilling, scaffolding, setting etc. all complete.	MT	5	586.688	-	-
702	Supply, Fabrication, transportation, delivery at site and erection, installation and alignment of mild steel foundation bolt assembly conforming to IS:2062 and grade 1 of IS:432 in concrete along with nuts, lock nuts (as per IS:1363, 1364 and IS:3138), washers, anchor plates, stiffener plates, protective tape, pipe sleeves, templates etc. including welding, cutting, grinding, threading, drilling etc. all complete.	MT	5	694.194	-	-
703	Same as above items 701 & 702 with BHEL supplied material free of cost including loading, transportation, unloading etc. all complete from BHEL store to plant site.					
a	Mild steel embedments, inserts, pipe sleeves, angle pieces, rungs of various diameters, plates of dimensions as required etc.	MT	0.5	162.998	-	-
b	Mild steel foundation bolt assembly conforming to IS:2062 and grade 1 of IS:432 in concrete along with nuts, lock nuts (as per IS:1363, 1364 and IS:3138), washers, anchor plates, stiffener plates, protective tape, pipe sleeves, templates etc.	MT	0.5	160.286	-	-
704	Supplying, fabricating, erecting and installing following items in concrete/brickwall for all kind of works, including setting material in concrete, layout, scaffolding, cutting, forming, grinding, drilling, bolting, welding, jointing, testing etc. all complete.					
a	MS pipes of all diameters	Kg	10	0.659	-	-
b	PVC pipes / conduits of all diameters	Kg	10	1.884	-	-
c	UPVC pipes / conduits of all diameters	Kg	10	3.029	-	-
d	Expansion anchor fasteners (galvanised) of HILTI make (HUD-1 Universal Fasteners) or equivalent of safe tensile capacity as specified below for brick work with expansion sleeve of A6 polyamide:					
i	8mm Dia	EACH	20	0.239	-	-
ii	10mm Dia	EACH	20	0.239	-	-
iii	12mm Dia	EACH	20	0.359	-	-
iv	14mm Dia	EACH	20	0.479	-	-
e	Expansion fasteners (mechanical galvanised) of HILTI make or equivalent of safe tensile capacity as specified below for concrete work with expansion sleeve of stainless steel:					
i	HST M8	EACH	40	0.959	-	-
ii	HST M10	EACH	40	1.438	-	-
iii	HST M12	EACH	40	2.278	-	-
iv	HST M16	EACH	40	4.077	-	-
v	HST M20	EACH	40	8.274	-	-
vi	HST M24	EACH	40	14.989	-	-

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Ae	Mechanical expansion fasteners, cold formed stud type having 3 way expansion sleeve of SS 316 grade approved for use in cracked concrete and seismic design with ETA C1/C2 approval or equivalent of safe tensile capacity as specified below for concrete work.					
i	HST3 M8	EACH	10	1.007	-	-
ii	HST3 M10	EACH	10	1.510	-	-
iii	HST3 M12	EACH	10	2.392	-	-
iv	HST3 M16	EACH	10	4.280	-	-
v	HST3 M20	EACH	10	8.687	-	-
vi	HST3 M24	EACH	10	15.738	-	-
f	Chemical Epoxy Anchor fasteners (galvanised) of HILTI make or equivalent of safe tensile capacity as specified below for concrete work with anchoring rod, nuts, washers, chemicals all complete, etc:					
i	HAS-E5.8 M8	EACH	90	2.413	-	-
ii	HAS-E5.8 M10	EACH	90	2.827	-	-
iii	HAS-E5.8 M12	EACH	90	3.510	-	-
iv	HAS-E5.8 M16	EACH	180	5.610	-	-
v	HAS-E5.8 M20	EACH	130	8.932	-	-
vi	HAS-E5.8 M24	EACH	90	11.941	-	-
Af	Adhesive type Chemical anchor fastener consisting of slow curing epoxy chemical adhesive and threaded rod of carbon steel (minimum grade of 5.8) including nut and washer usable in diamond core drilled holes and in wet/ water submerged holes dispensed through mechanical dispenser HIT RE 500 V3 or equivalent of safe tensile capacity as specified below for concrete work.					
i	HIT-V M8	EACH	10	2.534	-	-
ii	HIT-V M10	EACH	10	2.968	-	-
iii	HIT-V M12	EACH	10	3.685	-	-
iv	HIT-V M16	EACH	10	5.890	-	-
v	HIT-V M20	EACH	10	9.379	-	-
vi	HIT-V M24	EACH	10	12.538	-	-
707	Providing, laying and fixing rails (52kg/rm) and guide rails in concrete for transformer, rail track including cutting of rails, joining of rails, anchoring lugs etc all complete.	MT	0.5	799.231	-	-
	800 GROUTING					
	GROUTING: Grouting including all labour, material (unless otherwise specified in BOQ/contract specification), equipment, roughening surface, cleaning, ramming, curing etc. at all level, drawings and as directed by engineer - in - charge for the following:					
A801	Providing & grouting with cement slurry mix of approved ratio using pressure pump for structures/water retaining concrete structures as per approved procedure including cost of nipples/ nozzles, cement, admixture, curing, pressure pumps, slurry agitator etc. all complete. Cost shall include fixing of nipples at maximum 500 mm centre to centre spacing, cutting of nipples after completing of grouting, making good of the nipple hole with appropriate non-shrink cement paste, water tightness test etc. all complete wherever specified in the drawing.	SQM	2	7.930	-	-

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803	Providing & grouting of pocket holes, pipe sleeves and under base plate of structural steel work/ machinery/ pipe supporting structures including roughening of surface, cleaning, ramming, curing etc. all complete with mix 1:1:2 (1 cement : 1 coarse sand : 2 aggregate of 6 mm down graded stonechips) using non shrink admixture as per specification, drawing and direction of engineer-in-charge. (Cost of all material and cleaning the pocket by compressed air shall be in the scope of the contractor).	CUM	1	177.633	-	-
804	Providing & grouting of pocket holes, pipe sleeves and under base plates of structural steel work/ machinery/ pipe supporting structures including roughening of surface, cleaning, ramming, curing etc. all complete with ConbextraGP-1 or equivalent as per specification, drawing and direction of engineer-in-charge. (Cost of all material and cleaning of the pockets by compressed air shall be in the scope of the contractor).	CUM	1	311.664	-	-
805	Providing & grouting of pocket holes, pipe sleeves and under base plates of structural steel work/ machinery/ pipe supporting structures including roughening of surface, cleaning, ramming, curing, etc. all complete with Conbextra GP-2 or equivalent. (Cost of all material and cleaning of the pockets by compressed air shall be in the scope of the contractor).	CUM	3	346.293	-	-
806	Providing Chemical (epoxy) injection grouting with pressure pump in cracks, including fixing nozzles, cost of approved chemical, admixture, curing etc. all complete . Payment shall be made as per the consumption of chemical grout.	Kg	100	10.054	-	-
	900 DOORS, WINDOWS, VENTILATORS, LOUVERS					
	DOORS & WINDOWS: Doors, windows, ventilators, louvers, roof ventilators, rolling shutters, partitions including all labour, material (unless otherwise specified in BOQ/contract specification), equipments, transportation, handling, preparation of working drawings etc. at all level as per specification, drawings and as directed by engineer - in - charge for the following:					
903	Providing, fitting and fixing solid core flush door shutter as per IS 2202 part II, 35mm thick homogenous particle board bonded with BWP type phenolformaldehyde synthetic resin, partical board core conforming to IS 3087 type I, 35x12 mm thick teakwood beading all around including preparation of working drawings. godrej or equivalent make mortice lock with handels on both sides,approved ISI mark anodised fittings like door stopper,300mm long tower bolts,16x300mm long aldrops ,125mm long handles on both sides etc. butt hinges, sliding bolt, knobs, (all fittings shall be anoidised aluminium color dyed), finish synthetic paint over primer, screws etc. all complete as per drawing, specification and instruction of engineer in charge. with commercial faces and teak wood edges. (Finish painting paid separately)	SQM	3	50.289	-	-

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904	Providing and fixing single or double steel door shutters with 45mm thk flush design shutter comprising of two outer sheets of 18 gauge steel sheets rigidly connected and reinforced inside with continuous vertical 20 gauge stiffeners, spot welded in position at not more than 150mm on centres including void filled with mineral wool (density as per specification), all fittings, Godrej or equivalent make mortice lock with handle on both sides, shop and final painting etc all complete.	SQM	3	81.368	-	-
906	Providing and fixing anodized extruded aluminium doors (single or double shutter) conforming to IS:1948, IS:1949 fabricated from extruded sections of HINDALCO/JINDAL or equivalent make having minimum 3mm wall thickness as per IS:1285, IS:733 and anodized and electro color coating of required shade as per IS 1868 (minimum anodized coating of grade AC15). fixed with rawl plugs, expansion fasteners,SS screws / fixing clips necessary filling of gaps at Junctions, at top, bottom & sides with required PVC / neoprene felt for bi-metallic protection etc. Glazing shall be clear float glass of 6mm thickness including snap fit type beading, concealed screws, fixtures, Godrej or equivalent make Mortice lock with handle on both sides, etc all complete. Aluminium section shall be smooth, free of stains, straight, mitred & jointed mechanically wherever required. (Glazing shall be paid separately)	Kg	100	4.064	-	-
909	Providing and fixing anodised aluminium work of Jindal, Hindalco or other equivalent approved make for door frames, windows, ventilators, partitions, railing etc with extruded standard tubular and other sections including all fittings & fixtures and accessories of approved make conforming to IS733 and IS1285, anodised and electro color dyed to required shade according to IS 1868 (minimum anodic coating of grade AC15), fixed with rawl plugs, expansion fasteners, SS screws or with fixing clips, including necessary filling of gaps at junctions, at top, bottom and sides with required PVC/neoprene felt for bi-metalic protection etc. including preperation of working drawings, aluminium cleat angle, aluminium snap-on-beading for glazing/panelling, stair case tread nosing, with all fittings and fixtures (like tower bolts, handles, door stopper with rubber shoes, 'L' drops, stays, floor springs, hydraulic door closures etc.), CP brass/stainless steel screws, providing and fixing hinges/pivots, and making provision for fixing of fitting wherever required including cost of PVC/neoprene gasket, all complete as per drawing, specification and instructions of engineer in charge (Glazing and panelling shall be paid seperately).Weight of aluminium section only shall be measured.	Kg	2345	5.114	-	-
911	Providing and fixing of door closers as per specification ,of approved make & quality all complete of following type :					
a	Over head hydraulic door closures as per IS 3564	EACH	2	11.082	-	-
b	Floor mounted Hydraulic door closers as per IS 6315	EACH	1	18.945	-	-

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912	Providing and fixing pressed steel frames fabricated from 16 gauge M.S sheet mortised, reinforced drilled and tapped for hinges and locks bolts strikes, hold fasts adjustable floor anchors, floor tiles/weather bars ,paintings etc all complete as per specifications.	Kg	57	1.187	-	-
915	Providing, fixing and fitting of glazing of first grade class in steel/aluminium/wooden frames, where ever required, cleaning after fixing including hardware, gaskets, clips, beadings etc. all complete.					
c	5.5 mm thick clear float glass	SQM	100	11.955	-	-
h	6 mm thick clear toughened safety glass	SQM	110	18.265	-	-
i	Two nos. 6 mm thick clear toughened float glass hermetically sealed and separated by 12 mm thick air gap for thermal insulation (only single elevation area to be measured)	SQM	10	26.681	-	-
916	Supplying and fixing weather stripping of approved make and quality to doors as per instructions of engineer in charge and specification complete.	RM	10	1.513	-	-
917	Providing and fixing 12 mm thick BWP particle board, decorative veneer (prelaminated) on both sides, as panels in aluminium framed door shutter, fixed with necessary snap-on-beading etc. all complete (excluding aluminium works).	SQM	50	12.456	-	-
	1000 BRICKWORK					
	BRICKWORK: Brickwork masonry including all labour, material (unless otherwise specified in BOQ/contract specification), equipment, transportation, handling, scaffolding etc. at all levels as per specification, drawings and as directed by engineer - in - charge for the following:					
1001	Providing brick work in cement mortar 1:6 (1 part cement 6 parts coarse sand) in walls, chambers etc. in thickness varying from 230mm to 460mm at all depths, places and positions below plinth including raking out joints, curing, scaffolding etc. complete excluding plastering and painting.					
a	Using fly ash lime bricks confirming to IS 12894 with crushing strength of 75 kg/cm ² (including cost of cement for brick making)	CUM	5	46.620	-	-
c	Using burnt clay bricks of class designation 7.5 of nominal dimension	CUM	5	65.162	-	-
1002	Providing brick work in cement mortar 1:6 (1 cement 6 coarse sand) in walls, chambers etc. in thickness 230mm at all heights, places and position above plinth including raking out joints, curing, scaffolding etc complete excluding plastering and painting.					
a	Using fly ash lime bricks confirming to IS 12894 with crushing strength of 75 kg/cm ² (including cost of cement for brick making)	CUM	25	55.900		
c	Using burnt clay bricks of class designation 7.5 of nominal dimension	CUM	39	75.199		
1003	Providing brick work in cement mortar 1:4 (1 cement 4 coarse sand) in partition walls, chambers etc. in thickness 115mm at all heights, places and position above or below plinth/graded level including providing two nos. 6 mm diameter MS bars at every third					

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	layer, raking out joints, curing, scaffolding etc complete excluding plastering and painting as per specification.					
a	Using fly ash lime bricks confirming to IS 12894 with crushing strength of 75 kg/cm ² (including cost of cement for brick making)	SQM	5	7.005		
c	Using burnt clay bricks of class designation 7.5 of nominal dimension	SQM	5	9.266		
1005	Breaking of existing brick work at all levels including plastering, removing the rubbish up to a distance of 500 m including transportation, loading, unloading etc. all complete as directed by the engineer.	CUM	10	13.446		
1006	Providing and encasing of structural steel member with masonry work around flanges, webs etc. and filling the gap between steel and masonry by minimum 12mm thick mortar of 1:6. Encased member shall be wrapped with chicken wire mesh with 50mm lap etc. complete as per specification. (Chicken wire mesh to paid separately)	CUM	1	54.996		
1007	Providing and laying 75 mm thick bed of dry brick aggregate including of excavation, disposal of surplus earth spreading of earth, ramming, watering etc. complete in all respects as directed by the engineer.	SQM	30	1.930		
1008	Making openings in existing brick wall or partition wall including making good the broken edges/surface with cement mortar 1:6 etc. complete.	CUM	30	15.132		
	1100 DAMP PROOF COURSE					
	DAMP PROOF COURSE: Damp proof course including all labour, material (unless otherwise specified in BOQ/contract specification), equipment, transportation, handling, shuttering, centering, curing etc at all level as per specification, drawings and as directed by engineer - in - charge for the following:					
1101	Providing Damp Proof Course of following thickness with 1:1.5:3 concrete (10mm and down graded aggregate) with 2% of approved admixture of water proofing compound all complete. Two layers of hot bitumen coating 85/25 grade as per IS:702 @ 1.7Kg./sqm shall be applied one before & one after the DPC.					
b	50mm thick	SQM	7	3.568		
	1200 CEMENT MORTAR PLASTER					
	PLASTERING: Cement mortar plaster including making grooves wherever required including all labour, material (unless otherwise specified in BOQ/contract specification), scaffolding, curing etc at all level as per specification, drawings and as directed by engineer - in - charge for the following:					
1201	Providing 18mm thick plaster in two layers outside the building in cement mortar 1:6 on walls, finished to a smooth finish including providing 3mmx3mm size grooves at junctions of two dissimilar materials all complete	SQM	205	2.063		
1202	Providing 12mm thick plaster inside the building in cement mortar 1:6 on walls finished to a smooth finish as per specification	SQM	174	1.341		

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	all complete.					
1204	Providing 6mm thick plaster on ceiling in cement mortar 1:4 finished to a smooth all complete.	SQM	51	1.263		
	1300 FINISHES TO CONCRETE / PLASTERED SURFACES					
	Finishes, painting to concrete, plastered surfaces including all labour, material, equipment, surface preparation, scaffolding etc. at any level as per specification, drawings and as directed by engineer - in - charge.					
A1305	Providing and applying two or more coats of acrylic emulsion paint as per IS 5411 of approved brand, shade and manufacture to give smooth, hard, durable & glossy finish including surface preparation, primer and scrapping of existing paint/primer etc all complete as per manufacturers guidelines and direction of engineer-in-charge.	SQM	216	0.959		
A1307	Providing and applying two coats of Epoxy coating with suitable pigments of approved shade including surface preparation, primer and scrapping of existing paint/primer as per specification and direction of Engineer. The epoxy paint shall be a two pack material and shall be resistant to water, oil, splash, spillage & acidic environment. The epoxy paint coating shall be of minimum 150 micron thickness over epoxy primer.	SQM	10	2.635		
1317	Providing and applying 2 mm thick white cement punning on walls including preparation of surface, staging, etc to achieve a smooth even surface all complete as per specification and as directed by engineer.	SQM	5	0.740		
A1319	Providing and applying two or more coats of Acrylic emulsion weather coat paint of approved brand and manufacture and required shade including one coat of primer after necessary cleaning/ washing, scrapping of existing paint/primer, preparing the surface using coir brush/ wire brush, sand paper, including filling of cracks with putty wherever required and primer etc. all complete to give smooth, hard, durable & glossy finish over a coat of primer over prepared plaster surface as per manufacturers guidelines. The final finished coating shall be fungus resistant, UV resistant, water repellant and extremely durable with color fastness as per specification.	SQM	205	1.198		
1400	FLOORING AND SKIRTING: Flooring and skirting at all level including base layer, labour, material (unless otherwise specified in BOQ/contract specification), equipments, transportation, handling, curing, polishing etc. at all level as per specification, drawings and as directed by engineer - in - charge.					

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A140 1	Providing and laying 50 mm thick heavy duty cement concrete in flooring with metallic hardener pigmented topping 12mm thick uniform graded treated iron particles in flooring. Under layer of 38mm thick cement concrete mix 1:2:4 (1 cement: 2 sand : 4 stone aggregates 12.5 mm well graded) and top layer of 12mm thick metallic concrete of mix 1:2 (1 cement hardner mix with approved quality metallic hardening compound :2 stone aggregate 6mm nominal size) by volume including cement slurry, rounding off edges, aluminium strips, chipping the existing flooring etc. all complete for following (Quoted item rate shall be inclusive of providing glass joint strips):	SQM	52	4.860		
1402	Providing and laying 25 mm thick heavy duty cement concrete mix 1:2:4 (1 cement: 2 sand : 4 stone aggregates) flooring with metallic hardener pigmented topping of 10 mm thick uniform graded treated iron particles in skirting and dado. Under layer of 15mm thick cement concrete mix 1:2:4 (1 cement: 2 sand : 4 stone aggregates 12.5 mm well graded) and top layer of 10mm thick metallic concrete of mix 1:2 (1 cement hardner mix with approved quality metallic hardening compound :2 stone aggregate 6mm nominal size) by volume including cement slurry, rounding off edges, aluminium strips etc. all complete as per specification. (Quoted item rate shall be inclusive of providing glass joint strips).	SQM	5	3.645		
1416	Providing and laying vitrified ceramic tiles of polished variety of size 600x600 from reputed / approved manufacturer, complete including underbed of cement mortar 1:3 minimum 20mm thick underbed for flooring and 12mm thick underbed for dado/skirting with neat cement slurry @3.3Kg/sqm etc. all complete for following					
b	10mm thick tiles In flooring	SQM	35	9.550		
d	10mm thick tiles In skirting and dado upto specific height	SQM	5	9.787		
	1500 ROOFING / SIDE CLADDING					
	ROOFING / SIDE CLADDING: Roofing / side cladding work including all labour, material (unless otherwise specified in BOQ/contract specification), equipment, transportation, handling, scaffolding, laps, hooks, washers, corner pieces etc. at all level as per specification, drawings and as directed by engineer - in - charge for the following:					
1512	Providing and fixing insulation of resin bonded mineral wool of 50 mm nominal thickness conforming to IS 8183 having a density of 32 kg/cum glass wool or 48 kg/cum for rock wool, for cladding/under deck insulation including wrapping in black polythene black supported over weld mesh 75X75X1.6 MM dia to hold in position and application of glue & tying with lacing wire, for glass/rock wool as per manufacturer's recommendation.					
b	For underdeck insulation below RCC slabs	SQM	10	4.696		

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1504	Designing, providing and fixing External sheet of Permanent colour coated metal cladding with troughed M.S. sheets of 0.6mm bare metal thickness having minimum yield strength 250 MPa and zinc-aluminium alloy coating not less than 275 gm/sqm total on both sides including fixing to supports / rails by concealed fixing system, corrosion resistant self tapping / self drilling type fasteners with suitable cap, flashing etc. all complete. The exposed face of the sheet shall be permanently colour coated with Polyfluro Vinyl Coating (PVF2) of minimum dry film thickness (DFT) 20 microns over suitable primer. Inner face of the sheet shall be provided with suitable pre-coating of minimum DFT 7 microns over suitable primer. The permanent colour coated sheet shall meet the general requirements of IS : 14246 and shall conform to class 3 for the durability.	SQM	35	13.104		
	1600 FALSE CEILING					
	FALSE CEILING: False ceiling including all labour, material (unless otherwise specified in BOQ/contract specification), equipment, transportation, handling, suspension system etc at all level as per specification, drawings and as directed by engineer - in - charge for the following:					
1602	Providing, fixing and laying light weight mineral fiber tile false ceiling of minimum thickness 15 mm and exposed surface semi-perforated with depth of perforation as 4 mm and humid resistance of 95% RH and fire performance of class 0/1 as per BS 476 with metal suspension grid system with galvanized Tees of section 24 X 38 mm for main runners of approved colour and make as per specification including 50mm thick mineral wool insulation (density 48kg/cum) as per IS:8183 bound in polythene bags on top of panels. Additional hangers and height adjustment clips shall be provided for return air grills, light fixtures. A.C. ducts etc. suitable M.S. channel (minimum MC 75 @ 1.2m) grid shall also be provided above the false ceiling level for movement of personnel to facilitate maintenance of lighting fixtures, AC ducts etc. complete with cut-outs etc. The size of tiles shall be 600 X 600 mm or 600 X 1200 mm. Required MS channel shall be measured & paid extra under respective item unit rate.	SQM	25	9.479		
1603	Providing and fixing permanently colour coated aluminium false ceiling of approved colour and Luxalon 84 C or approved equivalent with corrosion resistant aluminium alloy panels of minimum thickness 0.5mm including 50mm thick mineral wool insulation (density 48 kg/cum) conforming to IS:8183 bound in polythene bags on top of panels. Additional hangers and height adjustment clips shall be provided for return air grills, light fixtures, A.C. ducts etc all complete. Suitable M.S. channel grid with minimum MC 75 shall also be provided above the false ceiling level for movement of personnel to facilitate maintenance of lighting fixtures, AC ducts etc. (Materials for structural platform grid made up of MS Channels/ Beams / Angles shall be	SQM	10	23.416		

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	supplied by BHEL and shall be paid under ST No 2301)					
	1700 RAIN WATER DOWN TAKE PIPES					
	RAIN WATER DOWN TAKE PIPES: Rain water down take pipes at all level including all labour, material (unless otherwise specified in BOQ/contract specification), transportation, 2 coats of approved paint over one primary coat, fixtures, accessories etc as per specification, drawings and as directed by engineer - in - charge for the following:					
1704	Providing and fixing galvanised MS down take pipes of 150 mm dia- Medium quality as per IS:1239(part-I) all complete.	RM	18	8.481		
	1800 MISCELLANEOUS WORKS					
	MISCELLANEOUS: Miscellaneous works including all labour, material (unless otherwise specified in BOQ/contract specification), equipment etc. at all level unless otherwise specified as per specification, drawings and as directed by engineer - in - charge for the following:					
1801	Providing and Filling in trenches, plinths, area paving and other underground structures with graded stone aggregate of size range 63 mm to 45 mm in layers not exceeding 230 mm in thickness including breaking of stone boulders to required sizes, filling the interstices with selected sand and compacting to 85 % of original volume of stone stack for all lifts etc. all complete. Payment shall be made for the measurement of the volume of the compacted fill.	CUM	26	15.515		
1802	Supply and laying approved quality Stone aggregate 40mm size in transformer yards.	CUM	10	20.160		
1805	Providing and mixing approved Bipolar Concrete penetrating Corrosion inhibiting admixture phenolic base (krishna conchem or equivalent) in concrete as per detail specification of manufacturer etc. all complete. Payment shall be made per cum of concrete.	CUM	1	5.670		
1806	Providing and mixing approved sodium nitrate based Concrete penetrating Corrosion inhibiting admixture of 'Hindcon' or equivalent in concrete as per detail specification of manufacturer etc. all complete. (For Payment, CUM quantity of concrete shall be measured)	CUM	1	1.511		
1808	Laying of earthing mats/rods including risers, transportation from yard stores, loading, unloading, cutting to length, welding, protective painting of joints etc. all complete. (Excavation & Back filling shall be paid separately under respective item of earth work. Earthing mats/rods shall be supplied by BHEL free of cost)	MT	10	87.754		
1809	Construction of below ground earthing system test pits as per drawing / sketches including concreting, reinforcement, formwork, providing & fixing GI strip etc as per drawing and specification (excavation & backfilling only will be paid under applicable BOQ items).	EACH	2	72.564		
1811	Construction of below ground earthing system earth electrodes as per drawing and specification. (Excavation and backfilling only	EACH	2	15.115		

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	will be paid under applicable BOQ items)					
1812	Construction of below ground earthing system - Earth connection and riser pig tails as per drawing and specification. (Excavation and backfilling only will be paid under applicable BOQ items& steel shall be supplied by BHEL free of cost.)	EACH	2	13.099		
1813	Providing Earthing pit as per drawing with charcoal & salt, GI pipes, GI earth electrodes, GI wire, GI strips, brick chamber with covers including associated earthwork etc. all complete.	EACH	2	147.203		
1815	Providing and fixing GI rungs in concrete/brick walls having zinc coating of minimum 900 g/sqm etc. all complete.	Kg	10	0.527		
1818	Fire proofing of steel structures with VERMICULITE cementious coating including supply of all materials for vermiculite materials, reinforcement mesh (3mm thick wire, 50x50 size mesh) , nuts, tie wires, weldings, suface preparation, curing, staging, compatible paintings etc. all complete.	CUM	2	703.059		
1824	Disposal of scrap steel, scrap wood, broken packing crates, cable scrap, debris and other civil waste, electrical waste materials etc. from project site to a designated place within 5 KM range, with all manpower T & P etc. including loading and unloading as and when directed by BHEL.					
a	Steel scrap / metal scrap	MT	1	3.950		
b	Debris & Other waste materials.	CUM	1	1.282		
A182 5	Providing, cuttings to required size and fixing glavanised steel wire fabric 25x25mm mesh of 12 SWG, to exposed reinforcement/ R.C.C. structural members- slab, beam, columns etc. for repair, rehabilitation works,at all height and locations, complete as per direction of Engineer in charge (cost of providing & fixing mechanical /chemical fasters if required , shall be paid for seperatly).	kg	10	0.763		
A182 6	Providing and fixing welded wire mesh, chicken wire mesh for encasing of structural steel member etc. all complete as per specification and direction of engineer-in-charge.	kg	20	0.608		
A182 7	Conducting assessment of existing structures and foundations including investigation of field problems, Non-Destructive/Destructive tests (including but not limited to rebound hammer test, Ultrasonic pulse velocity test, half cell potential test, carbonation depth test, core test, scanning of reinforcement bar in concrete structures, cover survey, details of crack, CAPO tests, chloride test, pH test, sulphate test etc as per IS/ASTM codes), Mobilization & Demobilization for testing team, site visits, detailed visual survey (internally & externally) by visual inspection (to record observation of distressed parts, level of deterioration, field problems), field measurements, Mapping of defects observed, Preparing Condition Survey report, Calibration of applicable instruments for tests, Method statement of tests, Photograph during testing, analysis of the test result, preparation of conclusive report, providing repair/strengthening recomendations, obtaining	LS	1	2024.54		

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	approval of BHEL/Customer on all documents etc all complete as per specifications and direction of Engineer-in-Charge.					
A1828	Providing coursed ashlar stone masonry in cement mortar 1:6 (1 part cement 6 parts coarse sand) with hard stone in thickness 230mm to 460mm at all heights, places and position above plinth including raking out joints, curing, scaffolding etc complete excluding plastering and painting.	CUM	1	408.953		
A1829	Dismantling of existing stone masonry work at all levels removing the rubbish including transportation, loading, unloading etc. all complete as directed by engineer-in-charge.	CUM	1	13.873		
A1830	Making openings in existing Stone Masonry wall including making good the broken edges/surface with cement mortar 1:6 etc. complete as directed by engineer-in-charge.	CUM	1	16.647		
A1831	Mixing and applying epoxy mortar using approved epoxy resin, hardener and silica sand in proportions as per manufacturer recommendations, specifications and direction of Engineer-in-charge complete. The rate shall include the cost of silica sand, the epoxy shall be paid separately based on actual consumption of resin & hardner by weight , nothing extra shall be paid for silica sand and epoxy bonding coat shall be paid separately as per relevant item.					
a	25 mm average thickness of slab	SQM	2	1.139		
b	50 mm average thickness of beams	SQM	2	2.279		
c	Deduct/Add for every less/extra 10 mm thickness	SQM	2	0.455		
A1832	Supplying approved epoxy for epoxy mortar(Payment shall be for total weight of resin plus hardener in manufacturer specified proportion)	Kg	12	3.389		
A1833	Strengthening RCC structural member(Beam/Column/Slab/etc.) with unidirectional high strength fibres comprising of E-glass fibres wrapped over prime coated surface with special epoxy, saturated after wrapping with saturant epoxy complete. Rate shall include cost of cleaning surface, patching up surface irregularities, rounding of the corners to min. radius of 20 mm, pre-cutting the fabric according to dimensions required, mixing the epoxy with high speed mixer for 5 minutes, saturating the fabric with epoxy manually or using the mechanical saturator, wrapping the member with high strength fibres after priming the surface with epoxy and curing for 24 hours at ambient temperature including applying cement plaster finish over the outermost layer etc. complete. Removing plaster from the parent surface, if involved, shall be paid for separately under the relevant item.(The rates shall be for finished surface area and shall cover the cost of overlaps, if any).	sqm per layer	160	13.850		
	2300 STRUCTURAL STEEL					
	STRUCTURAL WORKS: Structural steel works including all labour, material (unless otherwise specified in BOQ/contract specification), equipments unless otherwise specified, transportation, handling etc. at all level as per					

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	specification, drawings and as directed by engineer - in - charge for the following:					
2301	Supply, Fabrication, erection and alignment of structural steel with mild steel rolled section / built up section / combination of both conforming to IS:2062, pipes conforming to IS:1161/ IS:1239, chequered plate conforming to IS: 3052, mild steel rounds, monorails, stays, safety chains, ladders, MS grating etc. in columns, beams, gantry girders, bunkers, silos, hoppers, roof trusses, portals, laced purlins, space frames, hangers, struts, monorails, galleries, stiffeners, wall beams, sheeting runners, brackets, stub columns, bracings, cleats, trestles, base plates, splice plates, chequered plate flooring, decking and seal plates, steel frame grid over false ceiling, walkway platforms, ladders, stairs, stringers, treads, landings, hand-rails etc including 2 coats of red oxide zinc-chromate primer (one coat at shop and one coat after erection), connection design & preparation of fabrication drgs, collection of steel from stores, fabrication, straightening, cutting, bending, rolling, grinding, machining, drilling, welding, electrodes and other consumables, alignment, erection bolts & nuts (weight of erection bolts, nuts and welds not payable), assembly, edge preparation, preheating (min preheat and interpass temperature of 20° C for welding over 20 mm and upto 40 mm & 66° C for welding over 40 mm and upto 63 mm & 110° C for thickness over 63 mm & use of low hydrogen/ radiogenic electrodes), 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, installation of temporary structures, setting column bases, surface preparation by means of manual or mechanical power tools as per IS:1477 part 1, touch-up painting, rectification, dismantling and removal of all temporary structures (weight of temporary structures not payable), return of surplus / waste steel materials to store etc all complete. Including appointment of a seperate agency, approved by BHEL, for review and approval of fabrication drgs, in consultation with BHEL (BHEL to supply steel free of cost).	MT	21	608.087		
A2302	Extra over ST NO. 2301 for blast cleaning of steel structures to near white metal surface(Sa 2 1/2) and applying zinc silicate primer in coats of minimum 25 micron (DFT) at shop and 25 micron (DFT) after erection, instead of primer coat of red oxide zinc-chromate, including touch-up painting etc all complete.	MT	21	33.821		
2304	Extra over ST No. 2301 for providing and applying two coats of synthetic enamel paint with minimum 50 micron total dry film thickness (DFT) of approved make and shade to achieve an even shade over steel sections already having primer coats and keeping overall	MT	16	21.081		

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	DFT with primer not less than 110 microns including protection and cleaning, scaffolding etc. all complete.					
2305	Providing and applying intermediate coat of epoxy based Titanium dioxide(TiO ₂) or Micaceous iron oxide (MIO)of minimum 75micron DFT on steel surfaces already having primer coats, topped with two coats of epoxy based colour finish paint with minimum 70 micron total dry film thickness (DFT) of approved make and shade to achieve an even shade including further finishing with top coat of UV resistant (minimum 30 micron DFT) polyurethane of approved shade including protection and cleaning, scaffolding etc. all complete.	MT	5	28.588		
2307	Supplying, fabrication, erection and alignment of factory made electroforged galvanised grating units with mild steel having minimum galvanisation conforming to IS:2062 in flooring, platforms, drain and trench covers, walk-ways, passages, staircases with edge binding strips and anti-skid nosing in treads etc. including fixing clamps, fittings, fixtures, all taxes, duties, packing, grinding, drilling, welding, edge preparation, etc. all complete.					
a	Minimum galvanisation of 610 g/sqm	MT	1	980.269		
2308	Supplying, fabrication, erection and alignment of factory made galvanised welded grating units with mild steel conforming to IS:2062 in flooring, platforms, drain and trench covers, walk-ways, passages, staircases with edge binding strips and anti-skid nosing in treads etc. including 2 coats of redoxide zinc-chromate primer (one coat at shop and one coat after erection), fixing clamps, fittings, fixtures, all taxes, duties, packing, grinding, drilling, welding, edge preparation, etc. all complete.	MT	1	763.496		
2309	Extra over above ST NO. 2301 for finishing the grating units/bolts/inserts with hot dipped galvanisation @ 610 gm/sqm over blast cleaned steel surfaces instead of painting with two coats of red oxide zinc-chromate primer all complete.	MT	1	178.884		
2311	Providing and fixing in position of permanent mild steel bolts (class 4.6 as per IS : 1367 and grade 'C' as per IS: 1363) and nuts, washers etc. up to and inclusive of 39 mm diameter and upto 300mm long for structural steel work etc all complete.	KG	10	1.289		
2313	Dismantling of steel structure, lowering of material and carriage of the dismantled material up to field fabrication shop / projects storage including temporary dismantling, cutting, re-welding, supporting, and restoring to correct position all temporarily dismantled members, re-alignment of all adjacent connected members to their correct positions (weight of such adjacent members and temporarily dismantled members not payable), scaffolding, staging, tools & tackles, gas cutting, welding, consumables etc all complete.	MT	1	61.606		

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2314	Addition to, alterations in and/or modification of "Erection Marks" including cutting of parts, gauging of welds, cutting, grinding, fabrication, welding, drilling holes, straightening, removal of bends, raising to the required level, painting, transportation, return of unutilised steel pieces to the project store, temporarily dismantling, cutting, re-welding, supporting and restoring to correct position of all the temporarily dismantled members, realignment of adjacent connected members (weight of such temporarily dismantled and adjacent members not payable) etc all complete for the following:					
a	In erected position	MT	1	155.769		
2315	Re-erection of dismantled fabricated structural steel members including carriage of modified "Erection Marks" from the field fabrication shop to erection site, lifting to required position, aligning in position, tack welding, final welding and touch up painting including temporary dismantling and re-erection of temporarily dismantled members, cutting, rewelding, supporting and restoring to the correct position of all temporarily dismantled members, realignment of adjacent connected members (weight of such temporarily dismantled members and adjacent members not payable), scaffolding, staging, tools & tackles, gas cutting, welding, consumables etc all complete.	MT	1	100.608		
A232 1	Supply, fabrication and fixing of MS pipe hand railing of 32 mm/35mm/40 mm dia including transportation, loading/unloading etc. all complete. Payments terms - a) on receipt of materials at site - 65%; b) Erection & fixing - 35%	MT	1	739.873		

Note :- $C1 = 0.26 \times A$; Where 'A' = Total Lumpsum Value Quoted'

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ANNEXURE D

BILLING BREAK UP FOR SUB-CONTRACTOR FOR STORE SHED WORKS OF 3x27.5 MW KUTTIYADI HEP					
Item No.	Description	Unit	Qty	Weightage for amount of each item (Nearest to the 7 decimal points) w.r.t the total amount	Amount = C2 x weightage
A1	Clearing jungle including uprooting of rank vegetation, grass, brush wood, trees and saplings of girth up to 30 cm measured at a height of 1 m above ground level and removal of rubbish up to a distance of 50 m outside the periphery of the area cleared.	Sqm	600	0.0018624	-
A2	Cutting of trees having girth more than 300 mm (upto 600mm girth) measured at a height of 1m above ground level including removal of roots, stacking the seviceable material like trunks,branches etc at specified area within the plant boundary and disposal of unseviceable parts/materials witthin a lead upto 1km etc all complete.	Each	5	0.000470146	-
A3	Earthwork excavation in all kinds of soils including ash (except hard rock) by mechanical means (Hydraulic excavator)/ manual means over areas (exceeding 30cm depth, 1.5m in width as well as 10sqm on plan) including getting out and depositing within an initial lead of 50 m and lift upto 1.5m for foundations, drains, sewers etc., Rate to include baling, strutting, shoring, sectioning the sub grade to proper level, grade, watering & consolidating to receive the concrete bed all as per standard specifications.	Cum	50	0.00219899	-
A4	Earth work by means of crow bar, pick axe, pneumatic rock breaker attachment with excavator machine etc but does not require chiselling or blasting including setting out, levelling, dewatering (wherever required), shoring & strutting (wherever required), dressing the sides & bottom including getting out and disposal of excavated earth lead upto 50 m and lift upto 1.5 m, as directed by Engineer-incharge				-
i)	In ordinary rock including weathered rock	Cum	150	0.013260058	-
ii)	In hard rock (blasting prohibited)	Cum	5	0.001267605	-
A5	Back filling around foundations in plinths, trenches, drains, open field etc to proper grade and level with selected good soil from compulsorily excavated earth or earth supplied by BHEL/Customer, lead up to 50 m and lift upto 1.5 m, free from shingle, salts, organic materials, roots, sod or any other foreign substance including re-excavating loose thickness, watering and ramming in layers of 30cm thickness by manual/ mechanical means, dressing etc complete.	Cum	30	0.001630901	-

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A6	Earth work in filling upto any depth below ground level for grading to proper grade and level in layers not exceeding 300 mm consolidated thickness with approved borrowed soil (borrowed soil to be supplied by the bidder by mechanical transport upto a lead of 5km) and compacted as specified including supplying murrum, royalty/seignorage fee (if any), sorting, spreading, breaking clods, watering, ramming/compaction by manual/mechanical means, dressing, finishing to required lines, grades and slopes, teting, all lead and lifts etc all complete as per specification, drawing and as directed by the engineer.	Cum	25	0.001972922	-
A7	Supplying and filling in plinth with fine aggregate i.e manufactured crushed stone sand under floors, including watering, ramming, consolidating and dressing complete.	Cum	70	0.032385055	-
A8	Providing and laying PCC; 100 mm thick; mix 1:2:4 using 40mm size hard broken granite stone jelly including ramming,levelling, curing etc., for flooring and foundations including providing necessary slopes etc., complete as per standard specifications.	Cum	60	0.094598762	-
A9	Providing and laying PCC of mix 1:4:8 using 40mm size hard broken granite stone jelly including ramming,levelling, curing etc., for flooring, and side drains including providing necessary slopes etc., complete as per standard specifications.	Cum	2	0.002708415	-
A10	Providing and laying R C C of mix M25, using 20mm down size hard broken granite stone jelly for all types of RCC works at all heights including finishing, curing etc. complete, but excluding centering, shuttering, cost of reinforcement fabrication all as per standard specifications. Rate to include for providing necessary slope in the concrete as directed by Engineer in charge.	Cum	30	0.051359038	-
A11	Providing and laying damp-proof course 40 mm thick with cement concrete 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate 12.5 mm nominal size)	sqm	25	0.001984679	-
A12	Fairface form work with good quality water proof ply wood of required thickness and smooth surface below finished ground floor level for foundations, footings, base of columns, walls, columns, pilasters, beams, mass concrete, trenches etc.	sqm	180	0.011865914	-
A13	Providing, straightening, cutting, bending, placing in position at any level, binding in position of tor steel reinforcements confirming of grade Fe-500 confirming to IS:1786 including cost of binding wire, labour, transportation to & from stores etc complete all as per specifications, drawings and as directed by Engineer	MT	5	0.095956131	-

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A14	Supply, fabrication and fixing of embedments, inserts, pipe sleeves, angle pieces, anchor bolts of various diameters, plates of dimensions as required etc. including scaffolding, setting in position, transportation from BHEL site stores to work spot etc. all complete.	kgs	250	0.00497968	-
A15	Providing brick work in C.M 1 : 6 in foundation and superstructure using clay bricks as per standard specifications. Rate to include cost of scaffolding, labour, curing etc., complete.	Cum	30	0.035642061	-
A16	Providing plastering with CM 1 : 6, 15mm thickness all as per standard specifications, including rendering smooth, rounding of corners etc., complete.	Sqm	200	0.015752757	-
A17	Providing and applying 3 coats of water proof cement paint of approved make and color on exterior surface at all heights including material, labour, scaffolding, curing etc. including primer coat complete as per specification.	Sqm	200	0.006937985	-
A18	Random rubble masonry with hard stone in foundation and plinth including levelling up with cement concrete 1:6:12 (1 cement : 6 coarse sand : 12 graded stone aggregate 20 mm nominal size) upto plinth level with Cement mortar 1:6 (1 cement : 6 coarse sand).	Cum	5	0.007121468	-
A19	Providing and fixing wash basin of size 550x400 mm with CI brackets with 15 mm CP brass pillar caps, 32 mm CP brass waste of standard pattern including painting of fittings and brackets, cutting and making good the walls wherever required	Nos	1	0.000676178	-
A20	Supplying and fixing in position 15mm nominal size down type brass bib cock of approved make and quality (leader, dripless, or orient) as per standard specifications. Rate to include cost of bib cock, jointing materials, labour for carrying, fixing, and testing etc., complete.	Nos	1	0.0000650438	-
A21	Providing and fixing G.I. pipes complete with G.I. fittings including trenching and refilling etc. of 15 mm dia nominal bore	metre	100	0.005726263	-
A22	Supply and fixing 01 no 3 phase 30A digital energy meter of reputed make in a suitable metal clad box/ wooden board with 01 no 32 A TPN MCB as incoming and internal wiring complete	No	1	0.001844326	-
A23	Supply and fixing of Metal clad Lighting distribution board with of 32 A DB MCB as incoming and 2 nos 20A DB MCBs, 04nos 20A SP MCBs are out going with internal wiring complete in Bunk house	No	1	0.001844326	-
A24	Supply and fixing of Metal clad power point box with 02 nos 15A and 02 nos 5A flush type 3pin switched socket of anchor or oswal make with internal and external wiring of 3cx2.5sq.mm feexible cable from main LDB in Bunk house	No	2	0.00073773	-

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A25	Supply and laying of 3.5c x 25 sq.mm Alu. armoured power cable on above the ground of safe route from customer source point to BHEL bunk house	Mtr	100	0.002766489	-
A26	Making end termination of above power cable on both side including supply and using suitable cable gland and lugs complete	No	2	0.000368865	-
A27	Supply and making of earth pit using 3 mtr long 40 mm GI pipe, earth work excavation, filling of earth pit by using alternate layer of charcoal, excavated earth and salt, suitable earth connection to bunk house main switch board, earthing pit chamber and removable cast iron / Rcc cover slab complete	No	1	0.001844326	-
					-
B1	Supply of Mechanical items, electrical Items and Long rack shelf system for 15m x 30m closed storage shed.	L.S	1	0.468782811	-
B2	Erection of Mechanical items, electrical Items and Long rack shelf system for 15m x 30m closed storage shed	L.S	1	0.1313886752	-

Note :- $C2 = 0.07 \times A$; Where 'A' = Total Lumpsum Value Quoted'

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VOLUME – I A (PART – I): Chapter - XII GENERAL

12.0 GENERAL

BHEL has been awarded the work of Dismantling, Design, Manufacture, Supply, installation, erection, testing & commissioning of **3X27.5 MW KUTTIYADI HYDRO ELECTRIC POWER PROJECT**. The scope of work under the contract shall include Dismantling, renovation & repairs including capital repairs, transportation, material handling, loading, unloading storage & preservation, erection, testing, commissioning & Performance Guarantee Tests under Renovation & Modernization with New TG of the Units 1 to 3 and its associated facilities of Kuttiyadi hydroelectric project.

12.1 SCOPE OF WORK

- A. Receiving and Unloading of consignments from the Trucks/Trailers arriving from BHEL manufacturing units and its suppliers/vendors.
- B. Proper Stacking and Preservations of all the material.
- C. Keeping records and status of all materials as per BHEL practices. Verification of all the material received by contractor. Prepare shortages/damaged reports, if any.
- D. Transportation of materials from site stores to the powerhouse service bay or the pre assembly area as per site requirement and the instructions of site engineer.
- E. Construction of temporary shelters on some of the special items as per the instruction of the site engineer.
- F. Unloading and stacking of certain items in the service bay / work area with the help of EOT cranes / loading arrangement as per the instruction of BHEL engineer.
- G. Proper Housekeeping and safe working.
- H. Handing over of all the spares to customer at their stores.
- I. Handling and Transportation of scrap from power house to KSEB stores / scrap yard as per the instructions of BHEL engineer.
- J. Re-conciliation of materials with BHEL and KSEB.
- K. Dismantling, Erection, Testing, Commissioning and handing over as per BHEL drawing, contract specifications and as per the instructions of the BHEL engineer.

The materials will be supplied from our manufacturing units located all over the country as well as our vendors located both inland and overseas. The scope of work under this tender consists of taking delivery of the materials from transporters, unloading, shifting to their designated locations, verification & stacking etc. The delivery of these materials will mostly be inside the project campus by road transport. However, delivery of some items may also have to be taken from Godowns of transporters.

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The contractor has to handle whatever actual materials are dispatched for the project irrespective of any variations and payments shall be released for the actual gross tonnage handled for material handling purposes.

Though most of the material is being planned to be made available at site well in time for erection requiring proper handling, verification and storage. However certain items may be delayed, requiring direct delivery at site for erection. In such cases contractor has to unload the

material directly in powerhouse/ work place and verification to be carried out. Contractor for subject work will be eligible for payment as per the rate schedule. Besides above BHEL at its discretion may get the material handling/ unloading done at any location in the premises of powerhouse, store depending upon availability of space in powerhouse/ stores.

- 12.2 Tenderer may note that as the place of work is inside the POWER PROJECT and the premises is being manned by Security/Safety Force of KSEB, all necessary system related to entry of men, vehicle & material, safety & security systems, work permit system etc. as applicable will have to be followed by the contractor

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VOLUME – I A (PART – I): Chapter – XIII **Preliminary & Civil Works**

13.0 Preliminary & Civil Works

- 13.1 The contractor shall as a first field activity check all the foundations for the correctness of the same as per the drawings and satisfy himself in all respects such as location of foundations, absence of voids, **levels**, correctness of **bolt holes, pocket levels**, centre lines etc. and all measurements should be recorded and submitted to engineer **for approval** before erection.
- 13.2 Before starting erection job, contractor shall ensure that area connected to his scope of work is sufficiently enclosed against ingress of dust and water and all debris have been cleared of from the floor to a designated area as per instruction of engineer. The contractor shall arrange to get the working area and surroundings cleared daily to ensure the dust free atmosphere for working and shall maintain sufficient labour for general cleaning of work areas. Delay of work on this account will not be acceptable.
- 13.3 The contractor shall cover all opening on floor and put temporary hand railing on all sides of the floor to avoid any accident to the working personnel.
- 13.4 Contractor shall fix up and maintain plates, supports for X & Y axis and elevation at different locations as required for each unit and **transfer the same from bench mark and XY axis given at one point by BHEL's client**. Joint protocol records for such benchmarks shall be got signed from BHEL's Engineer/NHPC's Supervisory and QA Engineer.
- 13.5 Once X-Y axis and elevation are fixed at different floors and protected, marking for other equipment's shall be transferred from these and joint protocol as above shall be got signed for each equipment or as required as per drawings.
- 13.6 All matching surfaces of components shall be well cleaned with cleaning agent and burrs shall be removed by filing and blue matched. Wherever necessary sealing/lubricating/anti-sieze compounds shall be applied as per recommendation of Engineer. Machining/grinding required for fitting of keys, pins, packers , dowels etc. shall be carried out by contractor.
- 13.7 The accuracy of all equipment/ instruments and its functioning shall be established before they are permitted for use on the job. If the Engineer doubts the accuracy of the precision tools, at any time during erection, the contractor shall arrange the checking of tools/ equipment/ instruments at his cost.
- 13.8 All the works shall be performed to the lines, grades and elevations indicated on the drawings. The contractor shall be responsible to locate

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and layout the works. The horizontal & vertical control points established by the engineer shall be used as datum for the works under this contract. Any work done without being properly located may be removed and dismantled by the Engineer at the contractor's expenses if the contractor refuses to do it.

- 13.9 The contractor shall create all the facility at storage site as per the tender scope of work for unloading the equipment, its safekeeping and proper record and well protected. No material should be lying loose any where in the power house as well as in stores.
- 13.10 De-watering of the areas/ floors in general will be carried out by KSEB. However, contractor has to take care of general cleanliness in his area of work. For area cleaning within the premises of his work, the cleanliness shall be the total responsibility of contractor. Contractor within his scope of work shall keep the separate gang of workers for cleanliness operations. If the area under the scope is found unclean, BHEL can take measures on its own for cleaning and deduct the amount so spent from the running bills of contractor.
- 13.11 Necessary civil works during Erection of unit shall be done by Contractor. The dimensions & locations shall be checked by the contractor for its correctness as per drawings. Further, top elevation and axis/ centrelines of all the foundations shall be checked with respect to benchmark etc. During the civil works, contractor shall check for all the block-outs, dimensions as required in its various mechanical drawings for installation of components/ assemblies and help BHEL wherever required for checking. All adjustments of foundation level, dressing and chipping of foundation surfaces, enlarging the pockets in foundations etc., and repair of same as may be required for the erection of equipment shall be carried out by the contractor.
- 13.12 Besides above, any works required for safe and efficient operation of tools and tackles like grouting/ excavation/ casting of foundation/ anchor points for derricks, winches, guy ropes fastening scaffoldings etc. or any other temporary supports shall also be the contractor's responsibility. For these works all materials including cement/ steel and required facilities will have to be arranged by contractor at his own cost.
- 13.13 While on the job, care is essential to avoid too much chipping and resultant lowering of level. In case of excess chipping, contractor has to arrange additional packing plates as per requirements provided BHEL Engineer allows it. When required as per drawings/ manufacturing unit, the embedded sole plates shall be scraped and checked with Prussian blue to get the required contact with frames at no extra cost to BHEL.
- 13.14 The contractor shall ensure perfect matching of packer plates including scraping and blue matching with foundation by dressing the foundation, as well as perfect matching between the packer plates and the base plate of equipment to the satisfaction of BHEL Engineer.

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- 13.15 The contractor shall provide his T&P stores for special tools and instruments at a convenient place near to the working area.
- 13.16 All mechanical works of machine related to civil works including foundations, grouting, concreting, erection of chequered plates along with embedment in concrete, grouting of liners, any civil works relating to setting of anchor bolts and foundation bolts including preparation of bolt holes will be in the scope of contractor.
- 13.17 Storage area open shall be made available by KSEB for storage of new items/ equipment at a distance of about 1-2 Km from Power House building. Contractor will construct closed stores at one location. This area shall be used for storage of further plant material received from various manufacturing units of BHEL. BHEL shall be providing the General Security arrangement at stores and powerhouse. However, responsibility of security (watch and ward) arrangement of plant material/equipment during handling, in stores of BHEL, in stores of contractor, in power house, in valve house and all plant and equipment's whether erected/ yet to be erected shall lie with the contractor.

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VOLUME – I A (PART – I): Chapter-XIV Material Management at Stores & Power House

14.0 Materials Management at Stores & Power House

- 14.1 The scope of work mainly involves receipt, unloading from road carriers(Trucks/Trailers etc) of total materials for all units of 3 x 27.5 MW Kuttiyadi RMU Power Station at site or bringing from road carrier godowns to site stores/ storage yards and shifting from place of unloading to actual storage area (stores developed by BHEL), proper storing, stacking/ restacking of materials/ equipment (in closed store sheds/ open storage yards/ project site), verification of components including opening of cases, re-packing/ stacking and preservation of the same after verification including liasioning with carrier for waiver/ reduction of demurrage, security arrangement of plant material/equipment shall lie with the contractor. Fire fighting equipments including fire extinguishers is to be provided in closed, open storage yard and power house. Scope also includes transportation of materials to erection site as and when required, transportation of old and dismantled item to customer disposal yard. The contractor is to use Cranes and trucks/trailers (arranged by contractor) for the above work. Any other T&P required for transportation and material handling shall be arranged by the contractor.

The contractor shall maintain record of material such as receipts, issue, return, in Day – Book, ledgers, stock registers and computers, issue gate passes, record of shortages & MDR etc as per BHEL procedures and instructions. The contractor shall also assist BHEL for all correspondence regarding the insurance including preparation of claims.

- 14.2 The tentative weight of total new materials and dismantled material to be handled for all three units as indicated in Chapter-IV, Part-I of TCC is of the order of 1798 MT. Out of total 300 MT (tentative) as per the direction of engineer may be unloaded in powerhouse/valve house with the help of EOT crane from the truck/ trailers depending upon the requirement. However, the contractor required handling whatever actual materials are dispatched for the project irrespective of variations in weight and dimensions. Please refer Chapter II, Part –I of TCC. The bidders are required to take note of above points while quoting.
- 14.3 Chapter-IV, Part-I of TCC gives the general idea for tender's information about the weights and quantity of some major components/ equipment which are to be supplied by various BHEL manufacturing units. The weights and quantities shown are approximate and are liable to vary. No increase in quoted/ accepted rates/ prices should be allowed due to change in weights and dimensions of the equipment/ materials.
- 14.4 The contractor shall deploy adequate number of supervisors, storekeepers, riggers, carpenter, fitters and other skilled and unskilled workers as per

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requirement having adequate experience of jobs of similar nature till completion of work.

- 14.5 Contractor shall provide all necessary preservatives, paints, thinners, rust preventives, grease, lubricants etc. for preservation of components. All tools and tackles and other consumables required for the contractor at his own cost shall also provide preservation of components including supervision. Preservation of components also includes applying preservatives, paints, rust preventives, greasing of threaded portions, repainting of work order Nos./ DU nos./component codes etc. After preservation wherever necessary, components will be stacked properly as per original stacking for which no additional payment shall be made.
- 14.6 It shall be the responsibility of the contractor to keep in touch with Engineer at site and find out arrival of road consignments. The Contractor shall collect all the lorry waybills from BHEL site office either personally or through an authorised representative. The KSEB or his authorized representative shall, for the purpose, visit the said office every day and collect available LWB, PWB etc. While collecting the LWB, PWB contractor or his authorised representative will sign the register maintained for the purpose indicating the date and time of collection. The contractor shall keep in touch with carriers and arrange to effect delivery of consignments immediately on its receipts. Delay may cause deterioration of goods apart from attracting demurrage charges. Contractor shall also maintain a register indicating date of LWB, PWB date of collection of the materials from road transport agencies/ lorries and date of stacking them at storage yard of BHEL.
- 14.7 The contractor is required to find out and follow up regularly with carriers regarding arrival of consignments even prior to the receipt of GR, if any, and take delivery of the same on 'INDEMNITY BOND'. Indemnity bonds would be executed by BHEL when the Contractor furnishes intimation regarding arrival of consignment.
- 14.8 It is possible that in certain cases, LWBs, PWB may not be received in time but BHEL may receive Photostat copies of the same, it is, therefore, the responsibility of contractor to collect such Photostat copies while furnishing indemnity bond from BHEL authorities at site.
- 14.9 Payment of all demurrages/ wharfages that results due to contractor's faults would be the responsibility of contractor and to his account. If BHEL have to make payment of demurrage/ wharfage together with freight, the amount so paid as demurrage/ wharfage for the reasons stated above shall be paid by the contractor forthwith or would be recovered from bills of the contractor.
- 14.10 In any case contractor will pursue with concerned Carrier authorities at all level (local/ HQ etc) for waiver/ reduction to the minimum of such demurrage /wharfage charges. Whenever such demurrages/ wharfages become payable due to reasons not attributable to contractor, contractor

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will immediately bring it to the notice of BHEL with specific request to bear such charges. The decision of the Engineer in such case will be final and binding on the contractor.

- 14.11 The contractor has to ensure the unloading and removal of materials from unloading place within the permitted time and ensure to keep the area free and avoid jamming. Any loss to BHEL on this account shall be recovered from the contractor.
- 14.12 Any discrepancy/ shortage/ damage found in the consignment after taking delivery from the carriers after giving clear receipt would be the responsibility of the contractor and the amount liable to be lost by BHEL on such accounts is recoverable from the contractor.
- 14.13 In case of apparent damages/ shortages in consignments/ packing noticed by the contractor, such cases shall be brought to the notice of BHEL and cleared only with their consent/ approval. The contractor shall provide all the necessary assistance to BHEL for lodging the insurance claim and all correspondence with the insurer, surveyor and transport agency. The contractor shall also help in maintaining all the records in connection of insurance claims.
- 14.14 It would be responsibility of the contractor to examine the packages, consignments etc. on arrival and bring to the notice of carriers and BHEL authorities regarding loss/ damages, if any, observed in the consignments proposed to be taken delivery of.
- 14.15 Before taking delivery, particularly of consignments in 'smalls' the weight of the package shall be checked with the invoiced weight of the packages and any discrepancy shall be reported immediately to BHEL/ carriers. In all case of loss/ damages the contractor will take open delivery from the carriers and forward such open delivery certificates (ODC) to the engineer within 15 days of receipt of such consignment. All expenses connected there with shall be to the account of contractor. BHEL reserves right to claim losses, if any, accrued to BHEL in the event of contractor non-compliance to above.
- 14.16 In case of short delivery and non-delivery, immediate notice of loss shall be filed with the carrier at places of dispatch and destination as also at any intermediate stations, if it is different one, under intimation to BHEL authorities at site.
- 14.17 BHEL reserves the right to recover from the contractor any loss which arises out of undue delay/ discrepancy/ shortage/ damages or any other cause during transit between the carriers godown/ weigh bridges and BHEL storage yard/ store sheds/ project site or during unloading at carrier godown/ storage yard/ store shed/ project site or during stacking or any time during the custody of contractor. This is applicable for optional items.

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- 14.18 Unloading from lorries, transportation, unloading at storage area/ work site of heavy sophisticated equipment like stator, panels etc. shall be done in the presence of and as per the directions of BHEL representative, including stacking and re-stacking, if necessity arises.
- 14.19 Certain packages are likely to be received by BHEL by passenger bus. The relevant waybills will also be handed over to the contractor for clearing the from the Bus station. It is the responsibility of the contractor to clear the same at the bus station, transport and hand over to BHEL authorities at site under the scope of the contract. All the tender provisions indicated in the tender shall be applicable in this case also.
- 14.20 Since the trucks/ trailers are expected to arrive during any time of the day/ night, the contractor shall have his workmen round the clock at site as well as other places as required to unload the materials.
- 14.21 Consignments coming on Sundays and Holidays are also required to be handled by the contractor promptly. It will be the responsibility of the contractor to contact the site engineer /authorised representative of BHEL at their residence, if required, and obtain instructions to make suitable arrangements.
- 14.22 In the event unloading from the carrier is delayed by the contractor, the detention charges, if any, will be contractors account.
- 14.23 Under the scope of this contract, it shall be the responsibility of the contractor to provide all necessary facilities to open the packages in the presence of the engineer, verifying the contents of the packages, repackaging where ever and whenever necessary, properly stacking them as may be directed by the engineer so as to facilitate proper handling, periodical verification of material, receipt position, stock taking etc. for this, the contractor shall have experienced person at site who can maintain the records of dispatch/ receipt/ stacking/ verification/ shortages/ damage/ missing items etc. The verification of materials shall be carried out with in 15 days and report shall be submitted as a documentary proof.
- 14.24 All material shall be stored 6 inches above ground level by use of concrete or wooden sleepers. No material shall be left to remain on ground at any time. Material shall not be stacked in low-lying areas where it is likely flooded during rains. Wooden sleepers/ concrete block and tarpaulins for this purpose, wherever deemed necessary be arranged by the contractor. These items shall be stacked/ stored properly at the location(s) specified by BHEL when not in use.
- 14.25 The material/ equipment requiring indoor storage will be handed and stacked inside the storage shed (provided by BHEL) by the contractor using material handling equipment like Hydra crane, Fork lift etc.

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- 14.26 For checking/ verification of the components with packing slips/ LWB/ PWB etc. The contractor shall provide sufficient experience persons and other facilities as and when required by the engineer.
- 14.27 Stacking of the material shall be done as per the instruction and to the satisfaction of engineer. The materials shall be so stacked that the same should facilitate easy handling. In the event of any improper stacking BHEL may ask the contractor to restock the material properly or failing which BHEL may get the job done by another agency at the risk and cost of the contractor.
- 14.28 The contractor shall execute the work in the most substantial and workman like manner. The stores shall be handled with care and diligence. Any loss to BHEL due to contractor's lapse /negligence shall have to be made good by the contractor.
- 14.29 In case contractor is not able to unload, transport, stack the material at a predetermined area, as per direction of the engineer for any reason whatsoever (including non-availability of crane, tractor, trailer and other T&P etc.) BHEL shall be at liberty to get the work done by engaging other agency/ equipment / T&P etc at the risk and cost of the contractor.
- 14.30 It shall be responsibility of the contractor to keep the storage areas (closed/ open) in neat and tidy conditions. Any vegetation like grass, bushes, sarkandas etc. shall be cut in open storage area and removed as per requirement and instruction of BHEL engineer within the contractual value. All surplus/ unusable packing materials shall be removed and deposited at location(s) specified by BHEL within the project premises (including weighment of the same within the project premises if required).
- 14.31 Normally the consignments from BHEL manufacturing units/ their sub-suppliers are sent on freight paid basis. In case any consignment is received at any place or freight to pay basis, it will be the responsibility of the contractor to pay the freight and take delivery of such consignments. The amount of freight paid by the contractor at any point of time in such cases will be limited to Rs.5000/-. However, the freight paid by the contractor will be reimbursed by BHEL within a week's time on production of relevant receipt. In case of freight amounts exceed Rs.5000/- contractor may request BHEL well in time to issue cheque/ Draft for such additional amounts in favour of carriers towards freight charges. Receipt of payment and proof of taking delivery of cheque/ drafts as above shall not in any case be taken as a cause of delay in taking delivery of consignment resulting in wharfage / demurrage leviable by carriers.
- 14.32 In case some materials are required to be dispatched from Site to Manufacturing Units, other sites or any other place, the contractor may be asked by the engineer to get the same packed, loading into carriers godown and get the same booked. The contractor are therefore, requested to quote his rate for this work in rate schedule. In case of material required to be booked as freight paid the freight for the consignment

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limited to Rs. 3000/- shall be paid by the contractor. However it shall be reimbursed by BHEL on submission of receipt within a week's time. The funds for freight charges exceeding Rs. 3000/- shall be arranged by BHEL. Packing material required shall be provided by BHEL free of cost.

14.33 In case of consignment to be dispatched on full truck/ trailer load basis, where the carriers will place his fleet inside the plant for loading the contractor may be asked to collect them from different locations of stores shed / yard and load by using his crane and labour. Tenderers are required to quote rates for the work in rate schedule.

14.34 For any exigencies during execution of the contract, the contractor shall have to depute his personnel for collection/ delivery of any material meant for site from/ to outstation if desired and instructed by the Engineer. The contractor will however be reimbursed expenses incurred for such work for person deputed, as below:

- a. 2nd class train fare worth reservation / supplementary charges/ bus fare subject to furnishing details regarding ticket nos., journey details, amount of fare etc.
- b. Local conveyance charges (Actual bus/ cycle rickshaw/ auto rickshaw fare for local journeys at outstation) as permitted by the Engineer.
- c. Daily allowances @ Rs.100/- per day and @ Rs.250/- per day for lodging.
- d. Postal/ telegraph/ telephone charges if any subject to production of proof of having incurred such expenditure.
- e. Freight and other charges, if any, paid on production of actual receipts.
- f. Payment for the above will be made by BHEL within a month from the date of submission of bill along with details/ desired documents by the contractor subject to completion of work assigned to contractors personnel and to the entire satisfaction of engineer.

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VOLUME – I A (PART – I): Chapter – XV **Materials Handling and Storage & Transportation to Power House**

15.0 Material Handling and Storage & Transportation To Power House

- 15.1 Contractor shall plan in consultation with BHEL engineer, plant/ material to be received/ delivered in powerhouse as per erection progress/ schedules and fill in the requisite formats in standard forms.
- 15.2 Responsibility of security arrangement shall lie with the contractor. In case any equipment/ material is lost/damaged while in the custody of the contractor, the cost of repair/ replacement if any to bring back the equipment in original order shall be deducted from the contractor's bill. BHEL's decision in this regard shall be final and binding on the contractor.
- 15.3 All electrical panels, control gear, motors and such other devices shall be dried by heating before they are installed and energized. Exposed parts those required special protection such as bearings, slip rings, commutators and other fragile items shall be protected against moisture ingress and corrosion during storage and are periodically inspected.
- 15.4 Contractor shall also ensure that lifting heavy equipment such as generator rotor, stator, Main inlet valve, shafts etc. shall be done strictly in accordance with drawing given for the purpose and using of lifting tackles supplied for the purpose. Wherever required rubber/ leather pads shall be given between the slings and the machined parts to avoid any damages, scratches to the machined surface. Contractor shall cover bearing journals with grease and cloth as per direction of engineer to avoid damages to the surface.
- 15.5 As per the erection requirement contractor shall deliver material to powerhouse/ work site. The maximum care has to be taken during that time of loading the material at storage area, transportation and unloading at powerhouse. No untoward damage should occur to the material at that time. Any loss of item/ damages shall be to the contractors account.

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VOLUME – I A (PART – I): Chapter – XVI **Preservation of Components**

16.0 Preservation of Components

- 16.1 Contractor has to store all items in closed storage shed which require indoor storage not limited to bolts, pins, packing, tools, insulation materials, electrical parts with electrical devices attached, electric motors, electronic Panels, excitation equipment, automation equipment and associated equipment/consumables, instruments, welding material and equipment, all small parts and all parts of the plant which already have been finally painted etc. Partition required inside the closed storage shed for proper storage of items, shall be done by contractor.
- 16.2 In addition to the above, preservation of the other component shall be done as per Clause 6.2 of SCC.

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VOLUME – I A (PART – I): Chapter – XVII **Cleaning of Equipments**

17.0 Cleaning of Equipment's

- 17.1 The contractor shall thoroughly clean all the components before installation of the components whose surfaces are coated with protective coating and sent to site are to be thoroughly cleaned by suitable mechanical/ chemical means as per the approved procedure.
- 17.2 Contractor shall ensure that the items identified by BHEL shall be cleaned with kerosene/ petrol/ CRC before assembly and erection of the equipment. For cleaning purposes he shall use only soft cotton cloth. Contractor shall avoid use cotton waste for cleaning any equipment. The electrical equipment before erection shall be cleaned with dry air/ vacuum cleaner.
- 17.3 The contractor shall clean inside of all pipes and fittings from dirt, sand and loose scales, mechanically/ chemically and by air blowing before being erected. All pipe lines be thoroughly blown/ flushed. If necessary certain pipelines may have to be cleaned by acid pickling/ chemical cleaning. The procedure for the same shall be provided by BHEL. All chemicals and inhibitors shall be arranged by the contractor with in the contract. Disposal of chemical has to be carried out by the contractor at his own cost.

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VOLUME – I A (PART – I): Chapter-XVIII Erection

18.0 ERECTION

- 18.1 All works such as cleaning, checking, levelling, blue matching, aligning, assembling, temporary erection for alignment / dismantling of certain equipment for checking, cleaning, surface preparation, fabrication at site, cutting, grinding, straightening, chamfering, filing, chipping, drilling, reaming, dowelling, scrapping, machining, surface grinding, shaping, fitting up welding, tube expansion etc. as may be applicable in such erection works are to be treated as incidental to erection and necessary to complete the work satisfactorily & shall be carried out by the contractor as part of the work.
- 18.2 Any fixtures, scaffolding materials, approach ladder, concrete block supports, steel structures required for temporary supporting, pre-assembly or checking, welding, lifting and handling during pre- assembly and erection shall be arranged by contractor at his cost within the finally accepted rates.
- 18.3 No members of the ladder/ structure/ platform should be cut without specific approval of BHEL. In case it is necessary to cut, the contractor shall rectify/ repair in a manner acceptable to BHEL/ customer without any additional cost.
- 18.4 The contractor shall erect scaffolding/ temporary platforms for erection. These should be of adequate capacity and shall never be over loaded. These should be replaced when not found suitable during erection work and dismantled on work completion & removed from work site.
- 18.5 Corrections like straightening of ladders, tube support plates adjustment/ removal of ovalities in pipes and opening or closing the fabricated bends of piping to suit the layout shall be considered part of the work and the contractor is required to carry out such work within finally accepted price/ rate as per instructions of Engineer.
- 18.6 The contractor shall fabricate pipes, special bends, etc. threading and welding as required and carry out the chemical cleaning of fabricated piping.
- 18.7 The servicing and realignment of skid-mounted equipment if required or if directed by BHEL shall be carried out by the contractor at no extra cost to BHEL.
- 18.8 The contractor shall completely erect & test all the piping systems, covered in the specification including sampling lines up to and including sample coolers, hangers & supports, valves & accessories in accordance with the drawings furnished. This includes all necessary bolting, welding,

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pre-heating, stress relieving, testing, cleaning & painting. System shall be demonstrated in condition to operate continuously in a manner acceptable to the Engineer. Welding shall be used throughout for joining pipes except where flanged screwed or other type joints are specified or shown on the drawings. All piping shall be erected true to the lines & elevation as indicated in the drawings.

- 18.9 Pipes sent in standard length shall be cut to suit the site conditions and the layouts. Tubes or pipes wherever deemed to be convenient will be sent in running lengths. Bends shall be prepared and/or fabricated at site.
- 18.10 The contractor shall ensure lowering of pipes in position with adequate precautions as to avoid any damage to either material or men. Only the anchoring points earmarked for the purpose of lowering the pipes are to be used.
- 18.11 Certain adjustments in length may be necessary while erecting pipelines. The contractor should remove the extra lengths/ add extra lengths to suit the final layout after preparing edges a fresh by adopting specified heat treatment procedures, at no extra cost.
- 18.12 It is possible that a few flanges may not be matching. The contractor shall be required to cut and re-weld the same as and when required without any additional cost.
- 18.13 The contractor shall be responsible for any modifications of shop fabricated pipes prior to installation to accommodate minor site alteration in pipe which may include cutting/re welding of flanges/pipes for change of angles of bend or length adjustment at no extra cost.
- 18.14 All vents and drains for piping equipment covered in the scope whether shown in the drawings or not shall terminate in atmosphere and to pit as directed by BHEL.
- 18.15 Wherever piping erected by the contractor is connected to equipment/ piping erected by the other agencies the joint at the connecting point shall be the responsibility of the contractor of this specification.
- 18.16 Normally the valves will have prepared edges for welding. But, if it becomes necessary, the contractor will prepare new edges or recondition the edges by grinding or chamfering to match the corresponding tubes and pipes within quoted price. All fittings like 'T' pieces, weld neck flanges, reducers etc., shall be suitably matched with pipes for welding. The valves will have to be checked, cleaned or overhauled in full or in part before erection after chemical cleaning and during commissioning.
- 18.17 The contractor shall be responsible for correct orientation of all valves so that seats, stems & hand wheels will be in desired location. It is the responsibility of the contractor to obtain the information regarding

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orientation of valves not fully located on drawings before the same are installed.

- 18.18 Suspension for piping, etc., will be supplied in running lengths, which shall be cut to suitable sizes and adjusted as required.
- 18.19 The adjustment of all supports erected for maintaining the proper slopes of piping wherever required is also included in the scope of the contractor.
- 18.20 No temporary supports should be welded on the piping. In case of absolute necessity prior approval should be taken from BHEL Engineer. In such cases heat treatment if required, shall be carried out by the contractor as part of subject work.
- 18.21 All supports and anchors shall be installed as per drawing to obtain safe and reliable and complete pipe installation as per instructions of Engineer. Any additional support as called for by Engineer shall have to be fabricated and provided by the contractor. The raw materials required for fabricating such supports shall be arranged by BHEL.
- 18.22 Contractor shall install piping in such a way that no excessive or destructive expansion forces exist under any condition.
- 18.23 The contractor shall carry out the tightening of the field bolts on the equipment and piping covered under this specification by using either the calibrated torque wrench method or the turn of part method. The methods used, the tools and the equipment deployed shall be subject to the approval of Engineer. All the torque wrenches shall be calibrated at the start of each day's work and at least once during the day. The bolting work shall be carried out by the competent technicians.
- 18.24 The contractor shall ensure that all supporting elements, anchors & restraint have been installed and adjusted in accordance with the drawings / sketches & other written instructions of the Engineer.
- 18.25 Layout of small bore piping as required shall be done as per site requirement. Necessary sketch for routing these lines should be got approved from BHEL by the contractor. There is a possibility of slight change in routing the above pipe lines even after completion of erection or from aesthetic point of view which should be carried out at no extra cost.
- 18.26 All the valves, including motorised valves, flap valves, etc. shall be serviced and lubricated to the satisfaction of Engineer before erecting the same and during pre-commissioning also. Welding or jointing of extension spindle for valves to suit the site conditions and operational facility shall be part of erection work within the quoted rates.
- 18.27 Additional platforms and ladders of permanent nature incidental to the job for approaching different equipment/ valves as per site requirement, which may not be indicated in drawings, shall be fabricated and installed

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by the contractor. The materials required will be supplied by BHEL free of cost. Erection and welding of necessary instrumentation tapping points, valves to be provided on equipment, auxiliaries and pipe lines covered within the scope of this specification, will also be the responsibility of the contractor and will be done as per the instructions of BHEL Engineer at no extra cost.

18.28 All the items will be supplied in pieces/ loose and are to be assembled bolted and welded at site. Contractor has to work as per the drawings and instruction issued at site for erection and testing purposes. Weights for handling and erection are indicative only. No claim will be entertained on account of variations in weights or change from conventional design e.g from bolted to welded connections and vice versa, increase in number of pieces etc. The bidders should take care of this point while quoting lump sum price for subject works for handling and erection works. It may be possible that during routing /laying of pipelines, cable trays, HVAC ducts etc may foul with each other, the contractor has to re-route (Minor) the above as per the decision of BHEL without any financial implication to BHEL.

18.29 In view of the tight erection schedule, limited area in service bay and rotor assembly being in critical path, whatever pre-erection preparatory works can be carried out in BHEL store area shall have to be planned accordingly. In particular, the cleaning, de-burring, de-greasing and segregation of rim punching by weight shall definitely be planned and carried out in store area.

Since the subsequent units shall have to be erected/ commissioned in schedule time the contractor shall have to complete the rotor assembly in the service bay by working round the clock in this area. Moreover, two-shift working shall have to be adopted by the contractor to meet the erection schedule.

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VOLUME – I A (PART – I): Chapter-XIX Welding & NDT

- 19.0 WELDING, HEAT TREATMENT, ULTRASONIC AND OTHER NON-DESTRUCTIVE TESTING
- 19.1 The equipment and piping shall be erected in conformity with the provisions of standard/ specification and as may be directed by BHEL. The method of welding (arc, gas, TIG, MIG or other method) may be indicated in the detailed drawings/ schedules. BHEL Engineer will have the option of changing the method of welding as per site requirements.
- 19.2 Welding being a special process, all-welding shall be carried out by skilled and experienced welders holding valid certificates as per requirements of ISO 9002. The certificate shall be checked by BHEL before allowing the welders to be engaged on welding. BHEL at its own discretion may ask any or all welders to undergo welder Qualification Test as per Standard Procedure in accordance with requirements of ISO 9002 and as per welding manual of BHEL. The deployment of qualified welder and subsequent site testing of requisite numbers of welders shall be one of the prerequisite of contractor's site mobilization completion.
- 19.3 All welders including tack welder, structural and pipe welder shall be tested as per ASME section IX and approved by BHEL Engineer before they are actually engaged on work though they may possess the certificate. BHEL reserves the right to reject any welder if the welder's performance is not found to be satisfactory. The contractor in Performance given by BHEL Engineer shall maintain the records of qualification of welders. All the welders qualified for the work will be issued an identity card by BHEL Engineer and welder will keep the same with him at work place.
- 19.4 BHEL Engineer may stop any welder from the work if his performance is unsatisfactory for any technical reason or if there is a high percentage of rejection of joints welded by a particular welder which, in the opinion of the Engineer will adversely affect the quality of the welding though the welder has earlier passed the tests prescribed by Engineer. The welder's having passed qualification tests does not absolve contractor of contractual obligation to continuously check the welder's performance.
- 19.5 Faulty welds caused by the poor workmanship shall be cut and re-welded at the contractor's expenses including cost of materials. The Engineer prior to any repair being made shall approve the procedure for the repair of defective welds. Ultrasonic or any other NDT on completed field welds shall be conducted as per drawings or instructions of BHEL engineer.
- 19.6 The contractor shall carry out the root run welding of all piping, valves, instrumentation, tapping points etc. by TIG/ SMAW / MIG welding process. The contractor shall have to carry out full TIG welding of butt

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weld joints of tubes /pipes of lesser thickness if required. During the root runs of stainless steel joints, the contractor shall before and during welding have to purge the pipes with inert gas in case of stainless steel. All arrangements required for the above shall be the responsibility of the contractor at no additional cost.

- 19.7 All charges for testing of contractor's welders including consumables for welding / destructive and nondestructive tests conducted by BHEL at site or at laboratory shall have to be borne by the contractor only. The test coupons raw material will be supplied by BHEL free of cost.
- 19.8 The regulators used on welding machines shall be calibrated before putting these into use for work. Periodic calibration for the same shall also be arranged by the Contractor at his cost.
- 19.9 Only BHEL/KSEB approved electrodes and filler wire will be used. All electrodes shall be baked and dried in the electric electrode-drying oven to the required temperature for the period specified by the Engineer before these are used in erection work. All welders shall have electrodes drying portable oven at the work spot. The electrodes brought to the site will have valid manufacturing test certificate. The test certificate will have correlation with the lot No. /batch No given on electrode packets. No electrodes will be allowed to be used in the absence of above requirement. The thermostat and thermometer of electrode drying oven will be also calibrated and test certificate from Govt. approved / accredited test house traceable to National / International standards will be submitted to BHEL before putting the oven in use. Periodical calibration for the same shall also be arranged by the contractor within the finally accepted rates.
- 19.10 All butt / fillet welds shall be subject to dye penetration test as per drawing and document requirement and have to be carried out as per the instructions of the engineer within the quoted / finally accepted rates for this contract.
- 19.11 The contractor shall maintain a record in the form as prescribed by BHEL of all operations carried out on each weld and maintain a record indicating the number of welds, the names of welders who welded the same, date and time of start and completion, preheat temperature, ultrasonic results, rejection if any, percentage of rejection etc. and submit copies of the same to the BHEL Engineer as required. Interpretation of the BHEL Engineer regarding acceptability or other wise of the welds shall be final. All site welding joints shall be subject to acceptance by BHEL Engineer
- 19.12 All welds shall be painted with anticorrosive red oxide paint once ultrasonic and stress relieving works are over. Necessary consumables and scaffolding etc. including paints shall be provided by contractor at his own cost.

TECHNICAL CONDITIONS OF CONTRACT (TCC)

- 19.13 The contractor shall carry out the edge preparation of weld joints at site in accordance with the details acceptable to BHEL. Wherever possible machining or automatic flame cutting will be allowed only wherever edge preparation otherwise is impractical. All slag's / burrs shall be removed from cuts and all the hand cuts shall be ground smooth to the satisfaction of engineer.
- 19.14 Pre-heating, ultrasonic and other NDT tests, post heating and stress relieving after welding of tubes, pipes, including attachment welding wherever necessary, are part of erection work and shall be carried out by the contractor in accordance with the instructions of Engineer. All equipment and consumables essential for carrying out the above process shall be arranged by contractor at his cost.
- 19.15 Contractor shall arrange all necessary stress relieving equipment with automatic recording devices. Also the contractor shall have to arrange for labour, heating elements, thermocouples, etc. insulating materials like asbestos cloth, ceramic beads, asbestos ropes etc. required for heat treatment/ stress relieving operations. Temperature shall be measured by thermocouple and recorded on a continuous printing type recorder. All the recorded graphs for heat treatment works shall be the property of BHEL. The contractor has to provide thermal chinks, temperature recorders, thermocouple attachment units, graphs sheets, etc. for checking within the finally accepted rates. All stress relieving equipment will be used after due calibration and submission of test certificate to BHEL. Periodic calibration from Govt. approved / accredited Test Houses traceable to National / International standards will also be arranged by the contractor for such equipment at his cost. The contractor shall obtain the signature of BHEL Engineer or his representative on the chart of the recorder after setting up the weld joints for heat treatment operation prior to the starting.
- 19.16 The contractor shall also be equipped for carrying out other NDT like DP, UT etc. as required (if required) as per welding schedule/ drawings within the finally accepted price/ rates on all equipment welding and also in piping and other areas as applicable Necessary help including surface preparation and scaffolding required for conducting all the shall be rendered by contractor at his own cost.
- 19.17 The technical particulars, specification and other general details for NDT work shall be in accordance with ASME, ISO or as specified by Drawings and Manuals of BHEL / CUSTOMER.
- 19.18 The contractor shall assist BHEL Engineer in preparing complete field welding schedule/procedure for all the field welding activities to be carried out in respect of piping and equipment erected by him involving high pressure welding at least 30 days prior to the scheduled start of erection work at site. Such schedules shall be strictly adhered to by the contractor.

TECHNICAL CONDITIONS OF CONTRACT (TCC)

VOLUME – I A (PART – I): Chapter-XX **Testing, Pre Commissioning, Commissioning, Post Commissioning**

- 20.0 TESTING, PRE-COMMISSIONING, COMMISSIONING AND POST-COMMISSIONING.
- 20.1 On completion of erection of equipment, the contractor shall get the equipment checked up by the KSEB/BHEL, and their deputed supervisors, specialists concerned with the particular item of work. The testing of various equipment will be carried under the supervision of BHEL/ KSEB with the assistance of the Contractor in the manner decided by and in the presence of the owner and other authorized supervisors concerned, and to their entire satisfaction. On completion of these preliminary checks by the equipment supplier, the contractor shall make the equipment ready for conducting the test. The contractor shall rectify all defects found during the checking / testing as directed by the BHEL/ Consortium partner /Owner to ensure satisfactory operation of the equipment.
- 20.2 The contractor shall carry out the required tests as instructed by BHEL using contractor's own consumables, labour and scaffoldings.
- 20.3 All the tests shall be repeated till all the equipment satisfy the requirement / obligation of BHEL at various stages. Contractor shall also carry out repair of all the welded joints (site and suppliers) failed during testing.
- 20.4 The scope of testing activities cover installation of all necessary temporary piping, supports, valves, blanking, pumps, tanks etc. and other accessories with access platforms valves, pressure gauges, electric cables, switches, cutting of some of existing valve, placing of rubber wedges in the valves etc., required for hydro test, chemical cleaning, or for any other tests as the case may be and will carry out above activities under this scope of work as per instructions of BHEL. The scope also covers the off site disposal of effluents.
- 20.5 For testing of distributor, the necessary test pump and bulk heads shall be supplied by BHEL. Any other item which may be required additionally shall be arranged by contractor. The necessary blanks, pressure gauge, valve etc for testing of piping system including hardware shall be arranged by the contractor within his scope of work.
- 20.6 It shall be the responsibility of the contractor to provide various categories of workers in sufficient numbers along with Supervisors including necessary consumables, T&Ps, IMTEs etc., and any other assistance required during testing of equipment and attending any problem in the equipment erected by the contractor till handing over. Association of BHEL's/ Client's staff during above period will not absolve contractor from above responsibilities.
- 20.7 It shall be specifically noted that the above employees of the contractor may have to work round the clock along with BHEL Engineers and hence

TECHNICAL CONDITIONS OF CONTRACT (TCC)

overtime payment by the contractor to his employees may be involved. The contractor's finally accepted rates/ price shall be inclusive of all these factors also.

- 20.8 In case, any rework is required because of contractor's faulty erection which is noticed during testing, the same has to be rectified by the contractor at his cost. If any equipment/ part is required to be inspected during testing, the contractor will dismantle /open up the equipment / part and reassemble/ redo the work without any extra claim.
- 20.9 During testing, opening/ closing of valves, changing of gaskets, realignment of rotating and other equipment, attending to leakage and adjustments of erected equipment may arise. The finally accepted price shall also include all such work.
- 20.10 The contractor shall make all necessary arrangements including making of temporary closures on piping/ equipment for carrying out the hydro test on all piping equipment covered in the specification at no additional cost.
- 20.11 In case any defect is noticed during tests such as loose components, undue noise or vibration, strain on connected equipment etc., the contractor shall immediately attend to these defects and take necessary corrective measures. If any readjustment and realignment are necessary, the same shall be done as per Engineer's instructions including repair, rectification and replacement work by the contractor at his cost. The parts to be replaced shall be provided by BHEL.
- 20.12 The contractor shall carry out cleaning and servicing of valves prior to testing of the equipment under his scope. A system for recording of such servicing operations shall be developed and maintained in a manner acceptable to BHEL Engineer to ensure that no valves are left un-serviced. Wherever necessary as required by BHEL Engineer, the contractor shall arrange to lap / grind valve seats.
- 20.13 Cleaning & servicing of all the filters/ strainers, toppings of oils coming in the system shall be done by the contractor within the accepted price.
- 20.14 At the time of each inspection, the contractor shall take note of the decisions / changes proposed by the Engineer and incorporate the same at no extra cost.
- 20.15 Following tests will be carried out at site after installation:
- a. Dielectrics and insulation Test on all electric motors
 - b. Operation Tests on compressors for minimum 8 hour's continuous operation to establish trouble free operation without abnormal vibration and noise.
 - c. Operational tests on control panels and instruments.

TECHNICAL CONDITIONS OF CONTRACT (TCC)

VOLUME – I A (PART – I): Chapter-XXI Finish Painting

21.0 FINISH PAINTING

- 21.1 Primer painting wherever peeled off or damaged or if required is to be carried out after thoroughly cleaning of all dirt, rust, scales, grease, oils and other foreign materials by wire brushing, scrapping, any other method as per requirement of BHEL and the same being inspected and approved by the engineer before painting. Bare surfaces / unpainted surfaces shall be provided with two coats of suitable primer. The gas cut stubs / weld seams would require to be cleaned / ground before painting. After applying the primer paints all the equipment / items shall be finished with two coats of enamel paint or any other paint as issued by BHEL. The exterior surface may have to be cement / coal tar painted as directed by BHEL
- 21.2 As the equipment/ items are to be spray painted, the contractor shall make arrangements of the required equipment for spray painting. Spray painting at the job/ site shall be permitted only items approved by the owner / Engineer.
- 21.3 While the primers and paints will be issued by BHEL as free issue item, all tools and other consumables including scaffolding materials required for finish painting shall be supplied by contractor within their quoted rate.
- 21.4 All the plant equipment's /items shall be painted with required coat of red oxide primer & required coat of synthetic enamel paint, color as per drawings and site requirement. Paint shall be supplied by BHEL supplying units. The quantity to be supplied by manufacturing units is fixed. Contractor has to follow the painting procedure strictly, any deficiency in quantity of paints due to wrong procedure shall be borne by the contractor.

TECHNICAL CONDITIONS OF CONTRACT (TCC)

VOLUME – I A (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.

Clause 4.2.2.9 alone is revised as below.

In construction projects of this magnitude it is possible that all the areas/ approaches may not be ready. In such cases backfilling of approaches where ever necessary, 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.

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

EARNEST MONEY DEPOSIT

Proforma of Bank Guarantee (in lieu of Earnest Money)- Form WAM 23 is enclosed with this Tender.

Sl No. 5

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

TECHNICAL CONDITIONS OF CONTRACT (TCC)

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.: 6

Void

Sl. No.: 7

Procedure 2.3 that forms the part of Forms and Procedures is published as Chapter-9 in Volume IA Part II of this booklet (Volume-I Book-I).

Sl No.: 8

The chapter Reverse auction procedure published in 'Forms and Procedures' of Volume I Book-II stands deleted. 'Guidelines for Reverse Auction-2021' available in the website <http://www.bhel.com> -> Supplier Registration, shall be applicable.

Sl No.: 9

Existing format for BANK GUARANTEE FOR SECURITY DEPOSIT, as available in Form No. F-11 (Rev 00) of Volume ID Forms and procedures stands deleted. Refer Proforma of Bank Guarantee (in lieu of Security Deposit)-Form WAM 22 provided in Chapter- 09, Part-II of Volume-IA Technical Conditions of Contract.

Sl No.: 10

Existing format on Monthly Performance Evaluation of 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.: 11

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.: 12

Existing format for Integrity Pact, as available in Volume ID Forms and procedure stands Deleted. Refer revised format for Integrity Pact provided in Annexure – 7 of Notice Inviting Tender (NIT).

Sl No.: 13

2.14 QUANTITY VARIATION

Clause 2.14 QUANTITY VARIATION published in General Conditions of Contract (Volume IC Book-II) is revised as under:

2.14 QUANTITY VARIATION

2.14.1 Variation in Final Executed Contract Value

The quantities given in the contract are tentative and may change to any extent (both in plus side and minus side). No compensation becomes payable in case the variation of the final executed contract value is within the limits of Minus (-)

TECHNICAL CONDITIONS OF CONTRACT (TCC)

15% of awarded contract value. Also, no compensation becomes payable in case the contract gets partially executed/ short closed/ terminated/ work withdrawn under Rights of BHEL mentioned in Clause 2.7 of GCC. In case of work terminated / short closed under clause 2.7.4 of GCC, compensation may be considered only if BHEL receives compensation from customer.

Compensation due to variation of final executed contract value in excess of the limits defined in clause above, shall be as follows:

i) In case the finally executed contract value reduces below the lower limit of awarded Contract Value due to quantity variation specified above, the Contractor will be eligible for compensation @ 15% of the difference between the lower limit of the awarded contract value and the actual executed contract value.

ii) In case the finally executed contract value increases above the awarded Contract Value due to quantity variation, the Contractor is not eligible for any compensation 2.14.2 Variation in Individual Quantities of BOQ Item(s) The quantities given in the contract are tentative and may change to any extent (both in plus side and minus side). No compensation becomes payable in case the variation of the quantity of individual BOQ item(s) is within the limits of Plus (+) 100% of the quantity in the original price schedule.

In case executed quantity for a particular BOQ item(s) exceeds two times the quantity in the original price schedule (100% increase), then the revision in rates for such BOQ item(s) for the quantity in excess of two times the quantity in the original price schedule including any subsequent increase in quantity, may be considered based on request from the Contractor, however, BHEL decision in this regard shall be final. Revised rates for subject BOQ item (s) shall be worked out on the basis of prevailing market rates mutually agreed between BHEL and Contractor. PVC/ ORC will not be applicable for these revised rates.

BHEL, however, retains the right to arrange the excess quantity through any other source for expediting activities in the interest of the Project.

Note:

(a) Revision in rates under clause 2.14.2 will remain admissible in those cases also, where, the Contractor is eligible for compensation under clause 2.14.1 i).

(b) The value of work executed at revised rates due to variation in Individual Quantities of BOQ Item(s) shall be included while calculating the finally executed contract value in clause no. 2.14.1 above

Sl No.: 14

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

2.22 RETENTION AMOUNT:

TECHNICAL CONDITIONS OF CONTRACT (TCC)

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 all expenses/ other amounts due to BHEL under the contract/ other contracts entered into with them (contractor) by BHEL.

Sl.No.:15

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

2.17 PRICE VARIATION COMPENSATION

2.17.1 In order to take care of variation in cost of execution of work on either side, due to variation in the index of LABOUR, HIGH SPEED DIESEL OIL, WELDING ROD, CEMENT, STEEL, MATERIALS, Price Variation Formula as described herein shall be applicable

2.17.2 85% component of Contract Value shall be considered for PVC calculations and remaining 15% shall be treated as fixed component. The basis for calculation of price variation in each category, their component, Base Index, shall be as under:

SL NO.	CATEGORY	INDEX/ AVERAGE MINIMUM WAGE	PERCENTAGE COMPONENT ('K')				
			CIVIL PACKAGES (See Note A/B/C)			MECHANICAL PACKAGES	Electrical , C&I Material Management/ Handling and other labour oriented packages
			A	B	C		
i)	LABOUR (ALL CATEGORIES)	(a) MONTHLY ALL-INDIA AVERAGE CONSUMER PRICE INDEX NUMBERS FOR INDUSTRIAL	40	25	30	65	80

TECHNICAL CONDITIONS OF CONTRACT (TCC)

		WORKERS' published by Labour Bureau, Ministry of Labour and Employment, Government of India. (50% weightage out of component 'K') (Website: labourbureau.nic.in)					
		(b) Arithmetical average of minimum wages of Unskilled, Semi-skilled, Skilled and Highly skilled workers as applicable at project site location (50% weightage out of component 'K')					
ii)	HIGH SPEED DIESEL OIL	Name of Commodity: HSD Commodity Code: 1202000005 (See Note E)	5	3	5	5	5
iii)	WELDING ROD	Name of Commodity: MANUFACTURE OF BASIC METALS Commodity Code: 1314000000 (See Note E)				15	
iv)	CEMENT	Name of Commodity: ORDINARY PORTLAND CEMENT Commodity Code: 1313050003 (See Note E)		20	30		
v)	STEEL (Structural and Reinforcement Steel)	Name of Commodity: MILD STEEL: LONG PRODUCTS Commodity Code: 1314040000 (See Note E)		25			
vi)	ALL OTHER MATERIALS (Other than Cement & Steel)	Name of Commodity: ALL COMMODITIES Commodity Code: 1000000000 (See Note E)	40	12	20		

Note:

A) Cement & Steel: Free Issue (BHEL Scope)

B) Cement & Steel: In Contractor Scope

C) Cement in Contractor Scope, and Steel is Free Issue (BHEL Scope)

TECHNICAL CONDITIONS OF CONTRACT (TCC)

D) For Composite packages (i.e. Civil+Mechanical+Electrical and/or C&I or Civil+Mechanical or Mechanical+Electrical and/or C&I), the COMPONENT ('K') for various categories shall be as per respective packages as above.

E) As per the 'MONTHLY WHOLE SALE PRICE INDEX' for the respective Commodity and Type, published by Office of Economic Adviser, Ministry of Commerce and Industry, Government of India. (Website: eaindustry.nic.in). Revisions in the index or commodity will be re-adjusted accordingly.

2.17.3

2.17.4 Payment/recovery due to variation in index shall be determined on the basis of the following notional formula in respect of the identified COMPONENT ('K') viz LABOUR, HIGH SPEED DIESEL OIL, WELDING ROD, CEMENT, STEEL, MATERIALS.

$$P = K \times R \times (X_N - X_o) / X_o$$

Where,

P = Amount to be paid/recovered due to variation in the Index for Labour, High Speed Diesel Oil, Welding Rod, Cement, Steel and Materials

K = Percentage COMPONENT ('K') applicable for Labour, High Speed Diesel Oil, Welding Rod, Cement, Steel and Materials

R = Value of work done for the billing month (Excluding Taxes and Duties if payable extra)

X_N = Revised Index for Labour, Revised Average Minimum Wages for Labour, Revised Index for High Speed Diesel Oil, Welding Rod, Cement, Steel and Materials for the billing month under consideration

X_o = Index for Labour, Average Minimum Wages for Labour, Index for High Speed Diesel Oil, Welding Rod, Cement, Steel and Materials as on the Base date

2.17.5 PVC shall not be payable for the ORC amount, Supplementary/Additional Items, Extra works. However, PVC will be payable for items executed under quantity variation of BOQ items under originally awarded contract.

2.17.6 Base date shall be calendar month of the 'last date of submission of Tender'.

2.17.7 The contractor shall furnish necessary monthly bulletins in support of the requisite indices from the relevant websites along with his Bills.

2.17.8 The contractor will be required to raise the bills for price variation payments on a monthly basis along with the running bills irrespective of the fact whether any increase/decrease in the index for relevant categories has taken place or not. In case there is delay in publication of bulletins (final figure), the

TECHNICAL CONDITIONS OF CONTRACT (TCC)

provisional values as published can be considered for payments and arrears shall be paid/recovered on getting the final values.

2.17.9 PVC shall be applicable for the entire original contract period plus the extended period, i.e. for the complete execution period, as follows:

For PVC computation of the n^{th} month:

Let the cumulative delay attributable to the Contractor is D_n in the n^{th} month as per Form-14. Considering R_n as the billing value for the n^{th} month, PVC for the n^{th} month shall be calculated as follows:

a) PVC for the portion of R_n for an amount of $D_{(n-1)}$ shall be payable as per indices for the $(n-1)^{\text{th}}$ month.

b) PVC for the balance portion of R_n shall be payable as per indices for the n^{th} month

In case $D_{(n-1)}$ is greater than R_n , then entire R_n shall be payable as per indices for the $(n-1)^{\text{th}}$ month and the balance portion of $D_{(n-1)}$ shall be adjusted from $R_{(n+1)}$ of the $(n+1)^{\text{th}}$ month and will be payable as per indices for the $(n-1)^{\text{th}}$ month. The above process shall be continued for subsequent month(s) also till full $D_{(n-1)}$ is consumed.

i) For milestones mentioned in the contract, PVC shall be applicable as per average of the indices from the month of base date till the month of execution of milestone.

ii) PVC shall not be applicable for time extension provided for the delays solely attributable to the contractor. No PVC is payable during the period of Provisional Time Extension till grant of final time extension. Applicability of PVC will be decided at the time of grant of final time extension.

iii) The total amount of PVC shall not exceed 15% of the cumulatively executed contract value. Executed contract value for this purpose is exclusive of PVC, ORC, Supplementary/Additional Items and Extra works except items due to quantity variation.

Note: Work Planning in F-14 format to be meticulously done as per Clause 2.9 of this GCC

Sl.No.:16

Clause 2.9 PROGRESS MONITORING, MONTHLY REVIEW AND PERFORMANCE EVALUATION published in General Conditions of Contract (Volume IC Book-II) is revised as under

2.9 EXECUTION PLAN, PROGRESS MONITORING, MONTHLY REVIEW AND PERFORMANCE EVALUATION

TECHNICAL CONDITIONS OF CONTRACT (TCC)

2.9.1 A tentative plan/ programme for completion of the contractual scope of work as per the time schedule given in the contract shall be made jointly by BHEL and Contractor, before commencement of work. The above programme shall be supported by month wise deployment of resources viz Manpower, T&P, Consumables, etc. Progress will be reviewed periodically (Daily/Weekly/Monthly) vis-à-vis this jointly agreed programme.

Subsequently, every month, quarterly rolling plan will be made by BHEL based on budgeted targets. Monthly plan in F-14 format shall be drawn from this Quarterly plan. Monthly plan shall necessarily include activities required for achieving targets/ milestones unless inputs/ fronts are not available.

While planning and arriving on asking rate all available inputs shall be taken into consideration. Vendor will be required to execute the monthly plan in that month in addition to make full efforts to minimize the cumulative shortfall attributable to him up to the month. BHEL may require monthly work plan up to one and half times of average monthly value and demand matching manpower.

Where, Average Monthly Value = Total Contract Value (as per latest revision) / Period of Contract (in months)

Provided, this requirement is reflected in the rolling quarterly plan two months in advance.

If the Contractor refuses to sign the F-14 format, those F-14 formats requiring Contractor's signature shall be deemed to have been signed and accepted by the Contractor, if communicated to the Contractor through email or any other mode as stated in clause 2.3.1.

The Contractor shall submit periodical progress reports (Daily/Weekly/Monthly) and other reports/information including manpower, consumables, T&P mobilization etc. as desired by BHEL.

2.9.2 Monthly progress review between BHEL and Contractor shall be based on the agreed programme as above, availability of inputs/fronts etc., and constraints if any, as per prescribed formats (i.e. Form F-14). Manpower, T&P and consumable reports as per prescribed formats shall be submitted by contractor every month. Release of RA Bills shall be contingent upon certification by BHEL Site Engineer of the availability of the above prescribed formats duly filled in and signed.

2.9.3 The burden of proof that the causes leading to any shortfall is not due to any reasons attributable to the contractor is on the contractor himself. The monthly progress review shall record shortfalls attributable to (i) Contractor, (ii) Force Majeure Conditions, and (iii) BHEL

2.9.4 Performance of the Contractor shall be assessed as per prescribed formats and shall form the basis for 'Assessment of Capacity of Bidder' for Tenders where the Contractor is a bidder. BHEL reserves the right to revise the evaluation formats during the course of execution of the works.

TECHNICAL CONDITIONS OF CONTRACT (TCC)

Sl.No.:17

Clause 2.11 EXTENSION OF TIME FOR COMPLETION published in General Conditions of Contract (Volume IC Book-II) is revised as under

2.11 EXTENSION OF TIME FOR COMPLETION

2.11.1 If the completion of work as detailed in the scope of work gets delayed beyond the contract period, the contractor shall request for an extension of the contract and BHEL at its discretion may extend the Contract.

2.11.2 Based on the F-14 formats, the works balance at the end of original contract period less the backlog attributable to the contractor shall be quantified, and the number of months of 'Time extension' required for completion of the same shall be jointly worked out. Within this period of 'Time extension', the contractor is bound to complete the portion of backlog attributable to the contractor. Any further 'Time extension' or 'Time extensions' at the end of the previous extension shall be worked out similarly.

2.11.3 However, if any 'Time extension' is granted to the contractor to facilitate continuation of work and completion of contract, due to backlog attributable to the contractor alone, then it shall be without prejudice to the rights of BHEL to impose penalty/LD for the delays attributable to the contractor, in addition to any other actions BHEL may wish to take at the risk and cost of contractor.

2.11.4 Planning, progress monitoring, monthly review and performance monitoring shall be carried out as per Clause 2.9 of GCC.



**SPECIFIC TECHNICAL REQUIREMENT
FOR CIVIL & STRUCTURAL WORKS
FOR RMU WORKS OF KUTTIYADI 3x25
MW HEP**

SPECIFICATION NO. PE-TS-471-600-001

VOLUME - II B

SECTION - C | SUB-SECTION –

REV.NO. 00 DATE 19.02.2020

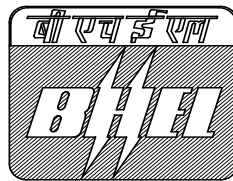
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SECTION – C

**SPECIFIC TECHNICAL REQUIREMENTS FOR CIVIL &
STRUCTURAL WORKS**

SPECIFICATION NO: PE-TS-471-600-C001



Bharat Heavy Electricals Limited

Power Sector - Project Engineering Management

PPEI Building, Plot No. 25

Sector – 16A, NOIDA (U.P.) - 201301



**SPECIFIC TECHNICAL REQUIREMENT
FOR CIVIL & STRUCTURAL WORKS
FOR RMU WORKS OF KUTTIYADI 3x25
MW HEP**

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**SPECIFIC TECHNICAL REQUIREMENT
FOR CIVIL & STRUCTURAL WORKS
FOR RMU WORKS OF KUTTIYADI 3x25
MW HEP**

SPECIFICATION NO. PE-TS-471-600-001

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PART-I

GENERAL CIVIL REQUIREMENT



**SPECIFIC TECHNICAL REQUIREMENT
FOR CIVIL & STRUCTURAL WORKS
FOR RMU WORKS OF KUTTIYADI 3x25
MW HEP**

SPECIFICATION NO. PE-TS-471-600-001

VOLUME - II B

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1. GENERAL

Two Volumes-Section C & Section D of this specification cover design and construction of Civil and Structural works. The scope of works covers complete Civil and Structural Works including supply of all materials, labour, tools and plants as required for successful execution of the packages. This Part-I of Section-C Lists Codes and Standards to be adopted and the principal structures of the plant, and briefly describes the basic concept, requirements and features pertinent to each.

If there is any ambiguity and/or contradiction between Section C and Section D, the provisions / requirements laid in Section C shall prevail. In case of ambiguity between BOQ and Part C former shall prevail.

(Contractor shall read the parts of the specification relevant to the contract and shall ignore the other parts of the specification. Relevant clauses of this section as applicable for respective package to be followed.)

2. CODES AND STANDARDS

Following is a general listing of Codes and Standards to be used in the design of the Plant. Specific applicable codes and standards will be identified in System Design Descriptions/ Technical Specifications as appropriate. The latest editions/ revision of following codes and standards along with addendums/ amendments, if any, shall be followed:

2.1. Earthwork

- a) IS-1498: Classification and identification of soils for General Engineering purposes.
- b) IS-3764: Safety Code for excavation work.
- c) IS-7293: Safety Code for working with construction machinery.
- d) IS-4701: Code of practice for earth work on canals.
- e) IS-9759: Guide lines for dewatering during construction.
- f) IS-10379: Code of practice for field control of moisture and compaction of soils for embankment and sub-grade.

2.2. Concrete

- a) IS-269: Ordinary and low heat Portland cement.
- b) IS-383: Coarse and fine aggregate from natural sources for concrete.
- c) IS-432: Mild Steel and medium tensile steel bars and hard (Part I & II) drawn steel wire for concrete reinforcement.
- d) IS-455: Portland Slag Cement.
- e) IS-456: Code of Practice for Plain and reinforced concrete.
- f) IS-457: Code of practice for general construction of plain and reinforced concrete for dams and other massive structures.
- g) IS-460: Test Sieves (all parts).
- h) IS-516: Methods of test for strength of concrete.
- i) IS-1199: Methods of sampling and analysis of concrete.
- j) IS-1566: Hard drawn steel wire fabric for concrete Reinforcement.
- k) IS-1786: High strength deformed steel bars and wires for concrete Reinforcement.
- l) IS-1791: General requirement for batch type concrete mixers.
- m) IS-1834: Hot applied sealing compounds for joints in concrete.
- n) IS-1838: Preformed fillers for expansion joints in concrete pavement and structures.



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- o) IS-2386: Methods of test for aggregates for concrete (all parts).(Part I-VIII)
- p) IS-2438: Specification for roller pan mixers.
- q) IS-2502: Code of practice for bending and fixing of bars for concrete Reinforcement.
- r) IS-2505: Concrete vibrators - immersion type.
- s) IS-2506: General requirements for screed board concrete vibrators.
- t) IS-2722: Specification for Portable Swing weigh batchers for concrete (single and double bucket type).
- u) IS-2750: Steel scaffolding.
- v) IS-2751: Recommended practice for welding of mild steel plain and deformed bars for reinforced construction.
- w) IS-3150: Hexagonal wire netting for general purposes.
- x) IS-3366: Specification for pan vibrators.
- y) IS-3370: Code of practice for concrete structures for storage of liquids (all parts).(Part I-IV)
- z) IS-3414: Code of practice for design and installation of joints in buildings.
- aa) IS-3558: Code of practice for use of immersion vibrators for consolidating concrete.
- bb) IS-4014: Code of practice for steel tubular scaffolding.(Part I & II)
- cc) IS-4656: Form vibrators for concrete.
- dd) IS-4925: Concrete batching and mixing plant.
- ee) IS-4948: Welded steel wire fabrics for general use.
- ff) IS-4990: Plywood for concrete shuttering work.
- gg) IS-5256: Code of practice for sealing expansion joints in concrete lining on canals.
- hh) IS-6452: High Alumina Cement for Structural use.
- ii) IS-6461: Glossary of terms relating to cement concrete.
- jj) IS-6494: Code of practice for water proofing of underground reservoir and swimming pools.
- kk) IS-6509: Code of practice for installation of joints in concrete pavements.
- ll) IS-7320: Concrete slump test apparatus.
- mm) IS-7861: Code of practice for extreme weather concreting.
(Part I & II)
- nn) IS-8041: Rapid Hardening Portland Cement.
- oo) IS-8112: High strength ordinary Portland Cement.
- pp) IS-9012: Recommended practice for shotcreting.
- qq) IS-9103: Admixtures for concrete.
- rr) IS-9417: Recommendations for welding cold worked bars for reinforced concrete construction.
- ss) IS-10262: Recommended guidelines for concrete mix design.
- tt) IS-458: Specification for precast concrete pipes.
- uu) IS-3935: Code of practice for composite construction.
- vv) IS-4995: Criteria for design of reinforced concrete bins for storage of granular (all parts) and powdery materials.
- ww) IS-5525: Recommendation for detailing of reinforced concrete works.
- xx) IS-11384: Code of practice for composite construction in structural steel and concrete.
- yy) IS-11682: Criteria for design of RCC staging for overhead water tanks.
- zz) IS:12118: Two parts polysulphide based sealants.
- aaa) IS:12200: Code of practice for provision of water stops at transverse construction joints in masonry and concrete dams.
- bbb) IS:13311: Non-destructive testing of concrete - methods of test.
Part I - Ultrasonic pulse velocity.
Part II - Rebound hammer.
- ccc) IS-13920: Code of practice for ductile detailing of reinforced concrete structures subjected to seismic forces.
- ddd) SP-16: Design codes for reinforced concrete to IS:456-1978.
- eee) SP-23: Hand book of concrete mixes.
- fff) SP-24: Explanatory handbook on Indian standards code for plain and reinforced concrete.
(IS: 456)
- ggg) SP-34: Hand book on concrete reinforcement and detailing.
- hhh) ACI-318: American Concrete Institute code for structural concrete.
- iii) IS-280: Mild steel wire for general engineering purpose.
- jjj) IS-10297: Code of practice for design and construction of floors and roofs using precast reinforced/prestressed concrete ribbed or cored slab units.
- kkk) IS-10505: Code of practice for construction of floors and roofs using pre-cast reinforced concrete waffle units.
- lll) IS-15658: Pre-cast concrete block for paving.



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2.3. Foundations

- a) IS-1080: Code of practice for Design and Construction of shallow foundations on soils (other than raft, ring and shell)
- b) IS-1904: Code of practice for Design and Construction of foundations in soils: General Requirements
- c) IS-2314: Steel sheet piling sections.
- d) IS-2911: Code of practice for Design and Construction of Pile foundations (all parts).
- e) IS-2950: Code of practice for design and construction of raft foundations.
- f) IS-2974: Code of practice for design and construction of machine foundations.
- g) IS-4091: Code of practice for Design and Construction of foundations for transmission line towers and poles
- h) IS-6403: Code of practice for determination of Bearing capacity of Shallow foundations.
- i) IS-8009: Code of practice for calculation of settlement of foundations: (all parts)
- j) IS-9556: Code of practice for Design and Construction of diaphragm walls.
- k) IS-11089: Code of practice for Design and Construction of ring foundation.
- l) IS-12070: Code of practice for design and construction of shallow foundations on rocks.
- m) IS-13301: Guidelines for vibration isolation for machine foundation.
- n) ISO 10816: Criteria for assessing mechanical vibrations of machines.
- o) ISO 1940: Criteria for assessing the st of balance of rotating rigid bodies.
- p) DIN: EN13906-1: Helical compression spring made of round wire and rod: calculation and design of compression.
- q) DIN: 2096 Helical compression spring out of round wire and rod: Quality requirements for hot formed compression spring.
- r) DIN: 4024 Flexible supporting structures for machine with rotating machines.
- s) IS: 7207 Criteria for Design of Generator Foundation for Hydel Power Stations.
- t) IS: 4247 Part I, Part II & Part III. Code of Practice for Structural Design of Surface Hydel Power Stations.

2.4. Loading

- a) IS-875: Code of practice for Structural safety of buildings - loading standards.
- b) IS-1911: Schedule of unit weights of building materials.
- c) IRC-6: Standard specifications & Code of practice for road bridges.

2.5. Masonry

- a) IS-712: Building limes.
- b) IS-1077: Common Burnt Clay Building Bricks.
- c) IS-1127: Recommendations for dimensions and workmanship of natural building stones for masonry work.
- d) IS-1528: Methods of sampling and physical tests for refractory materials.
- e) IS-1597: Code of practice for construction of stone masonry (all parts).
- f) IS-2212: Code of practice for brickwork.
- g) IS-2116: Sand for masonry mortars
- h) IS-2185: Concrete masonry units. (all parts - Hollow and Solid concrete blocks).
- i) IS-2250: Code of practice for preparation and use of masonry mortars.
- j) IS-2572: Code of practice for construction of hollow concrete block masonry.
- k) IS-2691: Burnt clay facing bricks.
- l) IS-3414: Code of practice for design and installation of joints in buildings.
- m) IS-3495: Methods of tests of burnt clay building bricks.
- n) IS-4441: Code of practice for use of Silicate type chemical resistant mortars.
- o) IS-4860: Acid Resistant Bricks.
- p) IS-1905: Code of practice for structural use of unreinforced masonry.
- q) IS-10440: Code of practice for construction of reinforced brick and reinforced brick concrete floors and roofs.
- r) SP-20: Hand book on masonry design and construction.
- s) IS-1489: Portland-pozzolana cement.
- t) IS-1542: Sand for Plaster.
- u) IS-12269: 53 grade ordinary Portland cement.
- v) IS-12894: Specification for fly ash lime bricks.
- w) IS-13757: Burnt clay fly ash building bricks.



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2.7. Roof and Flooring

- a) IS-2204: Code of practice for construction of reinforced concrete shell roof.
- b) IS-3201: Criteria for the design and construction of precast concrete trusses.
- c) IS-2210: Criteria for Design of R.C. shell structures and folded plates.
- d) IS-809: Rubber flooring materials for general purposes.
- e) IS-1195: Bitumen mastic for flooring.
- f) IS-1196: Code of practice for laying bitumen mastic flooring.
- g) IS-1198: Code of practice for laying, fixing and maintenance of linoleum floors.
- h) IS-1237: Cement concrete flooring tiles.
- i) IS-1443: Code of practice for laying and finishing of cement concrete flooring tiles.
- j) IS-2114: Code of practice for laying in situ terrazzo floor finish.
- k) IS-2571: Code of practice for laying in situ cement concrete flooring.
- l) IS-5491: Code of practice for laying in situ granolithic concrete floor topping.
- m) IS-5766: Code of practice for laying burnt clay brick flooring.
- n) IS-1197: Code of practice for laying of rubber floors.

- o) IS-2441: Code of practice for fixing ceiling coverings.

2.11. Earthquake Resistant Design

- a) IS-1893: Criteria for earthquake resistant design of structures.
- b) IS-4326: Code of practice for earthquake resistant design and construction of buildings.

2.12. Structural Steelwork

- a) IS-800: Code of practice for general construction in steel.
- b) IS-802: Code of practice for use of structural steel in Overhead Transmission Line (All Parts).
- c) IS-806: Code of practice for use of steel tubes in general building construction.
- d) IS-808: Rolled steel beams, channels and angle sections.
- e) IS-813: Scheme of symbols for welding.
- f) IS-814: Covered electrodes for manual metal arc welding of carbon and carbon manganese steel.
- g) IS-816: Code of practice for use of metal arc welding for general construction in mild steel.
- h) IS-817: Code of practice for training and testing of metal arc welders.
- i) IS-818: Code of practice for safety and health requirements in electric and gas welding and cutting operation.
- j) IS-819: Code of practice for Resistance spot welding for light assemblies in Mild Steel.
- k) IS-919: Recommendations for limits and fits for engineering.
- l) IS-1024: Code of practice for use of welding in Bridges and Structures subjected to Dynamic loading.
- m) IS-1161: Steel tubes for structural purposes.
- n) IS-1182: Recommended practice for Radiographic Examination of Fusion Welded Butt joints in steel plates.
- o) IS-1200: Method of measurement of steelwork and ironwork. (Part-VIII)
- p) IS-1239: Mild steel tubes, tubulars and other wrought steel fittings (all parts).
- q) IS-1363: Black hexagonal bolts, nuts and locknuts (Dia. 6 to 39 mm) and black hexagon screws (Dia. 6 to 24 mm). [all parts]
- r) IS-1364: Precision and semi-precision hexagon bolts, screws, nuts and locknuts (Dia. range 6 to 39 mm). [all parts]
- s) IS-1365: Slotted counter sunk head screws (Dia. range 1.6 to 20 mm).
- t) IS-1367: Technical supply conditions for threaded steel fasteners. (Part 1 to 18)
- u) IS-1443: Code of practice for laying and finishing of cement concrete flooring tiles.



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- v) IS-1608: Method for tensile testing of steel products.
w) IS-1730: Dimensions for steel plate, sheet and strip for structural and general engineering purpose.
x) IS-1731: Dimensions for steel flats for structural and general engineering purposes.
y) IS-1852: Rolling and cutting tolerances for hot rolled steel products.
z) IS-1977: Structural steel (Ordinary quality)
aa) IS-2016: Plain Washers
bb) IS-2062: Steel for General structural purposes.
cc) IS-2074: Ready mixed paint, air drying, red oxide zinc-chrome, priming.
dd) IS-2633: Methods of testing uniformity of coating of zinc coated articles.
ee) IS-3613: Acceptance tests for wire-flux combinations for submerged-arc welding of structural steels.
ff) IS-3664: Code of practice for Ultrasonic Pulse echo testing by contact and immersions methods.
gg) IS-3757: High strength structural bolts.
hh) IS-4000: High strength bolts in steel structures.
ii) IS-4759: Hot dip zinc coatings on structural steel and other allied products.
jj) IS-5334: Code of practice for Magnetic Particle Flaw detection of welds.
kk) IS-7215: Tolerances for fabrication of steel structures.
ll) IS-7280: Base-wire electrodes for sub-merged arc welding of structural steels.
mm) IS-7318: Approval test for welders when welding procedure approval is not required.
(Part-I)
nn) IS-8500: Structural steel - micro alloyed (medium and high strength qualities).
oo) IS-9595: Recommendation for metal arc welding of carbon and carbon manganese steels.
pp) AWS D.1.1 Structural Welding Code.
qq) IS-8640: Recommendations for dimensional parameters for industrial building.
rr) IS-9178: Criteria for design of steel bins for storage of bulk material (all parts).
ss) IS-12843: Tolerances for erection of steel structures.
tt) IS-1181: Qualifying tests for Metal Arc welders (engaged in welding structures other than pipes).
uu) IS-2595: Code of practice for Radiographic testing
vv) IS-2629: Hot dip galvanising of iron and steel
ww) IS-3502: Steel chequered plate.
xx) IS-3658: Code of practice for liquid penetrant flaw detection.
yy) IS-4353: Sub merged arc welding of mild steel and low alloy steel Recommendation.
zz) IS-5369: General requirements for plain washers and lock washer.
aaa) IS-6623: High strength structural nuts.
bbb) IS-6649: Hardened and tampered washers for high strength structural bolts & nuts.
ccc) IS-6911: Stainless steel plate, sheet and strip.
ddd) IS-7205: Safety code for erection of structural steel.
eee) IS-7307: Approved test for welding procedures
(Part I) Fusion welding of Steel
fff) IS-7310: Approval test for welders working to approval welding procedure.
(Part I) Fusion welding of Steel
ggg) SP-6: IS Handbook for structural engineers.

2.13. Painting

- a) IS-348: Specification for French Polish.
b) IS-427: Specification for Distemper, dry colour as required.
c) IS-428: Specification for Distemper, oil emulsion, colour as required.
d) IS-1477: Code of practice for painting of ferrous metal in buildings.
(Part I & II)
e) IS-2338: Code of practice for finishing of wood and wood based materials.
(Part I & II)
f) IS-2339: Specification for Aluminium Paints for general purposes in dual containers.
g) IS-2395: Code of practice for painting concrete, masonry and plaster surface.
h) IS-2932: Specification for enamel, synthetic, exterior - a) undercoating, b) finishing.
i) IS-2933: Specification for enamel, exterior - a) undercoating, b) finishing.
j) IS-5410: Specification for cement paint.
k) IS-162: Ready mixed paint, brushing fire resisting, silicate type for use on wood, colour as



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required.

- l) IS-1650: Specification for colours for building and decorative materials.
- m) IS-2395: Code of practice for painting concrete, masonry and plaster surfaces.
(Part I) Operations and Workmanship.
(Part II) Schedule.
- n) IS-2524: Code of practice for painting of nonferrous metals in buildings.
(Part I) Pre-treatment.
(Part II) Painting.
- o) IS-15489: Plastic emulsion paint.
- p) IS-6278: Code of practice for white washing and Colour washing.
- q) IS-10403: Glossary of term related to building finish.
- r) IS-12027: Silicone based water repellent.
- s) IS-13238: Epoxy based zinc phosphate primer (2 pack).
- t) IS-13239: Epoxy surface (2 pack).
- u) IS-13467: Chlorinated rubber for paints
- v) IS-14209: Epoxy enamel, two component glossy.
- w) BS-5493: Code of practice for protective coating of iron and steel structures against corrosion.

2.15. Plastering

- a) IS-1661: Code of practice for application of cement and cement lime plaster finishes.
- b) IS-2402: Code of practice for external rendered finishes.
- c) IS-2547: Gypsum building plaster.

2.17. Safety

- a) IS-1641: Code of practice for fire safety of buildings - General principles of fire grading and classification.
- b) IS-1642: Code of practice for fire safety of buildings - Details of construction.
- c) IS-3696: Safety code for scaffolds and ladders.
(Part I & II)
- d) IS-4081: Safety code for blasting and related drilling operations.
- e) IS-4130: Demolition of buildings - code of safety.
- f) IS-5121: Safety code for piling and other deep foundations.
- g) IS-5916: Safety code for construction involving use of hot bituminous materials.
- h) IS-7205: Safety code for erection of structural steel work.
- i) IS-7969: Safety code for handling and storage of building materials.

2.18. NDT

- a) IS : 13311 (Part 2) : Non-destructive Testing of Concrete –Methods of Test, Part 2 Rebound Hammer, BIS, New Delhi.
- b) IS: 13311 (Part 1) : Non-destructive Testing of Concrete – Methods of Test , Part 1 Ultrasonic Pulse Velocity, BIS, New Delhi.
- c) ASTM C876-15 STM for Half-cell Potentials of Uncoated Reinforcing Steel in Concrete
- d) BS EN 14630, Products and systems for the protection and repair of concrete structures. Test methods. Determination of carbonation depth in hardened concrete by the phenolphthalein method.
- e) ASTM C900-94 STM for Pullout Strength of Hardened Concrete
- f) AS 1012.20- Method of Testing Concrete - Determination of chloride and sulfate in hardened concrete and concrete aggregates
- g) BS 4408: pt. 1, “Non-destructive methods of test for concrete-electromagnetic cover measuring devices”, British Standards Institution, London
- h) BS 1881: Part 204: Recommendations on the Use of Electromagnetic Covermeters
- i) BS 1881: Part 201: Guide to the Use of Non-Destructive Methods of Test for Hardened Concrete
- j) BS 1881: Part 124: Methods for analysis of hardened concrete
- k) IS 456:2000 Plain and Reinforced concrete code of Practice
- l) IS 516:1959 Methods of tests for strength of concrete



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3. GENERAL

All the quality standards, tolerances, welding standards and other technical requirements shall be strictly adhered to. The Bidder shall fully apprise himself of the prevailing conditions at the proposed site, climatic conditions including monsoon pattern, soil conditions, local conditions and site specific parameters and shall include for all such conditions and contingent measures in the bid, including those which may not have been specifically brought out in the specifications. In case of any conflict between stipulations in various portions of the specification, most stringent stipulation would be applicable for implementation by the Bidder without any extra cost to the Employer.

4. LAYOUT

Before starting the work, the Contractor shall carry out the setting out of foundation and structures and provide levels, with reference to general existing grid and bench mark. **If the Contractor uses the grid, bench mark and reference pillar made by other Contractors, he shall coordinate with the Contractor and shall satisfy himself of the accuracy of the reference marks.** If he is required to set out the foundation afresh, he shall do so independently with reference to the one existing grid and bench mark which has been followed by other agency at the instruction of the Engineer. In case any discrepancy is found, it shall be immediately brought to the notice of the Engineer for any rectification/modification necessary. No complaint shall be entertained at a later stage. The Contractor shall accurately set out the position for holding down bolts and inserts.

If required, in the opinion of the Engineer, he shall construct and maintain pillars for grid, references and bench marks and maintain them till the completion of the construction. He shall also help the Engineer with instruments, materials and labours for checking the detailed layouts and levels. The Contractor shall be solely responsible for the correctness of the layout and levels, and Engineer's approval shall not be deemed to imply any warranty in carrying out the works correctly. The Tenderer's shall take into account the cost of these in quoting their price.

5. WORKMANSHIP

Workmanship shall be of the best possible quality and all work shall be carried out by skilled workmen except for those which normally require unskilled persons. Welding shall be done by experienced and certified welders in proper sequence using necessary jigs and fixtures. Fabrication shall be done in shops having proper equipment for accurate edge and shaping and dimensioning of anchor bolt assembly, inserts and other misc. items. In addition to the requirement specified above, if the bye laws of the local Govt., Municipal or other authorities require the employment of licensed or registered workmen for various trades, the Contractor shall arrange to have the work done by such registered or licensed personnel. In case of manufactured materials, the Contractor shall have, with no additional cost to the Owner, the services of the supervisors of the manufacturers to ensure that the work is being done according to the manufacturer's specifications.

6. TEMPORARY WORK

All scaffoldings, staging, temporary bracing and other necessary temporary work required for proper execution of the Contract shall be provided by the Contractor at his own cost and inclusive of all materials, labour, supervision and other facilities.

The layout and details of such Temporary work shall have the prior approval of the Engineer, but the Contractor shall be responsible for proper strength and safety of the same. All Temporary work shall be so constructed as not to interfere with any permanent work or with the work by other agencies. If it is necessary to remove any of the temporary work at any time to facilitate execution of the work or with the work of other agencies, such removal and re erection, if required, shall be carried out by the Contractor at the direction of the Engineer without any delay and any extra cost on this account shall be borne by the Contractor.

7. SEQUENCE OF WORK AND PROGRESS REPORT

The sequence in which the works are to be carried out shall be as approved by the Engineer in accordance with the construction method accepted by the Engineer and to be followed by the Contractor. A programme of work is to be submitted for the Engineer's review and approval and this has to be periodically updated and modified as per actual progress to enable timely completion.

The Contractor shall regularly submit to the Engineer progress reports for periods of working as specified by the Engineer showing up to date progress on all important items of work.



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8. CONSTRUCTION METHODOLOGY

Construction and erection activities shall be fully mechanized from the start of the work. All excavation and backfilling work shall be done using excavators, loaders, dumpers, dozers, porcelains, excavator mounted rock breakers, rollers, sprinklers, water tankers, etc. Manual excavation can be done with specific approval of engineer.

Dewatering shall be done using the combination of electrical and standby diesel pumps.

For concreting, weigh batching plants, transit mixers, concrete pumps, hoists, etc. shall be used.

All handling of materials shall be with cranes.

Heavy trailers shall be used for transportation.

Mechanized modular units of scaffolding and shuttering shall be used.

Grouting shall be carried out using hydraulically controlled grouting equipment.

All finishing items shall be installed using appropriate modern mechanical tools. Manual punching etc. shall not be permitted.

Heavy duty hoists for lifting of construction materials shall be deployed.

Compressors for cleaning of foundations and other surfaces shall be used.

Field laboratory shall be provided with all modern equipment for survey, testing of soil, aggregates, concrete, welding, etc.

All persons working at site shall be provided with necessary safety equipment and all safety aspects shall be duly considered for each construction/ erection activity. Moreover, only the persons who are trained in the respective trade shall be employed for executing that particular work.

9. MODIFICATION WORKS

The bidder shall visit site to assess the actual condition of foundation/structure and undertake investigation of field problems by critical visual examination and furnish assessment report and details of required field non-destructive tests. The bidder shall submit photographic records of observation of field problems mentioning area/structure details.

The bidder shall prepare scheme for dismantling works, if required, for modification in foundation/structure.

The bidder shall collect all the information/dimension, take all measurement, if any, required for carrying out modification/strengthening/refurbishment of foundation/structure.



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PART-II

SPECIFIC TECHNICAL REQUIREMENT

KERALA STATE ELECTRICITY BOARD LTD.

(Incorporated under the Indian Companies Act,1956)

RMU WORKS OF KUTTIYADI (3x25 MW) HYDRO ELECTRIC PROJECT

e-TENDER No.: CEPED/07/2018-19

VOLUME – 3

TECHNICAL SPECIFICATIONS (E&M WORKS)

Office of the Chief Engineer(Generation & PED)
Projects – Electrical Designs, #201,
Vydyuthi Bhavanam, Pattom P.O.
Thiruvananthapuram,
Pin – 695 004
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Phone: +91 471 2555030
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ceprojects@ksebnet.com

Sd/-
SIJI JOSE
CHIEF ENGINEER
(Generation & PED)

KERALA STATE ELECTRICITY BOARD LTD.

(Incorporated under the Indian Companies Act, 1956)

VOLUME – 3

TECHNICAL SPECIFICATIONS (E&M WORKS)

CERTIFICATE

Certified that this 'Technical Specifications' Bid Document for the Execution of
Electromechanical works for Kuttiyadi 3 × 25 MW HEP RMU Works contains serially
numbered pages from 1 to 622

Office of the Chief Engineer (Generation & PED),
Projects – Electrical Designs, #201,
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Sd/-
SIJI JOSE
CHIEF ENGINEER
(Generation & PED)

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1 PART-1 TECHNICAL REQUIREMENTS

1.1 General Requirements

1.1.1 Introduction

This section covers technical requirements supplement to all the technical specifications and requirements brought out in the accompanying sections on technical specification. The scope of this specification includes the ~~Mechanical, Electrical, Control, Protection, Instrumentation and Automation system etc...~~ for the plants supplied to complete in all respect for the safe and reliable operation of the units including the auxiliary system. The specification also covers complete planning, ~~design, detailed engineering, fabrication and inspection of equipment and components at manufacturer's works, supply, installation of supplied equipment / items at site, after dismantling the existing equipment / systems completely except those specified for retaining, all works needed to install the equipment / components supplied, site testing, providing necessary assistance for site testing, commissioning of equipment / components supplied, confirmation of reliability and warranty of the complete plants supplied for the tendered project.~~

It is not intended here to describe the design, arrangement or installation, or to specify each and every component required for the completeness of the plants or to select each material for safe and reliable operation of the proposed plants / equipment. In general the plant shall be complete in all respect with its equipment and accessories, in conformity with the existing civil works and the retained embedded parts of turbine header / spiral casing, as required to make a complete, highly reliable and maintainable installation, conforming to highest standards of engineering design, safety and workmanship.

Every component required for the completeness of the plants / equipment and suitable material required for safe and reliable operation of the proposed plants / equipment is deemed to be included.

The station layout is furnished in Volume-5. The final equipment arrangement shall be that proposed by the Contractor and approved by the KSEBL.

The Contractor shall strictly observe these General Technical Requirements in conjunction with the project related specification **2 "Specific Requirements for the Project"**. The contractor shall strictly observe those specifications / details specified in the above Specification for detailed engineering / design. If the Project Specific Specification has any contradiction with this Specification, the former shall prevail. If the contractor is having any

doubts, he shall contact the KSEBL before quoting for the same.

1.1.2 General

This section of the specifications covers the **general specifications** for planning, design, manufacture, testing at works, supply, erection and commissioning of the ~~mechanical systems, instrumentation and control systems, electrical systems~~, civil engineering works related to the equipment / plant supplied and other general requirements. These specifications stipulates the basic general guidelines to the Tenderer / Contractor for the design, manufacture, supply, standard and quality of workmanship, general finish of plant, compliance to the latest published edition (prior to the date of closing of tender) of the international standards and recommendations specified throughout the specifications.

The provisions of specific and detailed technical requirements given in other parts of these specifications shall take precedence over these general specifications in case of contradiction between these general specifications and other parts of these specifications. In case of any specific doubts or issues, clarifications shall be obtained from the KSEBL before proceeding.

The intent of specification is to provide services according to the most modern and proven techniques and codes. The omission of specific reference to any method, equipment or material necessary for proper and efficient execution of this work shall not relieve the contractor of the responsibility of providing such facilities to complete the work without any extra compensation.

1.1.3 Scope of Work

1.1.3.1

The work under these specifications broadly covers the complete ~~design, detailed engineering, equipment and components fabrication and testing at manufacturer's works, supply, transportation, storage, complete work of handling at storage yard / stores, transportation to work site, calibration, pre-assembly, erection of supplied equipment / items at site, assistance for all civil works to install the equipment / components supplied, site testing, pre-commissioning, commissioning, provision of necessary assistance for erection, operational testing, trial operation of equipment / components supplied as required, reliability and warranty confirmation of complete supplied plants~~ for the tendered project and handing over of various systems as listed under:

- Main Inlet Valves and their auxiliaries / controls

- Turbine and its auxiliaries / controls
- Generator, Neutral Grounding Cubicles, LAVT Panels etc...
- Unit Auxiliary Transformer, Excitation transformer etc...
- Governor Systems
- Segregated Phase Bus Ducts / MV cable systems
- LV Systems, DC battery system, Emergency Power systems, UPS Switch boards etc...
- Excitation equipment (Static / Brush-less etc...)
- Auto Sequencer (for units, feeders etc...), Synchronising equipment
- Protection and Control equipment for Generator, Transformers, Switch-yard equipment etc...
- Automation and HMI systems, Annunciation systems
- Cable Tray work, cabling system for Powerhouse and Switch-yard (including Power, Control, Signalling, Instrumentation, SCADA, Communication & PA system, Fire Protection, Air-conditioning and Ventilation etc...) complete with cable terminations, cable glands and lugs etc...
- Medium and Low voltage switchgear panels
- Fire detection and Protection systems for Generator, Generator Transformer, Power house, Switch-yard etc...
- Above Ground Earthing system
- Local control panel for auxiliaries
- Control & Relay panels
- HT / LT Motors
- Cooling water systems
- Dewatering and Drainage Systems
- Air-Conditioning and Ventilation systems
- Lightning Protection systems
- General Power and Lighting systems for Power house, Switch-yard etc...

~~The bidder should ensure supply of machines to suit the existing layout of Powerhouse building. Being a renovation project, the bidders are advised to carry-out a site inspection to ascertain the suitability of their proposed equipment with the pre-existing / retained systems in place.~~

1.1.3.2

All the E & M components shall be procured only from reputed manufacturers / company approved by the KSEBL. For this the equipment shall be sourced only from a Vendor / Manufacturers list submitted by the Contractor and approved by the Engineer-in-Charge or his representative prior to the start of procurement actions. The Vendor list should clearly mention the equipment details and complete address of the Vendor / manufacturer etc... Complete credentials including brochures / catalogue etc... of the Vendor / Manufacturer and details of performance of their product / equipment etc... shall be also submitted for the approval process.

1.1.3.3

The work to be carried out at site under the scope of this specification covers the complete work of loading, handling, transporting, unloading, pre-assembly, erection, calibration, testing, air flushing, pre-commissioning / commissioning / Acceptance tests, commissioning of systems, trial run of various auxiliaries and equipment as per the approved schedule, achieving various milestones till handing over of the unit to the KSEBL. The work shall conform to the various drawings submitted by the Contractor and approved and issued for construction by the KSEBL. If any portion of the work is found to be defective in workmanship or not conforming to drawings or other specifications, the contractor shall dismantle and redo the work duly replacing the defective materials at his cost, failing which the work will be got done by engaging other agencies or departmentally and recoveries will be effected from contractor's bills towards expenditure incurred including departmental charges.

1.1.3.4

The work shall be executed under the usual conditions without affecting power plant operation and in conjunction with numerous other operations at site. The contractor and his personnel shall cooperate with personnel of the KSEBL and other contractors including civil, coordinating his work with others and proceed in a manner that shall not delay or hinder the progress of work of the project as a whole.

1.1.3.5

The work covered under this specification is of highly sophisticated nature, requiring the best quality workmanship, supervision, engineering and construction management. The contractor should ensure proper planning and successful & timely completion of the work to meet the overall project schedule. The Successful bidder shall submit a Work schedule with

micro level details for approval prior to start of the work as specified in Clause 5.3.5 of Vol. 2 - Conditions of Bid and Contract. The contractor must deploy adequate quantity of tools & plants, modern / latest construction and project management aids, testing and commissioning equipment etc... He must also deploy and make available adequate trained, qualified, competent and experienced supervisory staff and skilled personnel during the period of the Contract and for the training of the operating staff during commissioning and providing assistance and required guidance during trial operations of the Plant.

1.1.3.6

All transport equipment, handling equipment, tools, tackles, fixtures, equipment, materials, manpower, supervisors / engineers, testing equipment, consumables for erection testing and commissioning etc..., except otherwise specified as KSEBL's scope of free issue, required for this scope of work shall be provided by the contractor. All expenditure including taxes and incidentals in this connection will have to be borne by him unless otherwise specified in the relevant clauses. The contractor's quoted rates should be inclusive of all such contingencies.

1.1.3.7

All works such as cleaning, levelling, aligning, trial assembly, dismantling of certain equipment / components for checking and cleaning, surface preparation, fabrication of sheets, tubes and pipes as per general engineering practice and as per KSEBL representative's instructions at site, cutting, gouging, weld depositing, grinding, straightening, chamfering, filing, chipping, drilling, reaming, scrapping, lapping, fitting up etc..., as may be applicable in such erection works and which are treated incidental to the erection works and necessary to complete the work satisfactorily, shall be carried out by the contractor as part of the work within the quoted rates.

1.1.3.8

The contractor shall plan and transport equipment, components from storage to erection site and erect them in such a manner and sequence that material accumulation at site does not lead to congestion at site of work. Materials shall be stacked neatly, preserved and stored in the contractor's shed and at work areas in an orderly manner. In case it is necessary to shift and re-stack the materials kept at work areas / site to enable other agencies to carry out their work or for any other reason, contractor shall do it most expeditiously. No claim for extra payment for such work will be entertained.

1.1.3.9

The Scope of work & description of system / equipment, testing requirements, spares etc... as given in the various clauses of this tender specification and schedules are only for understanding the system requirement, contractor shall note this point and assess the volume of work and the sizing of various equipment along with the required ratings for generating and transmitting the specified power at specified voltage level from the generator terminals, prior to submitting the offer. No compensation shall be considered later on for any omissions in this regard while quoting.

1.1.3.10

Any ratings, if mentioned, are indicative only and are a minimum for giving a base line. The Bidder should ensure that the ratings of the various equipment are sufficient to take care of the design requirements of the equipment offered for the concerned project. Any increase in rating during detailed engineering stage will not entitle the Successful Bidder / Contractor for any extra charges. The Contractor should submit for approval the calculations for arriving at the ratings of the various equipment.

1.1.3.11

The contractor shall have total responsibility for all equipment and materials in his custody at contractor's stores, loose, semi-assembled, assembled or erected by him at site. He shall effectively protect the finished works from action of weather and from damages or defacement and shall also cover the finished parts immediately on completion of work as per KSEBL's representative's instructions. The machine surfaces / finished surfaces should be greased and covered.

1.1.3.12

The contractor shall make suitable security arrangements and ensure protection of all materials / equipment in their custody and installed equipment from theft / fire / pilferage and any other damages and losses.

1.1.3.13

The contractor shall ensure that all the packing materials and protection devices used for the various equipment during transit and storage are removed before these equipment are erected in position.

1.1.3.14

The Control and Relay / Automation panels, Starter panels, Switchgear panels etc... shall

be transported from stores to the place of installation in vertical position. Care shall be taken such that the switches, lamps, instruments etc... mounted on the panel do not get damaged during transit. Panel and instruments once erected in position should be properly protected using necessary care to prevent ingress of dust / moisture. This will have to be periodically cleaned and surroundings have to be kept tidy. All unused openings / cable entry etc... shall be sealed properly to avoid entry of vermin etc...

1.1.3.15

Contractor shall prepare Marked-Up drawings incorporating modifications and deviations from original drawings or prepare fresh sketch for actual installation / connection details if needed, which can be converted to "As-Built" drawings for submitting after commissioning of the Work.

1.1.3.16

The contractor shall perform any services, tests etc... which may not be specified herein but are essential for the completion of work within quoted rates as per the direction of Engineer-in-Charge.

1.1.4 Specifications and Drawings

1.1.4.1

The Work shall be carried out in accordance with the latest Standards and codes, with the Technical Specifications and with the Drawings and Schedules appended hereto (Volume - 5 of the document) and additional Specifications and Drawings issued from time to time by the KSEBL.

1.1.4.2

In case of conflict between a general and more detailed requirement of the Specifications, the most stringent of these shall govern.

1.1.4.3

The drawings supplied by the KSEBL shall not be considered as defining the design of the Work but only as a simple indication of its general layout. All information provided in the drawings shall be checked at Site by the Contractor. **The bidders are advised to acquaint themselves with the site conditions, before bidding. No compensation whatsoever, on account of lack of familiarization with these, subsequent to bidding, will be**

entertained. The bidders have to design the equipment so that it can be accommodated in the space defined by the existing structure of the Powerhouse and on the foundation for the renovated unit. The size and weight of each component should be designed such that these are manoeuvrable by the existing crane through the space available.

1.1.5 Climatic Conditions

All equipment shall be suitable for indoor / outdoor installation under the following climatic conditions:

- Maximum ambient temperature :: 45°C
- Minimum ambient temperature :: 10°C
- Maximum relative humidity :: 100%
- Altitude :: < 1000 m
- Wind Speed :: 39 m/s (Zone 2)

The minimum ambient temperature may occasionally go below 10°C during the winter season.

1.1.6 Available Power Supply During Erection

Available electrical supply will be 3-phase, 4-wire, 50 Hz, 415V (Ph-Ph) and 240V (Ph-N). The KSEBL will not be responsible for interruption of power during execution of the Work. If necessary the Contractor has to arrange his own diesel generator set for availing power supply during interruption.

1.1.7 Civil Works

1.1.7.1

All civil works, required for this Contract shall be carried out by the Contractor.

1.1.7.2

The contractor shall verify the suitability of the foundation for the equipment to be erected and necessary tests may be done for the same.

1.1.7.3

Detailed schedules for Drawing submission, Supply and Construction shall be submitted for approval immediately on receiving the Letter of Acceptance. A Project schedule indicating

micro-level details and milestones shall be submitted prior to start of work as specified in Clause 5.3.5 of Vol.2 - Conditions of Bid and Contract.

1.1.7.4

For Work / equipment / items supplied under this Contract, all necessary embedded parts, steel structures, support / base frames, fasteners and anchor bolts etc... shall be supplied by the Contractor.

1.1.8 Temporary Provisions

Prior to the commencement of the works, it may be necessary to make provisions for the safety and storage of materials and works, for access control of the work site, etc... and to prevent dust spread, to the extent possible, to the existing plants at site. The Contractor shall install such temporary provisions after prior written approvals.

It is the responsibility of the Contractor to provide, erect, put into service and subsequently remove from site, such equipment as is deemed necessary, to facilitate these requirements. Contractor shall provide all material required for the temporary facilities.

All interfacing and integrating activities with existing systems, if required, shall be carried out only after obtaining the "Permit to Work" from the concerned authorities.

1.1.9 Units, Standards and Codes

1.1.9.1

Metric units according to the latest edition of the relevant International Standards Organization (ISO) publications shall be used for this Contract.

1.1.9.2

Unless another standard is specifically mentioned in these Specifications, all materials and Work used and provided under the Contract shall be designed, manufactured, constructed, installed and tested and all design calculations and tests shall be done in accordance with the latest edition, prior to the date of closing tenders, of the appropriate standards and codes published by the following issuing authorities wherever applicable as listed alphabetically:

Abbreviation	Designation
ACI	American Concrete Institute
AGMA	American Gear Manufacturer's Association

AISC	American Institute of Steel Construction
AISE	Association of Iron and Steel Engineers
AISI	American Iron and Steel Institute
ANSI	American National Standards Institute
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
ASME	American Society of Mechanical Engineers
AWS	American Welding Society
AWWA	American Water Works Association
BSI	British Standards Institute
CSA	Canadian Standards Association
IEC	International Electro-technical Commission
IEEE	Institute of Electrical and Electronics Engineers
IPCEA	Insulated Power Cable Engineers Association
ISA	Instrument Society of America
ISI	Indian Standards Institute
NEC	National Electrical Code of USA
NEMA	National Electrical Manufacturers Association (USA)
NESC	National Electrical Safety Code of USA
NFPA	National Fire Protection Association
SAE	Society of Automotive Engineers
SSPC	Steel Structure Painting Council
TEMA	Tubular Exchangers Manufacturers Association
UL	Underwriters Laboratories Inc. (USA)

1.1.9.3

The codes and / or standards referred to in these specifications shall govern in all the cases wherever such references are made. In case of conflict between such codes / standards and the specifications, the latter shall govern. Such codes / standards referred to shall mean the latest revisions / versions, amendments / changes adopted and published by the relevant agencies. In case of any further conflict in this matter, the same shall be referred to the KSEBL, whose decision, given in writing, shall be binding.

1.1.9.4

Other internationally acceptable standards, which ensure equal or higher performance than those specified, shall also be accepted subject to the prior approval of the KSEBL. Where required for purposes of approval, the Contractor shall supply necessary information to the KSEBL, in support of his claim that the Standard to which he proposes to work will ensure an acceptable quality in all respects in comparison with the specified Standards. The supply of such information shall include the free issue to the KSEBL, authenticated copies of the proposed Standards other than the international Standard, with English translation

for the purpose of this clause.

1.1.10 Compliance with Specification

1.1.10.1

Notwithstanding any description, drawings or illustrations which may have been submitted with the Tender, all details other than those shown on the Schedule of Deviations shall be deemed to be in accordance with the specification and the standard specifications and codes referred to therein.

1.1.10.2

No departures from the specification shall be made, whether minor or major, except those listed and shown in the Schedule of Deviations and approved by the KSEBL.

1.1.10.3

While complying with specification requirements, the Contractor shall endeavour to obtain with his supervisors / sub-Contractors a uniformity of supply for items such as electrical equipment, motors, relays, pumps, valves, instrumentation and control equipment.

1.1.10.4

A reduction in the number of makes / manufacturers for such equipment will be preferred that will facilitate the training of the maintenance staff of the KSEBL and reduce the number of spare parts. Contractor should make an earnest effort in this direction while executing the Work.

1.1.11 Quality Assurance

1.1.11.1

To ensure that the equipment and services under the scope of this Contract whether manufactured or performed within the Contractor's works or at his sub-contractor's premises or at the KSEBL's site or at any other place of work, are in accordance with the specifications, the Contractor shall adopt suitable quality assurance program to control such activities at all points necessary. Such a program shall be outlined by the Contractor and shall be got accepted by the KSEBL.

1.1.11.2

The quality assurance program of the Contractor shall generally cover the following:

- His organisation structure for the management and implementation of the proposed quality assurance program,
- Documentation control system,
- The procedure of purchase of materials, parts, components and selection of sub-contractor's services including vendor analysis, source inspection, incoming raw material inspection / verification of materials purchased, etc...,
- System for shop manufacturing and site erection controls including process controls and fabrication and assembly controls,
- Control of non-conforming items and system for objective actions,
- Inspection and test procedure both for manufacture and field activities,
- Control of calibration and testing of measuring and testing equipment,
- System for indication and appraisal of inspection status,
- System for quality audits,
- System for handling storage and delivery,
- System for maintenance of records.

1.1.11.3

For the components / equipment produced by the Contractor for the purpose of this contract, his purchase specifications and enquiry shall call for such quality plans along with their proposals. The KSEBL also reserves its right to carry-out quality audit and quality surveillance of the system and procedures of Contractor's / his vendor's quality management and control activities.

1.1.11.4

The Contractor shall furnish the field quality manuals for the various field activities detailing the procedures and inspection check-lists for transportation, storage / preservation,

erection, pre-commissioning and commissioning activities. The field quality manuals shall indicate the various assembly / erection / operation tolerances and the limits of deviations for each individual equipment and system.

1.1.12 Design & Construction Standardization

1.1.12.1

In complying with the requirements of the specifications, both with respect to arrangement and detail, the design shall conform to the best of the current engineering practice. Each of the several parts of the plant shall be of the manufacturers' standard design, provided that this design is in general accordance with the specification and proven to be satisfactory in its past operational experience.

1.1.12.2

All equipment coming under the scope of work shall be sourced only from reputed and qualified national / inter-national manufactures for which a Vendor approval procedure shall be followed as specified in Clause 1.1.3.2 above.

1.1.12.3

The essence of design shall be operational simplicity, safety and reliability in order to give long continuous service with acceptable economy and low maintenance costs. Particular attention shall be given to internal and external access, in order to facilitate inspection, cleaning and maintenance.

1.1.12.4

The design, dimensions and materials of all parts shall be such that they will not suffer damage as a result of stresses under the most severe service conditions. Fully detailed specifications of the several parts of the plant shall be submitted describing particularly the materials being used. The materials used in the construction of the plant are to be of the highest quality and selected particularly to meet the duties required of them. The design and construction shall ensure adequate drainage to prevent accumulation of water on equipment or on its enclosures. Where unavoidable, means shall be provided to minimize rust or corrosion.

1.1.12.5

Workmanship and general finish shall be of the highest quality and standard throughout its

engineering. All similar components or parts of similar standards of the Plant shall be interchangeable as far as possible. Parts of Plant including spare parts, which are intended to be inter-changeable, shall be manufactured to ensure that replacements will fit accurately in place without additional machining. Any item of a Plant, which may have to be replaced, shall be interchangeable with any item of the same type. The plants shall be constructed to allow complete inter-changeability of a maximum of parts with similarly placed parts of the other plants.

1.1.12.6

All equipment shall operate without undue vibration and with the least possible amount of noise and is not to cause an irritation. The noise level shall conform to the requirement specified in the relevant Standards. Special attention has to be paid to environmental impacts, mainly regarding visual aspect, noise level and water and air pollution.

1.1.12.7

Risk of accident shall be kept to the minimum, by adequate design. Risk of fire shall be reduced to the minimum by a relevant choice of materials and general arrangements. All materials and compounds used in the plant design and construction shall be free from health hazards.

1.1.12.8

The equipment shall also be designed to prevent ingress of all vermin, accidental contact with live parts and to minimize the ingress of dust and dirt. The use of materials, which may be liable to attack by termites or other insect, shall be avoided.

1.1.12.9

All materials used shall be of the best quality and of the class most suitable for working under the conditions specified and shall withstand the variations of temperature and atmospheric conditions arising under working conditions without undue distortion or deterioration or the setting up of undue stress in any part, and also without affecting the strength and suitability of the various parts for the work which they have to perform.

1.1.12.10

Cast iron shall not be used for chambers of oil filled apparatus or for any part of the equipment, which is in tension or subject to impact stresses. This clause is not intended to prohibit the use of suitable grades of cast iron for parts where service experience has shown it to be satisfactory.

1.1.12.11

All outdoor apparatus, including bushing insulators with their mountings, shall be designed so as to avoid pockets in which water can collect.

1.1.12.12

Means shall be provided for the easy lubrication of all bearings and, where necessary, of any mechanism of moving parts, which are not oil immersed. All mechanism shall, where necessary, be constructed of stainless steel, brass or gunmetal to prevent sticking due to rust or corrosion.

1.1.13 Drawings and Design Data

Preparation of all designs, finalisation of ratings and drawings in respect of the scope of work shall be the entire responsibility of the contractor.

1.1.13.1 *Information to be Submitted on Receipt of Order***1.1.13.1.1**

Immediately on receipt of Work order the Successful Bidder / Contractor shall submit detailed schedules for Drawing submission, Supply and Erection, Testing and Commissioning etc... for approval. A Project schedule indicating micro-level details and milestones shall be submitted prior to start of work as detailed in Clause 5.3.5 of Vol.2- Conditions of Bid and Contract.

The Contractor shall prepare all necessary detailed drawings, designs, logic diagrams, write-ups etc... giving full and complete information to enable the KSEBL to properly consider the design of the works. The design of the equipment should be in such a way that they should be accommodated in the existing space.

Drawings and design data shall be submitted without delay in the order in which they are required for finalization of Civil Design, ordering of material and / or installation at site.

All drawings and documentation shall be submitted to the KSEBL as outlined in the various sections contained in the Technical Specification.

The Contractor shall submit for approval the list of drawings and drawing schedule, indicating:

- **Each kind of drawing per job site, and the estimated first submission date**
- **Enough number of columns indicating approval stages and dates.**

The list of drawing shall be updated whenever necessary until completion of the works.

Where required, the Contractor shall submit copies of his drawing lists, having incorporated the updated drawing schedule as mentioned above. These lists shall clearly indicate the actual status of every drawing, i.e. **“For Information only”, “For Approval”, “Resubmitted for Approval”, “Approved or As-Built”**.

1.1.13.1.2

All drawings submitted by the Contractor shall be in sufficient detail to indicate the type, size, arrangement, weight of each component, breakdown for packing and shipment, external connections, fixing arrangements required, dimensions required for installation and interconnections with other equipment, clearances and spaces required between various portions of equipment and any other information specifically requested in the drawing schedules.

1.1.13.1.3

All manufacturing and fabrication work in connection with the equipment prior to the approval of the drawing shall be at the Contractor's risk. The Contractor may make any changes in the design, which are necessary to make the equipment conform to the provisions and intent of the contract and such changes will again be subject to approval by the KSEBL. **Approval of the Contractor's drawings or work by the KSEBL shall not relieve the Contractor of any of his responsibilities and liabilities under the Contract.**

1.1.13.1.4

The Contractor shall design the various components of the Plant and submit to the KSEBL for approval, drawings and other technical data and instructions required for manufacturing, shop assembly and testing, site erection and testing, operation and maintenance of the Work.

1.1.13.2 *Drawings & Design data during Engineering*

1.1.13.2.1

The Contractor shall submit drawings and documentation to the KSEBL as outlined in the Vendor Data Requirements Form contained in the Technical Specification. The drawings and data to be provided by the Contractor shall be in English with the units used in Metric /

SI system in ISO standard sheet sizes shall include but shall not be limited to:

1. Quality Assurance Plan	Full details of the quality assurance plan and outline of quality assurance procedures to be employed. Proof of certification with an approved national or international quality assurance standards organization.
2. Model Test Reports of Turbine	Including efficiency over whole operating range and runaway speed.
3. Detailed Inspection and Test Plan	A comprehensive schedule of inspection and testing (factory and site) for all major parts of the Work. This should include inspection and survey of the portions of the generating station pertaining to Work at the earliest practicable stage.
4. Schedule of Drawings	Indicating the proposed submission dates for KSEBL's approval. The schedules shall be revised and re-issued every month until completion of all drawings.
5. Design Documents	Calculations required by the KSEBL to substantiate the Contractor's design: • Cable sizing (HV & LV) • CT & PT sizing • Unit Auxiliary Transformer & Station Service Transformer sizing • Busbar Sizing, NGT sizing, NGR sizing • HVAC design, Ventilation system design • Battery and Charger sizing, UPS sizing etc... • Fire fighting and emergency water tank sizing etc... • Sag-Tension calculations, Clearance drawings • Appropriate calculations for determining the main sizes, stress levels, dimensions and operational characteristics, safety factors, clearly indicating the principles on which the calculations were based • The calculations shall include the formulae, standards, test results, basic assumptions, etc...
6. Single Line Diagrams	• Each electrical works and their circuits shall be represented by a single line diagram. It shall contain all required technical information of the Works

represented, e.g. voltage, current, capacity, short-circuit level, ratios, voltage variations, measuring transformer and protection relay indices, interlocking, kind of switch drive, code designation, etc... as applicable.

- Single-line diagrams of individual main components and switchboards shall additionally show the control, indicating, measuring, metering, protection, automatic, and other auxiliary electric devices separated for each individual installations item and location as applicable.
- Furthermore, the applied recommended setting of adjustable devices (protection and control elements, time relays, etc.) shall be indicated.

7. General Arrangement Drawings

Outline drawings to scale showing relation of major equipment components and accessories, principal dimensions, levels and weights sufficient for planning and coordination of the overall project. The General Arrangement Drawings shall show the physical arrangement of Works embedded and equipment and their layout in the Power House, switch-yard and appurtenances:

- General assembly drawings of the mechanical plants / equipment to be supplied together with sufficient sub-assembly drawings including piping layouts / isometrics, valve arrangements, etc...
- General assembly drawings of the electrical plants/equipment to be supplied together with sufficient sub-assembly drawings.
- General arrangement drawings, showing cable and grounding conductor routes with location of earth rods, test links and bonding connections to steelwork.
- General arrangement drawings of the emergency services such as location of fire extinguishers, emergency lighting, fire alarm panels, location of

detectors, fittings, etc...

8. Detailed Drawings	All details of equipment and materials required for fabrication and assembly. These drawings are to be cross-referenced to all other drawings. They shall include material of construction, coating / painting specifications for all equipment and materials etc...
9. Hydraulic Drawings and Diagrams	All data pertaining to hydraulic equipment including hydraulic schematic diagram and description of operation: • Schematic diagrams of turbine control and auxiliary systems like oil pressure unit, compressed air system, drainage / dewatering system, cooling water system, inlet valve etc... shall be supplied. These drawings shall show all instruments and control devices. • Standard abbreviations and component numbers shall be used as per relevant standards.
10. Electrical Drawings and Diagrams, Wiring Diagrams and Wiring Lists	All data pertaining to electrical equipment including rating & name plate details, Bill of materials (indicating make, type, rating etc... of electrical equipment), single line, schematic diagrams, logic diagrams, wiring connection and outline drawings and a description of operation: • Plant instrumentation and control layout and logic diagrams confirming to the requirements specified. • Electrical control, protection and instrumentation diagrams and logic schematic diagrams of the systems including panel layouts drawings, indication and alarm circuits and logic diagrams (including plant control and synchronising logic) and interlock circuits bearing nomenclature as specified. • Interlocking and control logics, Trip Matrix and trip logic etc... • General arrangement drawings showing the location of control gear, transformers and fuse boards, socket outlets, lighting points, controls and switches of indoor and outdoor lighting.

- Building services layout and detailed drawings, such as electrical lighting and power services layouts, AC and ventilation layouts, communication system layouts, computer local area network layouts (LAN), if any, other services layouts, etc...
 - Detailed interface drawings like inter-panel and inter equipment wiring / connection diagrams, cable schedules etc...
 - Block Diagrams
11. Erection Drawings All details and data in sequence as required for installation or erection of the work.
12. Foundation Drawings The contractor shall verify the suitability of the existing foundation and if found not satisfactory, all the required drawing for the modifications to be made in the existing foundation shall be provided.
13. Load Diagrams and Calculations Total static and dynamic loads, including short circuit forces, impact forces etc..., load centres and design calculations of major components.
14. Bill of Materials / Schedules A complete separate list giving details of make, type and rating of all materials, which the Contractor expects to provide:
- Cable Schedule and Inter-connection lists
 - Schedules for piping, valves, instruments, cables, alarms, controls etc..., in form as required by KSEBL.
 - The Alarm lists shall indicate all alarms and shall contain at least:
 - ✓ Description and priority level of alarm
 - ✓ Data of alarm detector (contact) referring to applicable circuit diagram.
 - ✓ Data of alarm annunciator (location and clear text labelling)
 - The piping and valve control list shall indicate all control actuators and control valves and shall contain at least:
 - ✓ Data of pipe and valve connections

	✓ Data of valve layout
	✓ Maximal required and rated power
15. Performance Data	To include graphs and all other pertinent information viz; Catalogues, performance curves, test certificates, data sheets of equipment etc...
16. Wearing Parts Drawings	Drawings of all component parts, which require replacement due to wear in normal operation. Drawings shall include notations as to Specification of materials for fabrication of replacement parts.
17. Motor List	A complete list of all electric motors supplied including all normal nameplate data.
18. Operation and Maintenance Manuals	Complete detailed instructions for operation, maintenance, future removal and replacement of equipment, including all components and accessories.
19. List of Spare Parts and Special Tools	Complete listing of special tools and replaceable spare parts with descriptions, catalogue numbers and illustrations.
20. Erection Procedures	Complete erection procedure / Method statement.
21. Inspection, Testing & Commissioning Procedures	Method Statement for Inspection, Testing and Commissioning complete with list of commissioning instrumentation and testing equipment.
22. As Built Drawings	All revisions, corrections and approvals, and any physical changes made during construction, assembly or erection, so that the drawing accurately represents that part or portion of the Work as it was actually completed and accepted by the KSEBL.
23. General	Any other Drawings / Documents as listed in the specification for each equipment.

1.1.13.2.2 Schematic Diagrams

Schematic diagrams of turbine control and auxiliary systems like oil pressure unit, compressed air system, drainage / dewatering system, cooling water system, inlet valve etc... shall be supplied. These drawings shall show all instruments and control devices. Standard abbreviations and component numbers shall be used as per relevant standards.

1.1.13.2.3 Single Line Diagrams

Each electrical Plant and their circuits shall be represented by a Single line diagram. It shall

contain all required technical information of the Plant represented, e.g. voltage, current, capacity, short-circuit level, ratios, voltage variations, measuring transformer and protection relay indices, interlocking, kind of switch drive, code designation, etc... as applicable. Single-line diagrams of individual main components and switchboards shall additionally show the control, indicating, measuring, metering, protection, automatic, and other auxiliary electric devices separated for each individual installations item and location as applicable: Furthermore, the applied recommended setting of adjustable devices (protection and control elements, time relays, etc...) shall be indicated.

1.1.13.2.4 Circuit Diagrams

The Circuit Diagrams shall show the power circuits in all phases with the main apparatus as well as the pilot circuits (measuring and control circuits). It shall show in full the functioning of part or all installations, Plant or circuits with all required technical information. A detailed Bill of Materials indicating the make, type no. and ratings of the devices / equipment used shall also be provided along with the schematic / circuit drawings.

Contact developments of the installed switches, contactors, relays and other apparatus which appear in the diagram shall be shown below the respective contactor coil, indicating by means of numbers and, if not on the same, also the page No., the circuit path (grid reference) in which the corresponding contact has been used.

Circuit diagrams shall also contain all terminals and their correct designations. Terminals shall be grouped together to terminal blocks of switchboards, distributors, etc...

The representation of electrical works and control circuits shall not be terminated at the limits of the scope of supply, but has to be extended beyond this limit by all switchgear, protective, measuring and monitoring equipment required for full comprehension of the whole circuit. All terminals and functions of Plant or Works to be supplied by others shall be taken over as well through proper cross-references.

1.1.13.2.5 Block Diagrams

The Block Diagrams shall be used to show in a simplified manner the main inter-relationships between the elements of a system by means of symbols, block symbols and pictures without necessarily showing all the connections. The symbols used for the individual kinds of components, e.g. servomotors, computing modules, etc..., shall clearly be explained on the diagram or on an attached legend.

1.1.13.2.6 Terminal Diagrams

Such diagrams shall be prepared for any type of terminal box, marshalling rack, control

cubicle, switchboard, etc..., and shall show the terminals (properly numbered) and the internal and/or external conductors (wires or cables) connected to them.

The terminal diagram of each individual switchboard, terminal box, panel, etc..., shall contain, but not be limited to the following information:

- Terminal number of terminal board with targets (terminal number and current path) of incoming and outgoing cables and wires.
- Cable designation.
- Type of cable.
- Number and cross-section of conductors.

1.1.13.2.7 Lists and Schedules

Following lists and schedules shall be supplied:

Cable Lists / Interconnection Lists

The Cable Lists shall include for each individual cable the following as a minimum:

- Cable number, in accordance with Identification System.
- Cable type .
- Rated voltage.
- Number material and size of conductors.
- Overall diameter.
- Cable termination at each end.
- Connection point at each end with cubicle/Works identification and terminal numbers.
- Cable routing.

In case interconnecting cubicles are used, the lists shall be prepared to show:

- Cable termination for incoming and out coming cables
- Interconnection wiring.

1.1.13.3 Final Drawing and Documentation

The Contractor shall submit final updated copies of above drawings and documentation to the KSEBL as outlined in the various sections contained in the Technical Specification. Drawings and documentation submitted to the KSEBL shall comprise one good quality sepia or polyester reproducible printed on the face side and clear prints with black lines on a white background. As-Built drawings and documents shall be provided in quintuplicate (five copies) for the use of KSEBL. Hard copy of the Drawings / documents shall be submitted **in an appropriate form, and in Hardbound volumes and/or with heavy-duty**

spiral binding, giving due importance to the document. Soft-copies of the Manuals / Documents submitted shall also be provided in a good quality CD / DVD.

Any software required for the configuration of various devices / equipment, supplied under the scope of work, shall also be provided in sufficient number of copies, free of cost, along with the required communication interfaces, connecting cables, converters and manuals, if any.

The Contractor shall also provide electronic files of drawings formatted in the latest version of AUTOCAD.

1.1.13.4 *Drawing and Document Submittal Procedure*

A Document Transmittal Letter (DTL) giving the titles and number thereof, status of the document and the action required by the receiver, shall accompany each submittal of drawings and design data.

In order to scrutinize drawings and documents in a reasonable period with priority, the Contractor shall submit the drawings/documents as detailed below:

- i. The drawings / documents are submitted as per the drawing / document schedule sequentially and in batches and not in bulk at a time.
- ii. All the required technical particulars, calculations, technical catalogues, relevant details plant/equipment are submitted.
- iii. All protection and control schemes are submitted with a detailed explanatory notes and logic and / or block diagrams for quick understanding.
- iv. Deviations, if any, from the specifications or the contract documents shall be listed and submitted with an explanation or justification.
- v. All the comments given by the KSEBL in the previous submissions are duly incorporated while resubmitting the drawings / documents for approval.
- vi. All the drawings and documents of the sub-contractor are checked and certified by the Contractor after affixing his signature that he has fully examined them for compliance with the contractual requirements.
- vii. For each drawings / documents, the Contractor shall indicate clearly the deviations, if any, from the contract documents, explaining the reason for the deviation and request the KSEBL explicitly for approval. Failure to do so shall not release the Contractor from his obligation to supply and execute the works in strict conformity with the contract documents, even if the deviated documents / drawings submitted by the Contractor were approved by the KSEBL.
- viii. The Drawings / documents shall be submitted in soft copy also in PDF format (by email) in addition to the hard copy as required above for facilitating faster

processing by various concerned sections during approval stage.

1.1.13.5 *Manuals and other Documents*

This shall generally include the following but not limited to these:

- Design Manuals
- Schedules
- Erection and Start-up Manuals
- Quality Assurance and Control Manuals
- Operation and Maintenance Manuals

All manuals and other documents shall be printed on A4 size paper unless other wise approved by the KSEBL.

A) Design Manuals

These generally include the design calculation sheets, design data sheets, stress analysis, computer outputs, manufacturer catalogues, etc..., which shall be provided by the Contractor during engineering stage of the contract to the KSEBL for approval or information.

B) Schedules

Various time schedules including site activity plans and drawing/document submittal schedule, Equipment Delivery Schedule etc...

C) Erection and Start-up Manuals

The Contractor shall provide detailed erection and start-up manuals covering the step-by-step erection, testing, start-up commissioning procedure of all the plants and equipment provided by him under the contract. These documents shall be provided at least 1 month prior to the erection or start-up works at site. Test procedure and protocols shall be provided at least one week prior to the test witness request.

D) Quality Assurance and Control Manuals

The QA/QC manuals shall generally include the following but not limited to these:

- Field test record manual
- Quality Assurance at manufacturer works, if possible
- Quality control at site for civil engineering works of electrical/mechanical equipment
- Quality control at site for erection / installation
- Safety plans at site
- Environmental plan at site

The Contractor shall submit entire field test record manual before the provisional taking over of the works.

Where applicable and requested by the KSEBL, the Contractor shall provide manufacturer / sub-vendor / QA / QC procedure manuals, along with the factory type / routine test certificates of the plants / equipment being supplied under the contract. Such documents shall be provided prior to the shipment of plant / equipment and got approved. It will not be sufficient to provide manufacturers standard brochures or copy of certificate issued by ISO or similar authorities.

E) Operation and Maintenance Manuals

The Contractor shall submit to the KSEBL 10 copies of the Operation and Maintenance Manuals.

The O & M manuals shall generally include the following but not limited to these:

- Operation manual
- Maintenance manual
- Detailed components manual
- Spare parts manual
- Consumables manual
- Operator trouble shooting manual

The Contractor shall provide detailed instruction manuals covering the operation and maintenance aspects of all the plants and equipment provided by him under the contract. It will not be sufficient to incorporate manufacturer's standard brochures as part of the text unless they refer particularly to the equipment supplied and are free of extraneous matter. The O & M manuals shall contain information in sufficient detail to enable the Purchaser to maintain, dismantle, reassemble, adjust and operate the Works with all its items of Works and installations. Details shall contain a complete and accurate description of the Works, all components and ancillaries, their assembling and dismantling. An accurate list stating clearances, tolerances, temperatures, fits, etc... shall be also included.

Required copies of the draft O&M manuals shall be submitted to the KSEBL for approval as per required schedule. In the event of any change to the plant or any variation of the instructions occurring after the approval of the manuals and before the end of the guarantee period, the Contractor shall submit the proposed amendments for approval and subsequently provide required copies for each of the manuals already supplied. The approved schematic diagrams, wiring drawings, logic diagrams, etc..., shall be mounted in hard cover folder with cover page embossed

with the document title.

All copies of operation and maintenance manual shall be original and shall be provided in hardbound volumes. The front side and spine (hard end) side of the bound cover shall be embossed with document title. All volumes of the operation and maintenance manuals shall be of same size and of thickness, which could be easily manageable and marked with volume numbers.

a) Operation Manual

This manual shall include basic step-by-step instructions on how to operate the plant/ equipment both with regard to individual items and to systems under all patterns of normal and abnormal conditions. The instructions shall include reference to the applicable operation limits. Precautions and warnings in relation to the safety of operator's life and equipment shall be included wherever relevant. The entire testing and adjustment procedure required for the Works after overhauls and during operation shall be described.

b) Maintenance Manual

The maintenance manual shall include the following but not limited to these:

- Preventive maintenance schedules
- Maintenance schedules
- Maintenance procedures and troubleshooting charts

The schedules and procedures shall be for all the items of the plant / equipment and shall include the following but not limited to these:

- A table indicating the inspections required at regular intervals, the routine cleaning and lubricating operations, the regular safety checks and similar steps.
 - The maintenance instructions shall include a tabular summary of the required activities sorted according to:
 - Daily
 - Weekly
 - Monthly
 - Quarterly
 - Yearly
 - (Or other) cycles as applicable.
- The step-by-step procedures for maintenance

- The checks to be made, including the limits of fits and other tolerances
- A fault diagnosis guide (where appropriate) giving Repair and adjustment procedures including fault tracing etc...
- The spares required
- The special tools required
- Drawings sufficient to illustrate the maintenance procedures, retrofitting of spares and fixing of special tools etc... shall be included
- Frequency of routine and overhaul maintenance

c) Spare Parts Manuals

The Contractor should provide a consolidated list of spare parts along with the blown up views for all the systems/plants/equipment provided by him, which normally require replacement. The manuals shall be organized such that it facilitate the procurement planning and optimum stocking of spare parts ease in identification and preparation of specification of spare parts for procurement and to reduce the duplicate stocking of similar spares and sub-assemblies, all placed together system wise, subject wise, and discipline wise.

The following details shall be incorporated in the spare parts list:

- Manufacturers part No. / Catalogue No.
- Name plate details and specification of standard spares so that these items can be purchased from alternative sources.
- Detailed drawing for each item of spare parts shall be supplied
- Indicate optimum stocking level of each item so that equipment availability and reliability is ensured without excessive stocks. The information should include minimum and maximum quantities of spares to be maintained by the project for a period of 5 years.
- Inter-changeability of spare parts between the similar equipment.
- The list further divided the spare parts into:
 - Operation consumables.
 - Operations back up.
 - Consumable for each type of scheduled works.
 - Back up for each type of scheduled works.

- Emergency or insurance spares.

d) Consumable Manual

This manual shall include a list of all consumables with the frequency of their replacement and consumption, manufacturer name and product name/type, identification code, if any, etc... The manual shall also include a schedule of lubricants. The schedule shall include all lubricants, greases and other consumables used in the plant / equipment

e) Operator Trouble Shooting Manual

This manual shall include a list of actions the operator has to take during the various process alarm conditions and during the emergency conditions. The manual shall describe each and every alarm that will be appear, immediate action and troubleshooting plans.

1.1.13.6 *Erection, Pre-Commissioning and Commissioning Procedures*

The Contractor shall submit to the KSEBL for approval erection, pre-commissioning and commissioning procedures for the Work as outlined in the various sections contained in the Technical Specification.

The **Erection / Installation procedures** shall describe in sequential steps the erection of major equipment and shall contain sufficient details such as equipment preparation on erection bay, handling of large and heavy pieces, levelling, anchoring, site welding, site painting, erection checks, site pressure tests, site flushing and cleaning of hydraulic systems, alignment and run out checks to allow the Engineer / Purchaser to plan and supervise the Works at site, if required. The manuals shall contain the Log Sheets for taking measurements during installation.

Pre-commissioning tests and procedures shall be described in sequential steps for the pre-commissioning of all electrical and mechanical equipment and shall also contain sufficient details viz. checking of installations, ratings, cable terminal checking and operation test of all auxiliary equipment etc... necessary Log Sheets shall be annexed to facilitate proper recording of test results.

The **Commissioning procedures** shall sequentially and in sufficient detail describe activities and tests for all systems covered by the Contract Document.

1.1.13.7 *Quality Assurance Plan and Test Reports*

The Contractor shall submit to the KSEBL copies of all tests required under the Contract as

outlined in the various sections contained in the Technical Specification along with the procedure for inspection and quality assurance.

Quality Assurance Plan for Manufacturing Works

Four copies of Quality Assurance Plan giving details of inspection, tests and customer witness / hold points shall be submitted with the bids. The quality plan shall contain the details of inspection and tests to be carried out for each major component of each functional assembly as recommended by the manufacturer as per their standard practice. The tests will include material composition and its properties, NDT, X-ray, hydraulic tests, leakage tests, insulation, high voltage tests and functional tests etc... along with the applicable standards and acceptance criteria.

The Contractor shall get the quality plans finalised and approved after the award of the Contract. The approved quality plan shall form the basis for inspection and acceptance of the equipment. The Engineer-in-Charge shall have the right to ask for more relevant tests if the same could not be included in the quality assurance plan at the time of their approval due to non availability of final design drawings.

Quality Assurance Plan for Site Installation & Commissioning

Four copies of Quality Assurance Plan giving details of stage inspection during installation, pre-commissioning and commissioning tests and customer witness / hold points shall be submitted with the bids. The quality plan shall contain the details of inspection and tests to be carried out for each major component of each functional assembly as recommended by the manufacturer as per their standard practice. Test Procedure shall be specified giving for each test item (kind of test) a description, test method / standards, used instruments, sample/routine test, test judgement.

The tests will necessarily include NDT, X-ray, hydraulic tests, leakage tests, insulation, high voltage tests and functional tests etc... along with the applicable standards and acceptance criteria.

The Contractor shall get the quality plans finalised and approved after the award of the Contract. The approved quality plan shall form the basis for inspection and acceptance of the equipment at site. The Engineer-in-Charge shall have the right to ask for more relevant tests if the same could not be included in the quality assurance plan at the time of their approval due to oversight and / or non availability of final design drawings.

1.1.13.8 *Drawing and Document Approval Procedure*

1.1.13.8.1

All specifications, drawings, reports, design calculation, data etc... shall be submitted for

KSEBL's approval. The KSEBL shall give comments or approval within specified period from the date of receipt of such documents. Any manufacturing work carried out prior to such approval will be at the Contractor's own risk and expense.

If the KSEBL fails to approve or comment on the documents submitted by the Contractor within the agreed period, the Contractor may request for a meeting with the Engineer in Charge or his representative, for sorting out any issues and getting approval without any inordinate delay.

1.1.13.8.2

Each document for which no approval is required shall be clearly marked "**FOR INFORMATION ONLY**" in a visible place. The KSEBL may, however, decide to treat such document as sent for approval, if deemed necessary.

Each document sent for approval shall be clearly marked "**FOR APPROVAL**" in a visible place. The KSEBL may, however, decide to mark such document "**Not subject to Approval**", if deemed necessary.

The Contractor must in no case distribute any document without either one of the above-mentioned marks or his approval of a sub-contractor's drawing without the mark "Approved, Date, Signature". Documents distributed otherwise may be regarded as non-existent.

1.1.13.8.3

As far as documents submitted for approval are concerned, the KSEBL will notify the Contractor, within 30 days after receipt, by returning one copy marked with one of the following categories, as applicable:

Cat. No. A: "For Information Only. Not Subject to Approval"

Cat. No. B: "NOT APPROVED"

Cat. No. C: "APPROVED EXCEPT AS NOTED. RESUBMIT"

Cat. No. D: "APPROVED – SUBMIT CERTIFIED COPIES (8Sets)"

Cat. No. E: "FINAL – ISSUED FOR CONSTRUCTION"

- i. The notification "**APPROVED**" authorizes the Contractor to commence the procurement or to proceed with the construction / fabrication of equipment covered by such drawings in compliance with his contractual obligations. On receiving this notification, the Contractor shall submit sufficient copies (8 copies for the Engineer-in-Charge's use) of the Drawings / documents after affixing his seal and signature for stamping under Cat E: "FINAL – ISSUED FOR CONSTRUCTION". **Only drawings stamped under CAT. No. E: "FINAL – ISSUED FOR CONSTRUCTION" shall be issued to site for Erection / Installation.**

- ii. The notification "**APPROVED EXCEPT AS NOTED**" authorizes the Contractor to commence the procurement at his risk or to proceed with the fabrication in compliance with his contractual obligations, subject to all corrections noted on the document or submitted on a comments list are acceptable to the Contractor and the Contractor ensures that the work at this stage is in full compliance with the KSEBL's requirements.

After incorporating the remarks fully, the document shall be resubmitted for approval at the earliest but within the specified period indicating clearly the details of the revision. **Every revision shall be clearly identified on the drawing with bubble mark indicating the revision number inside the bubble and described by number, date and subject in a revision block on all drawings.**

- iii. The notification "**NOT APPROVED**" indicates that the document must be revised and resubmitted for approval before proceeding further.
- iv. The information documents shall be notified as "**FOR INFORMATION ONLY**".
- v. If any specific approval is required or requires specific attention for a design/construction feature the Contractor shall notify accordingly.

1.1.13.8.4

During the preliminary stage of the design work, the Contractor may submit to the KSEBL drawings and documents for information and general review along with lists of deviations (if any), being basis for eventual design meetings. At the latest when quality, completeness and conformity with the contractual documents have reached satisfactory level, the Contractor shall submit these documents for approval. ***The Contractor should certify all the drawings / documents received from sub-vendors for equipment procured through out-sourcing and submit the same with a Cover sheet having Title Block and format as indicated in Clause 1.1.13.9 along with Contractor's drawing / document number.***

Each of the drawings / documents for a subject submitted as above shall be reviewed and checked by the KSEBL to reach the status "APPROVED".

1.1.13.8.5

At least 48 hours prior to starting any work, the Contractor shall have obtained the "APPROVED" or "RELEASED FOR CONSTRUCTION" status for the documents pertaining

to work and shall have supplied the required number of copies to the KSEBL's representative at site.

1.1.13.8.6

The KSEBL / KSEBL's representative may order the interruption of the execution of any work for which the Contractor cannot present approved drawings. Such an interruption shall not relieve the Contractor from executing his work as stipulated in the contract and shall be no reason whatsoever for claiming a delay or additional costs / escalation.

1.1.13.8.7

The approval of drawings by the KSEBL shall not exonerate the Contractor from any of his responsibilities under the Contract.

1.1.13.8.8

Should an error be found in a Contractor's drawing during the erection of structures or the installation of equipment, the Contractor shall correct the drawing thereon by including the delineations of any changes found necessary at Site and shall resubmit the drawing for approval as specified.

1.1.13.8.9

Both the KSEBL and the Contractor shall sign approved drawings and no departure from these drawings shall be allowed without the approval of the KSEBL.

1.1.13.8.10

After a drawing is finally approved by the KSEBL and signed by both the parties, sufficient number of copies of the approved drawings (8 copies) may be issued to the KSEBL.

1.1.13.9 *Format of Drawings*

1.1.13.9.1

The drawings of the Work shall be ISO standard sheet sizes as indicated in Clause 1.1.13.9.5, with a left-hand border of 30 mm and all other borders 20 mm.

1.1.13.9.2

Drawings shall have the title block placed in the bottom right corner with a space of approximately 75 mm x 150 mm immediately above it for use by the KSEBL to indicate approval or otherwise.

1.1.13.9.3

The "Project Name" field of the title block shall prominently display the information given in Clause 2.1.4.1.3 of Specific Requirement of the Project, in the upper part of the block.

1.1.13.9.4

The title block shall also contain the drawing number and its title, the date, scale, serial number, revision no, date of issue and date of revision. The names of Contractor and KSEBL ("KERALA STATE ELECTRICITY BOARD LIMITED" with Logo / Emblem on the Left Hand side) shall be prominently displayed and these shall be subject to approval of the KSEBL.

1.1.13.9.5

All drawings shall show the scales of the metric system, and all descriptive wording shall be in the English language.

The drawings shall have a size according to 'A' series of DIN 476 or equivalent international standards.

The drawing size shall conform to the following :

Site layout drawing	}	A0 Size
General arrangement drawing		
Civil construction drawing		
Equipment assembly drawing	}	A1 Size
Electrical single line diagram		
Electrical route layout drawing		
Piping layouts (Isometrics)		
Flow diagrams and schematics	}	A3 Size
Electrical schematics		
Control schematics		
Instrument hook-up drawings		
Interlock and logic diagrams	}	

The scales shall be according DIN 476 or equivalent international standard

- for reduction M 1:2.5, 1:5, 1:10, 1:50, 1:100, 1:200, 1:500, 1:1000, 1:5000
- for enlargement M 2:1, 5:1, 10:1

Drawings shall be folded according to DIN 824 (A4) being 297 mm in height.

1.1.13.9.6

Modified drawings shall bear a revision letter and revision date, and the nature of the modification shall be clearly stated and the modifications undertaken highlighted / marked in the corresponding areas, no matter if the drawing was already approved, approved with comments or not approved.

1.1.13.9.7

The erection works shall be carried out only as per approved drawings with all KSEBL's comments incorporated. These drawings shall be clearly and tidily updated with red ink incorporating all changes carried out at site during the erection and testing works. The changed or cancelled items shall not be deleted by eraser or liquid corrector, but crossed only, in order to keep visible the cancelled part. Two sets of these "marked up" drawings shall be handed over before the energizing of any section of works.

1.1.13.10 As-Built Drawings

As built drawings, technical documents and data sheets of the work as completed shall be prepared by the Contractor based on the "Marked Up" drawings approved by the KSEBL. These documents shall be sufficient in detail to enable the KSEBL to maintain, dismantle, reassemble and adjust all parts of the work. The "As-Built" documentation and file arrangement shall be subject to approval by the KSEBL. The documents shall be submitted in an appropriate form, and in Hardbound volumes and/or with heavy-duty spiral binding, giving due importance to the documents. Soft-copies of the Manuals / Documents submitted shall also be provided in a good quality CD / DVD.

It is understood that as a result of experience gained during commissioning of plant / equipment certain logic, schematic and wiring diagrams require revisions. The Contractor shall provide 2 draft copies of such revision mark-up drawings to the KSEBL's representative for their use until the final "As-Built" drawings are provided.

The Contractor shall obtain Authority's approval on each of the "As-Built" reproducible prior to making required copies. The Contractor shall provide required prints of as-built drawings mounted in suitable box file(s) with attached list showing contents in each file with

separation between the engineering disciplines i.e. civil, mechanical, electrical, control system, etc... The edges of as built drawing reproducible shall be suitably protected from wear and damage due to handling. The Contractor shall also provide electronic files of drawings formatted in the latest version of AUTOCAD.

1.1.14 Progress Reports

During each stage of Design, Manufacturing, installation etc... detailed progress reports shall be submitted by the Contractor as specified in **Clause 5.3.6 of Vol. 2 - Conditions of Bid and Contract** and as detailed below:

1.1.14.1 *During Design and Manufacturing*

During design and manufacturing the Contractor shall monthly submit four (4) copies of the progress reports in a format approved by the Engineer, detailing the progress of the work during the preceding period. The report shall contain (but not be limited to) the following information:

- A general description of the Works performed during the reporting period on each main activity, and includes any notable problems, which were encountered.
- The total overall percentages of design and manufacturing works completed, with reference to the CPM / PERT schedule. Appropriate comments shall explain any differences.
- The percentages of each main work activity completed during the reported quarter with reference versus the scheduled programme. Appropriate comments shall explain any differences.
- A list of activities scheduled to be started within the next period of two (2) months, with expected starting and completion dates. If the expected starting and / or completion dates are different from those shown on the CPM / PERT schedule, an explanation shall be given.

1.1.14.2 *During Installation at Site*

During erection the Contractor shall, submit four (4) copies of the fortnightly progress reports in a format approved by the Engineer, detailing the progress of the work during the preceding month. The report shall contain (but not be limited to) the following information:

- A general description of the Works performed during the reporting period on each main activity, and includes any notable problems, which were encountered.
- The total overall percentages of erection works completed, with reference to the

CPM / PERT schedule. Appropriate comments shall explain any differences.

- The percentages of each main work activity completed during the reported fortnight with reference versus the scheduled programme. Appropriate comments shall explain any differences.
- A list of activities scheduled to be started within the next period of two (2) months, with expected starting and completion dates. If the expected starting and/or completion dates are different from those shown on the CPM / PERT Schedule, an explanation shall be given.
- A list of local manpower (by trade classification) employed during the reporting period.
- A list of foreign personnel (by position) employed during the reporting period.
- A list of the Contractor's Equipment and materials presently located at the Site.
- Progress photographs of significant events. The Engineer may direct the inclusion of specific photographs if deemed necessary.
- A statement detailing the status of progress on the overall programme and how to regain any lost time or setbacks which may have occurred.
- A list of inoperable temporary equipment, and the estimated date when the repair will be completed.
- A statement concerning potential problems and recommendations on how they could be resolved.

1.1.15 Materials

1.1.15.1 General Specifications

1.1.15.1.1

The materials used in the construction of the Work shall be new, of high quality and selected particularly to meet the duties required of them. The material specification shall be indicated in the Contractor's detailed drawings. The use of materials liable to be attacked by termites or other insects will not be allowed. All workmanship is to be of the highest quality throughout to ensure smooth and vibration free operation under all possible operating conditions, and the design, dimensions and materials of all parts are to be such that the stresses to which they may be subjected shall not render them liable to distortion or damage under the most severe conditions encountered in service.

1.1.15.1.2

Materials shall meet the latest issue of the following ASTM Standard Specifications:

a)	Steel Piping, Tubing and Fittings	ASTM A53	Pipe, steel, black and hot-dipped, Zinc-coated, welded and seamless
		ASTM A181	Forgings, Carbon steel for general purpose piping
		ASTM A789	Seamless and welded ferritic / austenitic stainless steel pipe for general service
b)	Ferrous Castings, Ferro alloys	ASTM A743	Corrosion-resistant Iron-Chromium, Iron-Chromium-Nickel and Nickel base alloy castings for general application Grade CA-15, Grade CF-8M and Grade CA-6M
		ASTM A27	Mild to medium strength Carbon steel castings for general application grade 65-35, or 70-40
		ASTM A487	Steel castings for pressure service
c)	Steel Plates, Sheets, Strips	ASTM A176	Stainless and heat-resisting Chromium steel plate, sheet and strip
		ASTM A240	Heat resisting Chromium and Chromium-Nickel stainless steel plate, sheet and strip
		ASTM A345	Flat rolled electrical steels for magnetic applications
d)	Structural Steel, Pressure Vessel Plate and Forgings	ASTM A36	Structural steel
		ASTM A515	Pressure vessel plates, Carbon steel for intermediate and higher temperature service
		ASTM A516	Pressure vessel plates, Carbon steel for moderate and lower temperature service
e)	Steel Bars, Steel Forgings	AST A276	Stainless and heat resisting steel bars and shapes types 316 and 302
		ASTM A668	Steel forgings, Carbon and alloy for general industrial use Class D
f)	Copper and Copper	ASTM B23	White metal bearing alloys (known

Alloys

commercially as Babbitt metal)

ASTM B43	Seamless red brass pipe, standard sizes
ASTM B66	Bronze castings in the rough for locomotive wearing parts
ASTM B88	Seamless Copper water tube
ASTM B466	Seamless Copper Nickel pipe and tube
ASTM B584	Copper alloy sand castings for general application

1.1.15.1.3

Materials shall meet the latest issue of the following ANSI standard specifications:

ANSI B15-5	Flanges and fittings for steel pipes and valves.
ANSI C80.1	Rigid steel conduits, Zinc coated.

1.1.15.2 Trade Names

When, as described in these Specifications, certain work, articles, materials and/or manufacturing processes have been named by their trade names or by their catalogue name or number, these designations are meant to be followed by the words "or approved equal" even if they are not included in the text. The Contractor may substitute other work, articles, materials and/or fabrication processes subject to the approval of the KSEBL, provided these are equivalent in quality and type to those indicated and / or specified. It will be the Contractor's responsibility to demonstrate and prove to the KSEBL the quality and suitability of the alternatives proposed.

1.1.15.3 Fasteners**1.1.15.3.1**

Nuts, bolts, studs and washers for incorporation in the Work shall conform to the requirements of the appropriate Standard. Where non-standard fasteners are used in the Work, appropriate tools, including wrenches, taps and dies, shall be provided. Nuts and bolts for pressure parts shall be of the best quality bright steel, machined on the shank and under the head and nut.

1.1.15.3.2

All washers shall be included under the Contract, including locking devices and anti-vibration arrangements, which shall be subject to the approval of the KSEBL. Taper washers shall be fitted where necessary. Where there is a risk of corrosion, bolts and studs shall be finished flush with the surface of the nuts.

1.1.15.3.3

Bolts, except for high strength friction grip bolts, shall be designed so that, with the nuts fully tightened, the stress intensity at the bottom of the thread shall not exceed one half of the yield point of the material under all conditions. Connections employing high strength friction grip bolts as per ASTM A325 or A490 shall follow the requirements of "Specification for Structural Joints Using ASTM A325 or A490 Bolts" as given in the AISC Manual of Steel Construction. Bolts, nuts and screws, which are subject to frequent adjustment, frequent removal or immersion in the course of operation, shall be made of corrosion-resistant steel or bronze. The material of stainless steel bolts and nuts shall be selected to prevent galling. Spring type washers will not be permitted where they may damage any protective coatings.

1.1.15.3.4

Steel bolts and nuts exposed to atmosphere shall have suitable finish like cadmium plating or zinc plating for diameters above 6 mm. All bolts, nuts and pins used inside the equipment shall be locked in position.

1.1.15.3.5

On outdoor equipment, all bolts, nuts and washers in contact with non-ferrous parts, which carry current, shall be of phosphor bronze, where the transfer of current is through the bolts.

1.1.15.3.6

If bolts and nuts are placed so that they are inaccessible by means of ordinary spanners, suitable special spanners shall be provided by the Contractor.

1.1.15.4 *Forgings*

Forgings in excess of 150 mm in diameter shall be subjected to examination internally for the detection of flaws and to heat treatment for the relief of residual stresses. Particulars of

the heat treatment proposed for all forgings, and in each case the name of the proposed maker, shall be submitted to the KSEBL for approval. Each forging incorporated into the Work shall be clearly stamped with the heat number readily visible. All such forgings shall be jointly examined at the place of manufacture by the KSEBL and by a representative of the Contractor during the heat treatment and shall be examined by the latest non-destructive methods for the detection of defects.

1.1.15.5 *Castings*

1.1.15.5.1

Castings shall not contain damaging defects and they shall be satisfactorily cleaned before use. Surfaces that are not machine finished and which will be exposed after their final installation shall be such that grinding at site will not be required before painting. The presence of defective material shall be determined and it shall be removed down to sound metal. Castings shall be homogeneous and free from excessive non-metallic inclusions. An excessive concentration of impurities or a separation of the alloy elements in the critical points of a cast part shall be sufficient reason for its rejection.

1.1.15.5.2

Castings of main parts, including all those subject to hydraulic pressure and all castings, which underwent major repair, shall be radio-graphically examined as specified. Other castings shall be tested using radiographic, ultrasonic, dye penetration, magnetic particle or any other standard non-destructive test method approved by the KSEBL. The KSEBL has the right to ask the Contractor to carry out non-destructive tests to determine:

- the presence of defects;
- the maximum extent of defects;
- that the area to be welded is satisfactorily prepared;
- that the repairs are satisfactory.

The costs incurred by such tests shall be at the Contractor's expense.

1.1.15.5.3

Minor defects or imperfections which definitely do not affect the strength or utilization of the cast parts may be repaired by welding, according to the accepted practice for the repair of such parts, without requiring the KSEBL's approval. Minor defects shall be considered as such when the depth of the prepared cavity to be welded is not greater than 25% of the

effective wall thickness but in no case may it exceed 25 mm when the area to be welded is greater than 16,000 sq. mm. However, a cluster of minor defects shall be considered an important fault when judged by the KSEBL to cast serious doubts on the general quality of the casting and shall constitute cause for rejection at the KSEBL's discretion.

1.1.15.5.4

Before proceeding to repair any major defect, a written report shall be submitted to the KSEBL in which the fault is fully described, together with diagrams, photographs and reports of metallurgical tests, when applicable, as well as with the description of the proposed repair method. If the removal of metal required to correct any fault reduces the cross-section of the casting by more than 50% or such that the stress calculated in the remaining metal exceeds the permissible stresses by more than 50%, the cast part may be rejected by the KSEBL. Castings, which after the first heat treatment, have been repaired by welding of major defects, which has affected the dimensional stability of the repaired parts, shall be subject to a second heat treatment.

1.1.15.5.5

The thickness and other dimensions of castings shall agree substantially with the dimensions shown on the drawings and shall not be reduced by shop or casting practices to such an extent that the effective strength of the cast parts is diminished by more than 10% when calculated using the actual dimensions, or that the stresses allowed by these specifications are exceeded. Castings, which are warped or have any other type of deformation, shall not be used without submitting a complete report for the KSEBL's study, review and approval nor shall their dimensions be increased such that interference is caused in manufacturing operations or with the appropriate assembly with other parts.

1.1.15.6 *Steel Plates*

Rolled steel plates which are to be used in the fabrication of pressure vessels or parts that are subject to internal pressure and are encased in concrete, and rolled steel plates forming large highly stressed weldments shall be tested for laminations at the place of manufacture in accordance with ASTM A435. Mill sheets for all plates shall be supplied.

1.1.15.7 *Lubrication*

Unless otherwise specified the Contractor shall supply within the scope of contract, the initial fill of lubricants and up to the Provisional Take Over, all necessary lubricants such as

oil for system cleaning lubrication, control and cooling as well as all greases. In the case of grease lubricated roller type bearings for electric motors, lithium grease is preferred. The lubricants must preferably be non-inflammable and suitable for use in the specified equipment under the climatic conditions prevailing at site. However, self-lubricating system shall be preferred, wherever feasible.

A schedule of the oils and other lubricants recommended for all components of the plant shall be submitted to the KSEBL before commissioning. The type of lubricants shall be such that these are locally available.

The list shall mention (for lube oil and greases):

- The name of the equipment, the frequency of lubricant refills, the quantity required, the type of lubricant.
- The list shall terminate by following summary of all types of lubricants to be stored and given for each: -
 - Exact specification
 - Quantities to be stored up to provisional take over.
 - Brand names

The number of different types of lubricants is to be kept to a minimum. The lubricants shall be supplied in such a way as to ensure proper transportation as well as storage and handling at site. Copies of this schedule shall be included in both the draft and final copies of the operating and maintenance instructions required by this specification.

For any equipment for which oil flushing should be required, the Contractor shall provide the flushing oil when these items are fitted and started up and shall replace it after the specified period, by a fresh refill. The flushing oil should be same as the final lubricant.

The lubrication specified should be efficient in any service conditions, including transient temperature conditions that may be due to the absence of cooling.

For grease lubricated equipment, the contractor shall provide individual lubricating connections with grease nipples of uniform type and shall provide the necessary tubing to make the connections readily accessible to the operating personnel.

The contractor shall provide two grease guns for each type of lubrication connection nipple, which he supplies. **Where automatic lubricators are fitted, provision for manual lubrication shall also be provided.**

1.1.15.7.1 General Specifications

All the Bearings, Journals and locations where sliding among parts takes place, shall be provided with an adequate means of lubrication.

Adequate seals shall be provided where necessary to prevent the escape of lubricants during normal operation and the entry of foreign matter.

The Work shall be handed over to the KSEBL in acceptable running order with all moving parts properly lubricated and fully charged with the recommended lubricant.

1.1.15.7.2 Oil Lubrication

It is preferred that only one type of oil shall be used that is suitable for both the lubrication of bearings and gears, and high pressure oil actuated applications.

The oil shall be of a type that is readily available in India. The KSEBL will provide details of the preferred type of oil to be provided.

1.1.15.7.3 Self Lubricated Bushings

Unless otherwise specified all bushings shall be of the self-lubricated type. Grease lubrication will not be permitted except in special cases after approval by the KSEBL.

Unless otherwise specified, the self-lubricated material shall be selected from the following:

- Acetal resin thermoplastic reinforced with fluorocarbon, e.g., Delrin AF;
- Woven fluorocarbon with fibre reinforcing, e.g., Fibreglide, Lubron;
- Urethane polymers either as a solid bushing or as a lining for metallic backing, e.g. Thordon.

The Contractor shall demonstrate that his selection has operated satisfactorily for at least 10 years in a similar application, or has performed satisfactorily in extended and rigorous laboratory tests.

1.1.15.8 Insulating Oil**1.1.15.8.1**

The insulating oil shall conform to the requirement of IS 335, BS 148 or IEC Publication No. 298. No inhibitors shall be used in the oil.

1.1.15.8.2

Sufficient quantity of oil of uniform quality throughout, necessary for first filling of all tank and coolers at the proper level along with 10% extra oil for topping up shall be supplied in non-returnable containers suitable for outdoor storage.

1.1.15.8.3

The Contractor shall despatch the transformer in an atmosphere of nitrogen. Necessary arrangement shall be ensured by the Contractor to take care of pressure drop of nitrogen during transit and storage till the completion of oil filling during erection. A gas pressure-testing valve with necessary pressure gauge and adapter valve shall be provided. One cylinder of Nitrogen shall also be provided with each transformer to maintain the required pressure of nitrogen during transportation, in case it becomes necessary.

1.1.15.8.4

The Contractor shall warrant that the oil furnished is in accordance with the following specification or its equivalent.

<u>Sl. No.</u>	<u>Characteristics</u>	<u>Requirement</u>	<u>Method of test</u>
1.	Appearance	Clear, transparent and free from suspended matter sediment	
2.	Density at 20°C Max.	0.89 g/cm ³	IS 1448
3.	Kinematic viscosity at 27°C Max.	27 CST	IS 1448
4.	Interfacial tension at 27°C Min.	0.04 N/m	IS 6104
5.	Flash point Penskey Marten (closed) Min.	140°C	IS 1448
6.	Pour Point Max.	-10°C	IS 1448
7.	Neutralization value (Total acidity), Max.	0.03 mg KOH/g	IS 335 Appendix A
8.	Corrosive sulphur (in terms of classification of copper strip)	Non-corrosive	IS 335 Appendix B
9.	Electric strength (breakdown voltage) for new untreated oil, Min.	60 kV (rms). If the above value is not attained, the oil shall be treated.	IS 6792
10.	Dielectric dissipation factor (tan delta) at 90°C Max.	0.002	IS 6262
11.	Specific resistance (Resistivity)		

<u>Sl. No.</u>	<u>Characteristics</u>	<u>Requirement</u>	<u>Method of test</u>
	a)at 90°C Min.	35x10 ¹² Ohm-cm	IS 6103
	b)at 27°C Min.	1500x10 ¹² Ohm-cm	IS 6103
12.	Oxidation stability:		
	a)Neutralisation value after oxidation, Max.	0.40 mg/KOH/g	IS 335 Appendix C
	b)Total sludge after oxidation, Max. 0.10 % by weight		IS 335 Appendix C
13.	Presence of oxidation inhibitor	The oil shall not contain anti-oxidant inhibitors	IS 335 Appendix D
14.	Water content, Max.	50 ppm	IS 2362

1.1.16 Workmanship

1.1.16.1 General Specifications

1.1.16.1.1

All parts shall be manufactured true to drawing dimensions. All tolerances shall be defined on the Contractor's drawings for both manufacturing and installation purposes.

1.1.16.1.2

Fabrication tolerances shall conform to AISC Specification for the Design, Fabrication and Erection of Structural Steel for Buildings. Machining tolerances, allowances and gauges shall conform to ANSI Standard B4a - Tolerances, Allowances and Gauges for Metal Fits.

1.1.16.1.3

Holes shall be drilled full size or drilled under size and reamed during shop assembly. Punched holes will only be permitted in plates 20 mm or less in thickness provided all such holes are subsequently reamed full size during shop assembly.

1.1.16.1.4

Surface finishes shall be indicated on the shop drawings in accordance with ANSI B46.1 - Surface Roughness, Waviness and Lay. Compliance with the specified surface finish will be determined by sense of feel and by comparison with standard roughness specimens in accordance with ANSI B46.1.

1.1.16.2 Welders Qualifications

Welders shall be qualified in accordance with the following codes:

- a) for fabrication of pressure containing parts: ASME Boiler and Pressure vessel Code Section IX - Welding and Brazing Qualifications and, Section VIII Part UW - Requirements for Pressure Vessels Fabricated by Welding.
- b) for fabrication of structural steel parts: AWS Standard D1.175, Section 5B A - Qualification Procedure.

1.1.16.3 Welding**1.1.16.3.1 General Specifications**

The Contractor shall specify clearly on all relevant drawings the amount and type of material for each type of weld. The Contractor shall also provide detailed drawings showing joint preparation required for each type of welding to be carried out at Site and in the place of manufacture.

1.1.16.3.2 Preparation of Base Material

The parts to be joined by electric welding shall be cut precisely to the correct size by machine methods suitable for the type of weld to be used and to allow the proper penetration and good fusion of the weld with the base metal. The cut surfaces shall not have visible defects such as scabs, superficial defects caused by shearing or torch cutting operations or any other damaging defect. The surfaces of the edges to be welded shall be free from rust, oil, grease and other foreign matter. All welds exposed to water flow shall be ground to a smooth and even surface flush with the adjacent plate.

1.1.16.3.3 Lamination

Any plate in which lamination has been discovered after cutting shall be rejected unless the laminated portion of plate is local and can be cut out and replaced by welding of a new sound plate in the cut out area. In such cases, the KSEBL's approval for repairs will be required. Where such repairs are authorized, the welds of the repairs shall be ground smooth to assure neat appearance.

1.1.16.3.4 Electrodes

The Contractor shall indicate on all detailed drawings the type, size and material of electrodes he proposes to use for shop and/or field welding. Field welding electrodes shall be provided by the Contractor.

1.1.16.3.5 Welded Fabrications and Residual Stress Relief

All parts manufactured using welding methods, except those in which the stresses are not important, shall be designed, manufactured and inspected according to the ASME 'Boiler and Pressure Vessel Code', Section VIII –'Requirements for Unfired Pressure Vessels Fabricated by Welding' or equivalent. Welds shall be balanced insofar as practical to minimize distortion and residual stresses. The requirements of welding methods shall be submitted for approval.

1.1.16.4 Non-destructive Tests**1.1.16.4.1 Standards**

Unless otherwise requested by the Contractor and approved by the KSEBL, all non-destructive testing of materials shall be carried out in accordance with the following specifications:

1	Radiographic methods	ASME Section VIII, div.1 UW51 (welds) ASTM E446, E186 and E280 (castings)
2	Ultrasonic methods	ASME Section VIII, Appendix 12 (welds) ASTM A418 and A388 (forgings)
3	Magnetic particle methods.	ASTM E709
4	Liquid penetrant methods.	ASTM E165

The Contractor shall supply the KSEBL with procedure sheets and test data confirming the effectiveness and validity of each method he proposes to use.

All inspection and non-destructive testing requirements must be clearly specified on the drawings.

1.1.16.4.2 Radiographic Inspection

Radiographic inspection with X-ray machines or radioactive isotopes will be permitted. Limitations on the use of each method are outlined in ASTM and ASME standards. X-ray machines shall be used in preference to isotope cameras whenever possible. Single control Kilovolt-Milliampere X-ray machines shall not be used without the express approval of the KSEBL.

Final decision on acceptability shall rest with the KSEBL. Radiographic plates will only be accepted if they comply with the conditions specified in the ASME Code, Section VIII. All welds, which are rejected on the basis of the ASME Code, Section VIII or other, shall be repaired or replaced by an acceptable weld.

1.1.16.4.3 Ultrasonic Inspections

Ultrasonic Inspection of cast, forged and welded parts will be acceptable if an inspection program is presented together with evidence to prove the validity of the proposed method, all subject to the KSEBL's prior approval. Whenever radiographic inspection of welds is not possible, such as certain angular and back-plated welds, the Contractor shall demonstrate the validity of ultrasonic methods by inspecting a test sample, which has been prepared by identical methods and checked by radiography.

Ultrasonic testing shall only be acceptable if carried out with equipment of recognized brand. Welds, castings and forgings shall be inspected by direct contact of the probe with the surface. Under special conditions, ultrasonic inspection by immersion of forged parts may be required. Whenever angled probing is used, the angle of incidence shall be suitable for the thickness of the part, and shall be as recommended in ASTM and ASME standards. Equipment shall be calibrated regularly on a test sample prepared as described above, or on a test sample containing flaws similar to those being sought. The ultrasonic method shall not be used until technical literature describing the process, proposed methods, equipment sensitivity, probes, etc... is submitted to the KSEBL together with proof of competence of the Contractor's technicians.

Inspection reports and supporting drawings, sketches or photographs shall be submitted to the KSEBL, together with all details needed to reproduce accurately any ultrasonic test at any time. The final decision on acceptance rests with the KSEBL.

1.1.16.4.4 Complementary Inspection

Complementary inspections of castings, forgings and welded joints may be carried out using liquid penetrant and magnetic particle methods. These methods shall conform to the requirements of ASTM E709 and ASTM EI65.

These methods are only acceptable for detection of flaws on the surfaces of components or on welds. Striations and irregularities shall be removed before testing.

For liquid penetrant testing, the surface shall be conditioned or effectively cleaned before the application of the penetrant.

Magnetic particle examination shall be so conducted that surface deterioration or burning does not occur at electrode contact points. Current intensity and duration of application and orientation of the magnetic field shall be as specified in the standards. A magnetic field meter shall be used regularly. Provision shall be made for demagnetisation of components if residual magnetism is a potential problem. Final acceptance rests with the KSEBL.

1.1.16.4.5 Special Inspection

For all components fabricated with segments joined by full penetration butt welds, the inspection requirements shall be specified on the drawings and submitted for the KSEBL's approval. Ultrasonic inspection shall be done when radiographic inspection cannot be performed and/or where the design standards allow it. Non-destructive testing shall be performed after heat treatments.

When the verifications specified on the drawings are partial, the Contractor shall perform these at the locations specified by the KSEBL. When defects are found, the necessity of repair will be evaluated by the KSEBL allowing for the level the stresses may reach in that spot and for the severity of the defects.

The repair work shall be done by gouging to defect-free metal, as conformed by a non-destructive inspection. Repair welding will be allowed only if the defect has been eliminated to the satisfaction of the KSEBL. The repaired welds will be checked again according to a procedure approved by the KSEBL.

1.1.17 Ladders and Platforms

1.1.17.1 Floor Plate

Floor plates shall be chequered steel plates with a minimum plate thickness excluding raised pattern of not less than 10 mm. Edges of plates shall be planed and joints shall be cut where practicable so as to maintain continuity of pattern.

1.1.17.2 Ladders and Stairways

Steel ladders or stairways shall be provided where necessary to afford access for operation and maintenance of the equipment. Ladders shall not exceed about 7.5 m in length and suitable platforms with handrails shall be provided between each length. Where a ladder does not extend above a floor or platform level, hand-grips or other suitable means of support shall be provided. Protective cages shall be provided for ladders longer than 4.5 m. Ladder rungs shall not be less than 20 mm diameter and stringers not less than 400 mm apart. Stairways shall be provided with handrails and shall have a slope not greater than 45°.

1.1.17.3 Handrails

Handrails shall be provided wherever necessary for the safety of personnel. The handrails shall consist of at least two horizontal tubular members approximately 35 mm in diameter,

mounted on tubular or flat bar upright. The handrail shall be approximately 1100 mm above finished floor level. The handrails and supports shall be designed to withstand vertical and horizontal uniformly distributed loads of 750 Nm applied simultaneously on the top of the railing. Openings in the handrails shall be closed by removable chains.

1.1.18 Piping

1.1.18.1 General Specifications

1.1.18.1.1

Piping, joints, hangers and supports shall conform to the ANSI Specifications B31.1. Pipes, which connect with piping supplied by the KSEBL, shall be terminated by a flange or by a pipe union. Welded connections at termination points will not be allowed. Oil and air piping shall be of steel. Oil piping greater than 25 mm nominal bore shall be of seamless high quality steel pipe conforming to minimum API-5L GR.B or equivalent grade as per process requirement, whereas pipes less than 25mm bore shall be of stainless steel.

1.1.18.1.2

Unless otherwise specified, water piping, fittings and valves shall be made of the following materials:

<u>Location</u>	<u>Diameter</u>	<u>Material</u>
Exposed	50 mm and above	Steel
	Less than 50 mm	Stainless steel, Copper-Nickel
Embedded	Less than 25 mm	Stainless steel
	50 mm and above	Stainless steel
	Less than 50 mm	Stainless steel, Copper-Nickel
	Less than 25 mm	Stainless steel

1.1.18.1.3

Embedded pipes less than 50 mm in diameter shall be enclosed in a conduit for protection during concrete placement.

1.1.18.1.4

The minimum steel pipe wall thickness shall be the "normal" or "standard" wall thickness as stated in the applicable standards.

1.1.18.2 Piping Details

1.1.18.2.1

The entire piping system shall be prefabricated in the shop, insofar as practicable, leaving

only such joint connections as may be necessary for assembly or possible subsequent dismantling for repair and consistent with the requirements of shipment. Pipes below 50 mm in diameter shall be fitted with screwed or socket type welding fittings.

1.1.18.2.2

Unless otherwise stated, all piping shall be designed for a "nominal pressure" PN 10. All piping shall be tested with 1.5 times the design/nominal pressure. All required piping shall be furnished complete with flanges, joints, expansion joints, gaskets, packing, valves, drains, vents, pipe suspensions, supports, etc... Flanged connections or joints shall be provided only as required for transport, installation or for reasons of dismantling for repair. Metric (DIN)-flanges shall be used throughout.

1.1.18.2.3

Adequate clearance shall be given to parallel pipes to allow for easy maintenance without disturbing other lines. All overhead piping shall have a minimum clearance of 2.00 m from operating floors and platforms.

1.1.18.2.4

Where required water piping shall be provided with anti-condensation insulation.

1.1.18.2.5

Pipes over 50 mm in diameter shall be flanged. Alternatively, Victaulic type couplings may be used where approved by the KSEBL. Junction of copper to ferrous pipes shall be made with bronze adapters. Wherever feasible, long radius pipe bends shall be used in place of pipe fittings. Plugged drain holes shall be provided at low points in each pipe run. Necessary provisions such as suitable location, long stems, etc..., shall be made so that all valves can be conveniently operated from floor level.

1.1.18.2.6

All necessary studs, bolts, screws, cold finished nuts, washers, gaskets, packing, supports, etc..., required in connection with the field assembly of the piping systems shall be designed and supplied by the Contractor.

1.1.18.2.7

Piping shall be painted in different colours to indicate their contents. The colours to be used shall comply with the KSEBL's standard colour code as detailed below:

- High Pressure Oil - Dark Red

• Drainage Oil	-	Golden Yellow
• High Pressure Grease	-	Orange Red
• High Pressure Water	-	Smoke Grey
• High Pressure Air	-	Oxford Blue
• Low Pressure Air	-	Sky Blue
• Cooling Water Inlet	-	Dark Green
• Cooling Water Outlet	-	Opaline Green
• CO ₂	-	Pure Red

1.1.18.2.8

All valves, pumps, etc... shall be connected to the pipe work by sufficient flanges or spherically seated unions to allow their easy removal for servicing or replacement. No screwed or compression fittings shall be used within partitions, walls, or in inaccessible positions.

1.1.18.2.9

Pipes shall be cut by saw or pipe cutters and all burrs removed by reaming, Gas cutting will be permitted only if the pipe ends are ground clean and to shape for welding.

1.1.18.2.10

Pipes which pass through openings in walls, floors, etc... shall be clear of such openings. Any such holes or openings shall be cleanly and neatly cut or sleeved to a size sufficient to accommodate the pipe with reasonable clearance to allow for movement due to expansion.

1.1.18.2.11

Sleeves, in concrete shall be either non-metallic, i.e. PVC or polyethylene, or of the same material as the pipe to pass through the sleeve.

1.1.18.2.12

All pipes shall be supported / restrained / anchored in order to contain the forces/moments at the terminal point nozzles within permissible limits as well as not to cause any undue localized stress and deflection / sagging anywhere along the piping length. For the above purpose standard support attachments such as clamps, saddle plates, braces, angles/cleats, guides etc... and support components such as hangers, rods, turn buckles, spring boxes etc... shall be used by the contractor.

1.1.18.2.13

Un-galvanized steel piping shall be painted on the exterior to prevent rusting. The paint treatment shall be of the same system as used for the turbine exterior. Paint damaged during erection and commissioning shall be repaired prior to Handing-Over.

1.1.18.3 *Hangers and Supports*

All pipe work and accessories shall be mounted and supported in a safe and neat manner. All brackets, stays, frames, hangers and supports for carrying and staying the pipes, including their fasteners shall be included in the supply and completed by the Contractor at the Site. Pipes and fittings shall be supported at or near flanges wherever possible. All heavy valves and other mountings shall be supported independently of the pipes to which they connect, to the satisfaction of the Engineer-in-Charge. Supports for brackets shall be by means of steel inserts cast into the concrete substructure or substantial clamps to the superstructure. Drilling for expansion anchors in concrete or welding to the superstructure will normally not be permitted, however, if inevitable, same will be permitted only without affecting the existing structure / concrete. Where hanger rods are proposed for piping, they shall be vertical without bends or offsets and provided with lateral bracing to resist earthquake-generated forces. Vertical runs shall be supported by means of pipe clamps or collars and horizontal runs shall be provided with flexible joints where the pipe crosses contraction joints. Chain or strap hangers shall not be used. Hangers and supports shall be painted unless they are for copper tubing, in which case they shall be copper plated. All piping shall be supported so as to avoid pockets, which will not completely drain.

1.1.18.4 *Cleaning and Shipping*

Pipes and fittings shall be thoroughly cleaned before being shipped. Oil piping shall be acid pickled and flushed. Pipes shall be suitably protected against corrosion in transit and storage. Oil piping shall have a protective coating applied to prevent corrosion occurring during transport and storage. For shipping, the ends of oil pipes shall be equipped with end protectors and plugged to prevent ingress of water. All other pipes shall be positively protected against ingress of foreign matter.

1.1.18.5 *Testing*

The Contractor shall shop test all pipelines to 50% above their maximum working pressure and shall supply all labour, materials, test media, pumps, plugs, gauges and other equipment necessary to make the complete test at site. Hydraulic piping shall be pressure tested after erection as site. The pressure shall be maintained without loss for one hour.

The lubricating oil piping shall be pressure tested after erection at a pressure 50% greater than maximum pump pressure. The pressure shall be maintained without loss for one hour. Piping systems shall be flushed clean prior to and after the testing. Piping shall be tested and flushed using the same media for which the system is designed. Where practicable, piping may also be tested in sections, in which case temporary supports and end caps shall be fitted.

Oil pipe work internal bores shall be chemically cleaned and passivated prior to use. Water, air and drain piping shall be blown through with high pressure air and flushed with water prior to use.

1.1.19 Pumps

1.1.19.1

Materials of the pumps shall be:

- Casing - Cast steel
- Impeller - stainless steel
- Shaft - stainless steel
- Sleeves - stainless steel
- Wear rings - bronze
- Keys - stainless steel

1.1.19.2

The impeller diameters shall be neither maximum nor minimum impeller size for the selected pump size.

1.1.19.3

The pumps shall withstand corrosion and wear by abrasive matters within reasonable limits.

1.1.19.4

Shafts sealed by packing glands shall be fitted with sleeves. Seals shall be exchangeable without extensive disassembly of the pump. Leakage water shall be directed to suitable drainage facilities.

1.1.19.5

The size of the pump motor shall be 15 % higher than the maximum power required by the pump at any operation point.

1.1.19.6

For any pump, the overall pump-motor efficiency for the specified rated head and discharge shall not be less than 60%.

1.1.20 Gauges and Instruments**1.1.20.1**

Scales of all gauges and instruments shall be graduated in metric (ISO) units.

1.1.20.2

Provisions shall be made for all gauges and instruments to be suitably located so that they can be conveniently read from floor level. Where this is not possible, permanent platforms shall be provided by the Contractor.

1.1.20.3

All mechanical parts of instruments shall be suitably protected against shocks and vibrations, heat, humidity and splash water, etc... Pressures gauges shall be provided with a damping liquid, e.g., glycerine, to compensate vibrations. Pressure gauges without damping means are not permitted, unless approved by the Engineer-in-Charge.

1.1.20.4

All gauges and instruments shall be tested by the Contractor, including those used during commissioning at site, using suitable means to demonstrate their proper functioning and to confirm factory calibration and contact settings.

1.1.21 Design and Stresses**1.1.21.1**

The design, dimensions and materials of all parts of the Work shall be such that they will not suffer damage under the most adverse service conditions. Mechanisms shall be so constructed as to avoid sticking due to rust or corrosion. Equipment weighing more than 50 kg shall be provided with lifting lugs.

1.1.21.2

The Contractor shall be responsible for an adequate design. Except as otherwise specified, the principal stresses in the materials used shall not exceed the values given in the following table under maximum normal operating conditions:

<u>Material</u>	<u>Tension</u>	<u>Compression</u>	<u>Shear</u>
Carbon cast steel	83 MPa	83 MPa	Note 1
Plate steel for principal parts	Note 2	Note 2	Note 1
Alloy cast steel and other miscellaneous materials	Note 3	Note 3	Note 1

Note 1 60% of the allowed tension stress

Note 2 25% of the ultimate strength or 50% of the yield strength, whichever is lesser (not to exceed 120 MPa)

Note 3 20% of the ultimate strength or 33% of the yield strength, whichever is the lesser.

1.1.21.3

At runaway speed and under testing conditions, stresses up to a maximum of $\frac{2}{3}$ (two-thirds) of the yield point will be acceptable for the rotating parts of the turbine, generator, exciters etc... For other materials used in the manufacture of the generator and exciter etc... the maximum stresses due to the most severe operating conditions shall not exceed one-third of the yield point nor one-fifth of the ultimate strength of the material. For temporary overloads, unit stresses not exceeding one-half the yield point stress will be permitted.

1.1.21.4

The equipment shall be designed for operation in an earthquake zone. Each part of the Work shall be strong enough and sufficiently well connected to resist total operating stresses, including any stresses resulting from an earthquake with a ground acceleration of 0.1 g in both in the Vertical and Horizontal direction. The forces being caused by earthquake including hydraulic loads, which may occur additionally, shall be taken into account for the computations.

1.1.21.5

Complete information regarding maximum unit stresses used in the design shall be provided by the Contractor.

1.1.21.6

The Work shall be designed to:

- Operate in a stable way under all operating conditions, including load, net head, voltage and frequency variations, and it shall be free from resonance, vibration and pressure surges judged detrimental by the KSEBL,
- Minimize the risk of fire and any consequential damage;
- Prevent accidental contact with live parts;
- Be capable of continuous operation or as required with minimum attention and maintenance under the conditions prevailing in a power station in a tropical climate;
- Limit noise levels to 70dB at a distance of 5 m unless otherwise specified.
- Natural frequency of the machine be kept well away (higher) from the magnetic frequency of 100 Hz (twice the generator frequency). The natural frequency must be much away from multiple of runner blades passing frequency.
- Vibration detectors or eccentricity meters on turbines and generators should be provided for alarm and shut down.
- For mercury contacts, Anti vibration type mercury switch be used.

1.1.22 Tropicalisation**1.1.22.1 General Specifications**

In choosing materials and their finishes, due regard shall be given to the humid tropical conditions under which the Work is to operate, and tropical grade materials should be used. In general, metals such as iron and steel shall be painted or coated with protective coatings or treated by an approved method to prevent corrosion. Core laminations shall be lacquered or compounded heavily. Steel screws, nuts, bolts, etc...,when used shall be of galvanized or chromium plated. To the extent possible contact of dissimilar metals shall be avoided, else suitable method shall be used to reduce the potential difference between the two metal parts to eliminate by-metallic corrosion.

Adhesives, sealants, etc..., shall be carefully selected to avoid moisture condensation. Use of wood shall be avoided completely. Filter media, fabrics, cork, paper, etc...,where used shall be impregnated and adequately treated with an approved fungicide.

Some relaxation of the following provisions may be permitted where Work is hermetically

sealed but it is preferred that tropical grade materials should be used wherever possible.

1.1.22.2 *Metals*

Iron and steel shall generally be painted or galvanized as appropriate. Indoor parts may alternatively have chromium or copper-nickel plated or other approved protective finish. Small iron and steel parts (other than rustles steel) of all instruments and the metal parts of relays and mechanisms shall be treated in an approved manner to prevent rusting. Cores, etc..., which are built up of laminations or cannot for any other reason be anti-rust treated, shall have all exposed parts thoroughly cleaned and heavily enamelled, lacquered or compounded. When it is necessary to use dissimilar metals in contact, these shall, if possible, be so selected that the potential difference between them in the electrochemical series is not greater than 0.5 V. If this is not possible the contact surfaces of one or both of the metals shall be electroplated or otherwise finished in such a manner that the potential difference is reduced to within the required limits, or, if practicable, the two metals shall be insulated from each other by an approved insulating material or a coating of approved varnish compound.

1.1.22.3 *Screws, Nuts, Springs, Pivots etc...*

The use of iron and steel shall be avoided in instruments and electrical relays wherever possible. Steel screws, when used, shall be zinc, cadmium or chromium plated, or when plating is not possible owing to tolerance limitations, shall be of corrosion-resisting steel. Instrument screws (except those forming part of a magnetic circuit) shall be of brass or bronze. Springs shall be of non-rusting material, e.g. phosphor bronze or nickel silver, as far as possible.

1.1.22.4 *Fabrics, Cork, Paper etc...*

Fabrics, cork, paper and similar materials, which are not subsequently to be protected by impregnation, shall be adequately treated with an approved fungicide. Sleeves and fabrics treated with linseed oil or linseed oil varnishes shall not be used.

1.1.22.5 *Wood*

The use of wood in equipment shall be avoided so far as possible. When used, woodwork is to be of thoroughly seasoned teak or other approved wood, which is resistant to fungal decay and shall be free from shakes and warp, sap and wane, knots, faults and other blemishes. Woodwork shall be suitably treated to protect it against the ingress of moisture and from the growth of fungus and termite attack, unless it is naturally resistant to these

causes of deterioration. Joints in woodwork shall be dovetailed or tongued and pinned as far as possible. Metal fittings where used shall be of non-ferrous material. Wood screws shall be of dull nickel plated brass or of other approved finish.

1.1.22.6 *Adhesives*

Adhesives are to be specially selected to ensure the use of types that are impervious to moisture, resistant to mould growth, and not subject to the ravages of insects. Synthetic resin cement only shall be used for joining wood. Casein cement shall not be used.

1.1.22.7 *Rubber*

Neoprene and similar synthetic compounds, not subject to deterioration due to the climatic conditions, shall be used for gaskets, sealing rings, diaphragms, etc... instead of the standard rubber-based materials.

1.1.23 *Finishes*

1.1.23.1 *Galvanizing*

1.1.23.1.1

Materials to be galvanized shall be of the full dimensions shown or specified and all punching, cutting, drilling, screw tapping and the removal of burrs shall be completed before the galvanizing process commences. Galvanizing shall be done by the hot dip process with spelter, not less than 98% of which must be pure zinc. No alternative process may be used without the approval of the KSEBL. No components shall be galvanized which are likely to come into subsequent contact with oil. Bolts shall be completely galvanized including the threads, but the threads shall be left uncoated in the case of nuts.

1.1.23.1.2

The zinc coating shall be uniform, clean, smooth and as free from spangle as possible. In the case of component parts, the zinc coating shall weigh not less than 610 gm of zinc per square metre of the area covered and be not less than 0.09 mm in thickness.

1.1.23.1.3

All galvanizing shall comply with the requirements of IS 2633 or relevant ASTM standards. The KSEBL may select for test as many components to be weighed after pickling and before and after galvanizing as they may think fit. All galvanized parts shall be protected from injury to the zinc coating due to differential aeration and abrasion during the periods of

transit, storage and erection. The preparation of galvanizing and the galvanizing itself shall not adversely affect the mechanical properties of the coated material.

1.1.23.2 Chromium Plating

The chromium plating of the Work shall comply with the requirements of the relevant ASTM standards.

1.1.24 Anti-corrosion Measures

1.1.24.1 Materials

1.1.24.1.1 General Specifications

Materials shall be approved by the KSEBL. Materials shall be of first grade and used strictly in accordance with the Specifications and the manufacturers' written directions as approved by the KSEBL.

Detailed or special requirements are covered below in these Specifications. In general, materials and paint systems, which meet the following specifications, shall be used.

1.1.24.1.2 Cement Latex Milk

The cement latex milk shall consist of ten parts Portland cement (by weight), five parts of water and one part of modified latex emulsion.

1.1.24.1.3 Primer

Where specified shall be zinc-rich inorganic coating in conformity with SSPC PS 12.00-68T Red lead based primers shall not be used.

1.1.24.1.4 Coal Tar Epoxy

This shall be of the two package cold curing type, one package containing resin and the other the curing agent. Coal Tar Epoxy shall conform to SSPC-PS11.01.

1.1.24.1.5 Aluminium Paint

Aluminium paste for aluminium finish paint coat shall conform to ASTM Specification D962, Type II, Class B. Aluminium paint shall conform to SSPC-Paint 101-64T.

1.1.24.1.6 Rust Preventive Coating

Shall be gasoline soluble and shall conform to SSPC PS8.01-64T Type D.

1.1.24.1.7 Alkyd Enamel

Shall conform to SSPC-Paint 104.

1.1.24.1.8 Vinyl Paint

Shall conform to SSPC-PS4.02 or SSPC-PS4.04.

Items 1.1.24.1.7 and 1.1.24.1.8 above are acceptable alternatives for non-immersed steel.

1.1.24.2 Surface Preparation for Protective Coating**1.1.24.2.1**

The interior and exterior surfaces that will not be embedded in concrete shall be cleaned as specified and in accordance with SSPC-SP-10 for steel surfaces immersed in water and in accordance with SSPC-SP-6 for non-immersed steel surfaces.

1.1.24.2.2

Exterior surfaces which will be embedded in concrete shall be cleaned by power tool cleaning in accordance with SSPC-SP3-63.

1.1.24.2.3

Grease and oil deposits shall be removed by wiping the surfaces with a clean cloth dipped in mineral solvent.

1.1.24.2.4

After dry-blast cleaning, the surface shall be dusted off or blown off with compressed air free of detrimental oil and water.

1.1.24.2.5

Surfaces to be painted shall be completely dry, clean and free from moisture at the time of painting.

1.1.24.3 Extent of Protective Coating**1.1.24.3.1**

After surface preparation for each component, the surface shall be protected using the paints specified in the following manner. Paint shall be applied in accordance with SSPC-PA 1-64.

a) Steel Immersed in Water

Immersed steel surfaces shall be shop painted with 3 coats of coal tar epoxy paint.

Each coat shall be applied to a minimum dry film thickness of 0.125 mm. The paint for each coat shall be tinted so as to give distinct and easily visible colour difference to facilitate inspection. Areas adjacent to field welds shall be left unpainted and shall be protected for shipment by application of one coat of rust preventive coating.

b) Non-immersed Surfaces

Except where otherwise specified all non-immersed steel surfaces shall be painted with one shop coat of primer. The primer shall be applied to a minimum dry film thickness of 0.075 mm. Areas adjacent to field welds shall be left unpainted and shall be protected for shipment by application of one coat of rust preventive coating.

The shop intermediate coat will have a dry film thickness of not less than 0.04 mm. The intermediate coat shall be tinted to a colour contrasting with the shop and field prime coats.

The field finish coat will be applied to a minimum dry film thickness of 0.04 mm.

c) Embedded Surfaces

Embedded surfaces and all attachments to the embedded parts shall receive one coat of Cement Latex Milk.

1.1.24.4 *Shop Protective Coating Application*

1.1.24.4.1

The shop paint application shall be carried out in accordance with SSPC-PA-1. Except where otherwise specified, shop painting shall be:

- a) Immersed steel - 3 coats of coal tar epoxy paint;
- b) Non-immersed steel - one prime coat and one intermediate coat;
- c) Machined Surfaces - one coat anti-rust compound;
- d) Embedded steel - one coat cement latex milk;
- e) Field Weld Areas - one coat anti-rust compound;
- f) Generator Instrument Cubicles, Gauge Panels and Terminal Boxes:
 - Steam Phosphate treatment - one coat alkyd metal primer with dry film thickness 0.025 mm;
 - Interior - one coat white enamel with dry film thickness 0.025 mm;

- Exterior - one coat glossy alkyd paint with dry film thickness 0.025 mm.

1.1.24.4.2

Certain mechanical and other electrical auxiliary equipment (pumps, motors, cabinets, etc...) may be shop painted with primer and finish coats with the prior approval of the KSEBL.

1.1.24.5 *Field Procedure Coating Application*

Site painting and site repair to shop painting will be carried out by the Contractor and Contractor shall provide the following:

- a) all paint needed for the following to work at Site:
 - Immersed steel, at welds - 3 coats of coal tar epoxy paint;
 - Non-immersed steel - final coat (after prime coat and intermediate at welds, if applicable);
 - Surfaces and other appurtenances not shop painted which are rendered inaccessible after completion of erection - intermediate and finish coat (before erection).
- b) 25 litres of each type of paint used for shop painting for Site repair,
- c) 25 litres of each type of paint provided for Site painting for the Owner's subsequent use.

1.1.24.6 *Colours*

KSEBL will specify the final paint colours to be provided by the Contractor for the various Work components after award of Contract.

1.1.25 Electrical Requirements

1.1.25.1 *General*

This section of the specification covers the general technical requirements of **Electrical systems** to be provided under the scope of this tender contract. The provision of specific and detailed technical requirements given in other sections of this tender document shall take precedence over these general specifications in case of contradictions between these general specifications and the specific and detailed specification of other sections.

Following shall be considered while planning the general arrangement / layout of the plants:

- All outdoor equipment / devices are to be weather protected.

- All outdoor electronic instruments / devices are to be mounted in a weather proof housing with glass visor.

1.1.25.2 *General Design Requirements*

1.1.25.2.1

All equipment shall be of approved and reliable design. The highest extent of uniformity and inter-changeability shall be realized. The design shall facilitate easy maintenance and repair of the components.

1.1.25.2.2

The equipment shall be pre-assembled to the highest possible extent in the manufacturer works, e.g. wiring of panels, desks, etc..., including installation of internal components.

1.1.25.2.3

The contractor shall assume full responsibility for a coordinated and adequate design of all equipment specified and shall ensure that such equipment conforms to the best engineering practice for the operating conditions specified. When requested by the Engineer-in-Charge, the Contractor shall furnish complete information as to the maximum stress and other criteria used in the design.

1.1.25.2.4

All equipment shall be tropicalized and suitable for the prevailing climatic conditions on site. Open air installed equipment, if required by the KSEBL shall be protected against sun radiation by means of adequate metal covers.

1.1.25.2.5

Unless otherwise specified, all the electrical equipment shall be designed for tropical conditions with minimum class - B insulation according to relevant standards, except for motors, which shall have class - F insulation with class - B temperature rise.

1.1.25.2.6

The equipment shall operate satisfactorily under load, voltage and frequency variations as well as under short circuit and transient conditions within specified ratings and guarantee limits.

1.1.25.2.7

All electrical connections and contacts shall be amply dimensioned to carry continuously the specified currents without undue heating and shall be secured by bolts or set screws of ample size, fitted with lock nuts or lock washers. Lock nuts shall be used on stud connections carrying current.

1.1.25.2.8

All metal jointing surfaces and all moving, rubbing or wearing surfaces shall be machined or ground.

1.1.25.2.9

Means shall be provided for the lubrication of all bearings and of any mechanism or moving part. The lubricating points shall be easily accessible and in a conspicuous position.

1.1.25.2.10

All apparatus shall be designed to obviate the risk of accidental short circuits due to animals, birds and vermin.

1.1.25.2.11

All live, moving and rotating parts shall be adequately secured in order to avoid danger to the operating staff. All electrical components shall be electrically earthed.

1.1.25.2.12

All apparatus shall be so designed that water / oil / dust cannot collect at any point.

1.1.25.2.13

All interior surfaces including contactor or relay coils shall be treated in an approved manner to prevent mould growth; such treatment shall in no way interfere with the satisfactory operation of the equipment, either electrically or mechanically.

1.1.25.2.14

Copper employed for current carrying parts in the Works shall be electrolytic copper having a purity of not less than 99.9% and conductivity as per the relevant standard.

1.1.25.2.15

Cast iron shall not be used for any part of the equipment liable to fracture due to stress or shock. All mechanisms subject to action of atmospheric agents shall be constructed of stainless steel, brass or gun metal to prevent sticking due to rust or corrosion.

1.1.25.2.16

Electrical Equipment shall be designed to prevent ingress of vermin, dust and dirt. Where wiring, piping or ductwork passes through openings in equipment housings, such openings shall be constructed to prevent ingress of vermin. Wiring and piping enclosures and ductwork shall also be vermin proof.

1.1.25.2.17

Thermostat-controlled anti-condensation heaters shall be fitted in generator housing, cubicles or panels containing control and / or relay equipment, whether or not they are ultimately to be in an air-conditioned zone. They shall also be installed in all outdoor junction boxes. The heaters shall be suitable for 230 V AC, 50 Hz operation with sufficient capacity to raise the internal ambient temperature by 5°C. The design shall be such that when the equipment is in service with the heaters energized, the maximum permitted rise in temperature for the equipment shall not be exceeded.

1.1.25.2.18

The construction of panels and the location of heaters shall be such that an effective circulation of air is ensured. Equipment shall be provided with suitable drainage for condensation and shall be designed to be free from pockets where moisture can collect. Cable entries shall be sealed type.

1.1.25.2.19

All outdoor equipment whose performance is affected by the atmospheric temperature such as motors, compressors, etc... shall be weatherproof and protected by a sun canopy.

1.1.25.2.20

Separate trenches for power and control cables shall be provided as far as possible.

- Optimum routing and arrangement of all the cables shall be done.
- No cables shall be buried under foundations.

1.1.25.2.21

Regular cleaning of the panels as per the instruction of KSEBL's engineer till handing over of the set to customer is to be carried out by the contractor free of cost.

1.1.25.2.22

Suitable lifting eyes and forcing off bolts shall be provided where required or where they will be useful for erection and dismantling.

1.1.25.3 *Clearances*

The layout of the Equipment on the site shall provide for ready access for operation and maintenance whilst the remaining sections of Equipment are alive. Working clearance provided between isolated Equipment and nearest live metal work shall be as per Indian Electricity Rules and Relevant Standards.

1.1.25.4 *Power Supplies (Low Voltage)***1.1.25.4.1**

Equipment and devices requiring electric power shall conform with the following power supply parameters:

- (1) 415V, 3-phase 50Hz, 4-wire for power
- (2) 240V, single phase, 50 Hz for lighting, indication, and anti-condensation heaters and Alarm.
- (3) 110V D.C. for essential indication, controls, protection, alarms, closing and tripping supplies etc...
- (4) 48V DC for Communication etc...

1.1.25.4.2

The Contractor shall clearly indicate voltage, current and power requirements for each item of equipment.

1.1.25.4.3

Unless otherwise specified in this Specification or any appropriate Standard Specification, all electrical equipment shall be suitable for reliable operation at frequencies and voltages over the following ranges.

1.1.25.4.4

Voltage variations:

AC - 90% to 110% of nominal

DC - 75% to 120% of nominal

1.1.25.4.5

Frequency variations are between 47.5 Hz and 51 Hz.

1.1.25.4.6

Equipment furnished shall withstand the voltages and frequencies unbalanced continuously without damage, overheating, undue vibration or degradation beyond that expected for normal balanced three phase operation.

1.1.25.4.7

The single line diagram of the auxiliary system is indicated on the main single line diagram included in the tender drawings. The Contractor shall supply and connect all Control, Protection, Annunciation, signalling and power supply cabling required between various equipment and the low voltage AC and DC distribution panels and MCC's supplied under this Contract.

1.1.25.4.8

Double-pole switches shall be used to break single-phase A.C. mains supplies.

1.1.25.4.9

Following practices shall be adopted for DC supply:

- It shall be possible to remove / replace cards from / to electronic equipment without damage and without interfering with the operation of the rest of the equipment or system; if necessary consideration should be given to switching off the supplies locally to a card to prevent inadvertent interference to the equipment or system during removing / replacing a card.
- Application of battery or earth via a test lamp to any external interface point or test point shall not lead to any component damage.
- Power supply bus bars in cubicles shall be carefully routed and each bus bar shall be shrouded. It shall not be possible to inadvertently short bus bars either between themselves or to earth.

1.1.25.5 *Current Ratings*

The current ratings of the electrical equipment / devices shall be in accordance with relevant standard unless otherwise approved. The current ratings, if specified, are the

continuous current ratings required at the site under specified maximum operating temperature conditions.

Every current carrying part of the equipment shall be capable of carrying its site rated current continuously, without assistance from any forced cooled ventilation or air conditioning plant, under the site conditions as specified, and in no condition shall the permitted temperature rise be exceeded.

1.1.25.6 *Electrical Equipment Protection Classification*

All electrical equipment enclosures shall comply with the relevant Standard.

If not specified otherwise in the relevant specification the electrical equipment enclosures shall be designed to meet the following protection degrees.

A) Electrical Rotating Equipment

- Indoors located in ventilated areas - IP44
- Outdoors located - IP54
- Indoor / Outdoor located but in areas Where water spray / splashing is possible - IP65

B) Electrical (non-rotating) equipment (Switch gears, panels, lights etc.)

- Indoors located in the A/C or Ventilated areas - IP32
- Indoor located in non-ventilated areas - IP52
- Indoor / Outdoor located where heavy condensation is possible - IP54 with measures as per IEC 60528
- Indoor / Outdoor located but in areas where water spray / splash is possible - IP65

All luminaries installed in the areas where operation conditions and surroundings can lead to accumulation of gases, vapours or danger of explosion shall be of explosion proof. All luminaries installed in the enclosures where operation conditions may lead to high temperature surroundings shall be designed to withstand such temperatures.

1.1.25.7 *Protection against Live Contacts*

All live parts of the electrical equipment, which could be reached by hand, shall be

protected against direct contact by means of insulation or by special design and construction such as shields, shrouds, etc... Measures may be taken to prevent the occurrence or persistence of excessively high potentials on conductive parts of electrical equipment induced by faults in insulation.

Protection against direct contact must be ensured by suitable method when the switch-gears or control panels have been opened up for operation or maintenance. Suitable grounding equipment shall be provided for the discharge of high potential attained when the protective devices are withdrawn. Suitable protective grounding grid of copper shall be provided as a protection for conductive parts.

1.1.25.8 *Electric Motors*

1.1.25.8.1

The Contractor shall be fully responsible for determining that the motor duty cycle, rating, performance, tests and mechanical arrangements are all entirely relevant and suitable for compliance with all standards for the application in the power station and environmental and site conditions specified.

1.1.25.8.2

All the equipment driven by the electric motors shall give their rated performance even at a power supply frequency of 47.5 Hz.

1.1.25.8.3

The preferred type of AC motor is squirrel cage, totally enclosed, fan cooled, 1.0 service factor or single-phase motor under 0.5 HP where Contractor's standard type are acceptable subject to approval. Motors above 0.5 HP shall be 3 phase, if AC supplied. Motors shall be sized so that calculated horsepower requirements do not exceed 85% of nameplate ratings. Motors for frequent automatic starting shall have an adequate rating. In the motor list the contractor shall state the frequency of starts permitted in compliance with the motor design.

1.1.25.8.4

Generally, all motors shall be able to withstand five cold starts per hour, equally spaced. In addition, each M.V. motor shall be capable of enduring two successive starts with the motor initially at operating temperature. Each L.V. motor shall be capable of withstanding three successive starts under the same conditions or once every fifteen minutes without

detrimental heating. Motors for frequent automatic starting shall have an adequate rating. In the motor list the contractor shall state the frequency of starts permitted in compliance with the motor design.

1.1.25.8.5

The stator insulation shall be Class F or a higher class, but in each case temperature rises shall be limited to Class B where practicable on full continuous rated load. It shall be suitable for operation in damp locations and for fluctuations in temperature.

1.1.25.8.6

All motors shall be of the totally enclosed fan-cooled type, protection class IP54 according to IEC Recommendation 144. Cable termination points shall be of class IP55. They shall have a closed internal cooling air circuit re-cooled by an external cooling air circuit drawn from the opposite side of the driving end.

1.1.25.8.7

Vertical motors shall be provided with a top cover to prevent the ingress of dirt, etc...

1.1.25.8.8

Ball or roller bearings, lubricated for life, shall be used, and the ball or roller-locating cage shall not be in contact with the races. Lubrication devices shall be provided for the bearings. All other motors with ratings of about 1 kW and above shall be equipped with lubricators permitting greasing while the motor is running and preventing over-lubrication. Additionally, the bearings shall be fitted with grease nipples permitting the use of a universal grease gun. Vertical shaft motors shall have approved thrust bearings.

1.1.25.8.9

The terminal box shall be weatherproof and firmly fixed to the motor frame. The terminal studs shall be sized to be adequate for the current duty required and marked in accordance with applicable Standards. Terminal boxes shall have approved cable adapter plates, sealing chambers or conduit entries. The terminal boxes shall be of ample size to enable connections to be made in a satisfactory manner. Supports shall be provided at terminal boxes as required for proper guidance and fixing of the incoming cable. The terminal boxes with the cables installed shall be suitable for connection to supply systems with the short-circuit current and the fault clearance time determined by the motor protective devices. A permanently attached connection diagram shall be mounted inside the terminal box cover. If motors are provided for only one direction of rotation, this shall be

clearly indicated

1.1.25.8.10

The arrangement of the terminal box shall be such as to facilitate installation of cables, and allow interchanging of any two phase leads, without disturbing the sealing compound, if this is used at cable terminations.

1.1.25.8.11

Where practicable, the motor end cover remote from the driving end shall have a removable plug to allow the speed to be checked by means of a portable tachometer.

1.1.25.8.12

All motors supplied under this Contract shall be finished with its combination of magnetic starting contactors with disconnect switches and thermal overload devices which shall be mounted on or adjacent to pumping unit.

1.1.25.8.13

A permanently attached connection diagram shall be mounted inside the terminal box cover.

1.1.25.8.14

Motors having a mass of 10 kg or more shall be fitted with appropriate lifting lugs.

1.1.25.8.15

For earthing purposes, each motor shall have adequately sized bolts with washers at the lower part of the frame. In addition, each terminal box shall contain one earthing screw. Each equipment / panel shall be earthed by at least two separate earthing strips.

1.1.25.8.16

All precautions shall be taken to avoid any type of corrosion.

1.1.25.9 *Noise Level and Vibrations*

Under all operating conditions, the noise level of motors shall not exceed 85 dB (A). In order to prevent undue and harmful vibrations, all motors shall be statically and dynamically balanced.

1.1.25.10 *Tests*

Each motor shall be factory tested and shall undergo a test at site. The following tests shall

be performed under full responsibility of the Contractor.

Workshop Tests:

- Measurement of winding resistances
- No-load and short-circuit measurements
- Measurement of starting current and torque
- Efficiency measurement (type test)
- Heat test run
- Dielectric test
- Measurement of insulating resistance

1.1.25.11 *Starters and Contactors*

1.1.25.11.1

Motor starters shall be equipped with short circuit protection and local disconnecting devices. Preferably all starters shall be of one manufacturer. The control circuit voltage shall be obtained from a 415 / 230 V isolating transformer with primary circuit breaker and secondary fuse. The secondary winding of this transformer shall be grounded. The operating coils of the contactor shall be connected between the grounded side of the transformer and the control contacts.

1.1.25.11.2

Starters and contactors shall be suitable for direct on-line starting up to 50 kW, uninterrupted electrical duty and above 50 kW Star Delta starter shall be provided. They shall be installed in ventilated enclosures for indoor installation and weatherproof enclosures for outdoor installation unless otherwise approved by the KSEBL. The enclosures shall be complete with locks, cable sealing boxes, conduit entries, cable gland plates, bus bars, internal wiring, terminal boards, etc..., as required by the duty of the starter, or contactor.

1.1.25.11.3

Starters and contactors shall be capable of satisfactory operation, without injury, for a period of 5 minutes at a voltage 25% below nominal, at nominal frequency.

1.1.25.11.4

Each starter shall have sufficient number of auxiliary contacts required for interlocking and indication purposes plus two spare convertible contacts for KSEBL's use.

1.1.25.12 Moulded Case / Miniature Circuit Breakers

Moulded / Miniature circuit breakers shall be used instead of fuses and shall provide better protection and control under emergency and short circuit conditions.

Moulded case circuit breakers shall be of two or three pole as required, having thermal time delay and instantaneous trips with 'On-Trip-Off' indicating operating mechanism. Circuit breakers used in combination type motor starters or contactors shall have the operating mechanisms interlocked with the starter or contactor cover so that the cover cannot be opened unless the circuit breaker is open.

Miniature circuit breakers shall have suitable fault rating and shall comply with the requirements of IEC or equivalent standard and shall be of the high impedance design contained in an enclosure of high impact insulating material with ventilated deionising arc chutes. The circuit breaker shall be equipped with thermal and magnetic overload trips, shall have a trip free mechanism and have a tripping characteristic of 0.01 seconds at 7 times full load current.

Miniature circuit breakers shall be rated for the ambient temperatures prevailing at site and shall have the trip devices correctly calibrated, both according to the manufacturer's instructions. The selection and grading of the MCB's shall be as approved.

They shall be clearly labelled, both on the panels and the associated wiring diagrams.

MCB's shall be connected to enable all or any of the control circuits to be isolated for maintenance purposes. For DC circuits, isolation shall be provided on both poles. All MCB's shall be provided with required no of Auxiliary switches / Alarm contacts for MCB tripped indication.

1.1.25.13 Control Relays

Relays used as auxiliary control devices in conjunction with motor starters and magnetic contactors shall be of the type designed for machine tool application featuring contact convertibility. Contacts shall have a minimum rating of 10A over a range of 6 to 600V.

Relays shall be of approved type complying with relevant specifications and shall have approved characteristics and be flush mounted in dust proof cases. Relay cases shall generally be finished in bright black enamel. Classification shall comply with appropriate standard.

Relays contacts shall be suitable for making and breaking the maximum current they are required to control. Separate contacts shall be provided for alarm and trip functions.

Each relay shall be provided with at least two spare normally open and one spare normally closed contact.

Relays where appropriate, shall be provided with flag indicators of approved type phase coloured where applicable. Flag indicators shall be of the hand-reset pattern and shall be capable of being reset without opening the case. Where two or more phase elements are included in one case, separate indicators shall be provided for each element. Relays of the hand reset type shall be capable of being reset without opening the case.

Where adjustments of settings are required, the design of the relays shall be such that the adjustment can be carried out during operation without taking the relays out of service.

Approved Test Plugs shall be provided on the relay panels for the testing of protective relays and associated circuits.

To minimize the effect of electrolysis, relay coils operating on DC shall be so connected that the cells are not continuously energized from the positive pole of the battery.

Relays shall be provided with clearly inscribed labels at the front describing their application, rating and wiring diagram, in addition to the general information.

Protective relays shall be rated to match the designed system fault ratings and comply with classification type C to IEC 60292, where applicable.

Trip relay, where specified shall be of the high speed mechanically latching type with electrical resetting facilities and a common trip relay resetting push button, as required.

Under voltage protection relays should be of self-resetting type unless otherwise required. Relays shall be thermally matched such that the operating time do not exceed the thermal withstand time of the relay.

1.1.25.14 Control Switches and Push Buttons

Control switches for electrically operated Circuit breakers shall be of pistol grip type arranged to operate clockwise when closing the circuit breaker and anti clockwise when opening them. They shall be designed to prevent accidental operation and interlocked to prevent two successive operations in the 'Close' direction. All control switches and push buttons shall be in accordance with relevant IS or equivalent standard.

Switches for the other apparatus shall be operated by shrouded push buttons or to have handles of the Spade / Oval type, the pistol grip type being reserved for circuit breaker operation only. Control, reversing selector and test switches shall be mounted, constructed and wired so as to facilitate the maintenance of contacts without the necessity for

disconnecting wiring.

Control switches for circuit breakers and for motor operated setting devices, e.g. governor control, field rheostat control, etc..., shall be non-locking type with spring return to the 'neutral' position. Such switches shall be controlled by independent springs; the use of contact springs alone for restoring not being acceptable. Switches for special applications like Synchronising Selector shall be Keyed one (Lockable type) as required by the application philosophy.

All push buttons shall be of the non-retaining type made of non-hygroscopic material, non-swelling and fitted to avoid any possibility of sticking. All push buttons provided for remote stopping of motor control gear and all emergency stop push buttons shall be of the '**hold-in**' / **Stay-put** type requiring to be reset by being pulled out, or by a separate release device, which may be, associated 'Start' push button. The Emergency Push buttons shall be red coloured and provided with a cover, preferably in Red Colour. The contacts of all switches and push buttons shall be strong and to have a positive wiping action when operated.

All control switches shall be provided with labels complying with the specification in addition to clear indication as to the direction of each operation, for example, 'Open', 'Close', 'Raise', 'Lower', etc...

1.1.25.15 *Pilot Devices*

1.1.25.15.1

Pilot devices such as selector switches, push-button stations and thermostats shall be of heavy-duty type, and where mounted outdoors they shall be housed in weatherproof enclosures specially designed for the environment.

1.1.25.15.2

Electrical contacts for control, alarm and shut-down shall have a capacity of not less than 5 A at 110 V DC.

1.1.25.16 *Anti-condensation Heaters*

Any major items of electrical equipment which are liable to suffer from internal condensation due to atmospheric or load variations shall be fitted with heating devices suitable for electrical operation at 230 volt AC 50 Hz single phase of sufficient capacity to raise internal ambient temperature by 5° C.

Heaters in rotating electrical machines shall be switched on automatically by opening of the starter or breaker or vice versa. Heaters in switchgear / MCC cubicles, control cubicles, panels, desks etc... shall be controlled automatically by adjustable thermostat. The heaters shall be covered by metallic mesh to avoid accidental contacts and heater terminals shall be adequately shrouded. Each heater shall have built in over temperature protection.

The electrical apparatus so protected shall be designed so that the maximum permitted rise in temperature is not exceeded if the heaters are energized while the apparatus is in operation.

1.1.25.17 *Plugs and Sockets*

Plugs and sockets shall meet relevant Indian Standards.

1.1.25.18 *Indicating Lamps and Fittings*

The Indicating lamps shall be of LED type. Indicating lamps fitted to the faces of switch and instrument cubicles or panels shall be adequately ventilated. Lamps (**bunched LED type**) shall be easily removed and replaced from the front of the panel by manual means not requiring the use of extractors. The material holding the lamp glass shall be of an approved finish and to be easily removable from the body of the fitting so as to permit access to the lamp and lamp glass.

The lamps shall be clear and are to fit into an accepted standard form of lamp holder. The rated lamp voltage should be 10% in excess of the auxiliary supply voltage, whether AC or DC. Alternatively, if approved, low voltage lamps with series resistors could be provided, if proved to be of long life.

The lamps glasses shall be translucent and in standard colours, red, green, blue, white and amber and shall comply with relevant IS / IEC or equivalent standard. The colour shall be in the glass and not an applied coating and the different coloured glasses shall be interchangeable.

Transparent synthetic materials may be used instead of glass.

Unless otherwise specified all lamp colours shall conform to the following practice

Red	Energized or operative position.
Green	De energized or inoperative position.
Amber	Fault or abnormal condition.
White	Healthy or normal condition.

Blue

Control Supply monitoring / Signal used with label.

1.1.25.19 *Auxiliary Switches*

Where appropriate, each item of plant shall be fitted with all necessary auxiliary switches, contactors and mechanisms for indication, protection, metering, control, and interlocking supervisory and other service. Auxiliary switches shall conform to relevant Standard.

All auxiliary switches, whether they are in use or not in the first instance, shall be wired up to a terminal board on the fixed portion of the plant and shall be arranged in the same sequence on similar equipment.

Auxiliary switches mechanically operated by the circuit breakers, contactors, isolators, etc... shall be to the approval and contacts mounted in accessible positions clear of the operating mechanism of the circuit breaker, contactor, isolator, etc..., and they shall be adequately protected against accidental electric shock.

Auxiliary switches shall be provided to interrupt the supply of current to the trip coil of each circuit breaker and contactor immediately after the breaker or contactor has opened. These auxiliary switches shall make before the main contacts, during a closing operation.

The contactors or all auxiliary switches shall be robust and shall have positive wiping action when closing. Provision shall be made for extension of the switches and terminal boards when needed.

A minimum of four spare auxiliary switches, two normally open, two normally closed shall be provided for each circuit breaker, Isolator and contactor for KSEBL's use.

1.1.25.20 *Measuring Systems*

Electric measuring signals of 4-20 mA shall be transmitted to the control room for essential or regulating circuits. In this case the absence of live zero signal shall lead to a warning signal. Measuring signals for indicating purposes will be 4-20 mA. The components shall quickly respond to any changes of the measured magnitudes.

Measuring ranges of indicators, transducers, etc... shall be selected in such a way that the rated value of the measured magnitude covers approx. 75% of the range.

All local instruments shall, as far as practicable, be mounted vibration free to allow good reading. Wherever required, damping elements shall be used.

Corresponding systems shall be grouped together in local panels.

1.1.25.20.1 Temperature Measurement

Resistance thermometers and thermocouples shall be equipped with waterproof connection heads. The temperature sensors shall be selected in such a way to minimise the number of different spare inserts.

Resistance thermometers shall be used as far as possible and shall generally be of type Pt100.

The use of dial-type contact thermometers shall be restricted to bearing metal and oil temperature measuring.

1.1.25.20.2 Pressure Measurement

Pressure gauges shall be shock and vibration-proof (preferably by filling with glycerine) and shall be equipped with toothed wheels and toothed segments of the machined type. They shall completely be made of stainless steel.

The error for pressure transmitters shall be limited to $\pm 0.5\%$.

Each gauge, pressure switch and transmitter for absolute or differential pressure shall be equipped with a pressure gauge isolating valve including a test connection of the screwed type M20 x 1.5 mm so that such device can be removed without any disturbance of the plant operation.

If the pressure is pulsating, the devices concerned shall be connected via flexible tubes or other pulse-absorbing means.

The adjustment of the pointer shall be possible by means of an adjustment device without removing the pointer from its axle.

All casings shall be dust and watertight and be made of stainless steel.

1.1.25.20.3 Level Measurement

The liquid level measurements in reservoirs and tanks with atmospheric pressure shall be made by means of displacement-type transmitters, float-disc-transmitters or capacitance measurement type. The errors shall not exceed $\pm 1.0\%$ of the total measuring range. Level switches shall be of the externally mounted float or displacement operated type.

1.1.25.20.4 Electrical Measurement

All Electrical instruments shall be of flush mounted design, dust and moisture-proof.

Indicating instruments shall be flush mounted and shall comply with the latest standards applicable. All indicating meters shall be Digital Multi-function Meters (DMM) of Class 0.2S capable of displaying various parameters like voltage, current, MW, MVAR, MWh, MVARh, power factor, frequency etc... The Digital Multi-function Meters shall be provided in

duplicate. The LED digits shall be of sufficient size so as to have easy readability from the operator work table. The Digital Multi-function Meters shall have communication facility as per latest protocols which shall be finalised during detailed engineering in consultation with KSEBL.

Energy meters shall be suitable for unbalanced systems and accuracy of energy meters should be of 0.2S accuracy class.

All indicating instruments shall generally withstand without damage a continuous overload of 20% referred to the rated output value of the corresponding instrument transformers.

Ammeters shall not be damaged by fault-currents within the rating and fault duration time of the associated switchgear via the primaries of their corresponding instrument transformers.

All instruments mounted on the same panel shall be of same style and appearance.

All metering circuits shall be terminated in marked terminal blocks for remote metering purposes.

1.1.25.20.5 Position Measurement

Position transmitters for continuous position indication and measuring transducers shall have an output current of 4-20 mA and auxiliary supply voltage (if required) 48 V D.C.

1.1.25.20.6 Limit Switches

Limit switches shall be mounted suitable for easy adjustment and for rigidly locking in position after being adjusted. They shall be of heavy-duty rating and have two change-over contacts suitable for 48V D.C. Operation.

Switch fixings shall be positive and shall be unaffected by vibration. At the same time they should be capable of easy adjustment to suit changing parameters of the associated plant.

Particular attention shall be paid to potentially harmful environmental conditions, including water, oil, dust, dirt, temperature variations and differential expansions.

1.1.25.20.7 Contact Devices

Contacts of level switches, pressure switches, temperature switches, limit switches, and of all other devices shall be of the snap action type (SPDT). Contact devices for interlocking systems shall be separate, i.e., contact devices serving commonly for interlocking and other purposes will not be accepted.

1.1.25.21 Distribution Boards and Isolators

1.1.25.21.1

Distribution boards shall be provided throughout the plant for local distribution of lighting,

small power and welding supplies. The welding supply boards shall be completely separate, but the lighting and small power circuits may use a common distribution board.

1.1.25.21.2

Distribution boards shall be of 440V AC, 110V DC rating and conform to relevant standard and shall have an insulation withstand level 1 kV, AC, 1-2 kV DC respectively. All distribution boards shall be of the approved weatherproof enclosure type as specified elsewhere in the specification and shall be arranged so that the door or cover can be locked in the closed position.

1.1.25.21.3

Distribution boards shall be capable of with-standing without injury the mechanical and electrical stresses set up by fault currents for twice the period required to disconnect such fault on any circuit.

1.1.25.21.4

Distribution boards shall be provided with removable top and / or bottom knockout type gland plates for the outgoing cables corresponding to the circuit capacity of the distribution board. A suitable brass, grounding stud running throughout the length of distribution board shall be provided at top and / or bottom as required.

1.1.25.21.5

Indoor distribution boards shall be of sheet steel of 2 mm thickness with either a galvanized or enamelled finish. The finish colour of all indoor distribution boards shall be chosen to match the adjacent switchboards.

1.1.25.21.6

Outdoor distribution boards shall be of sheet steel with galvanized finish. The boards will be painted and the finish colour shall be to the approval of the KSEBL.

1.1.25.21.7

Neutral bars shall be drilled for an appropriate number of ways relative to the size of the board.

1.1.25.21.8

Barriers or fireproof insulation material shall protect the metal surface adjacent to any live

part and all spaces between phases.

1.1.25.21.9

Switch fuse units or isolators connected on the incoming side of distribution board shall be mechanically attached to the board with solid copper electrical connections between the units. A suitable insulated barrier shall be supplied to prevent copper or carbon dust released under fault conditions passing from one unit to the other.

1.1.25.21.10

The current rating of the bus bars in each distribution board shall not be less than the sum of maximum current rating of all outgoing circuits. The neutral connection for each circuit is to be direct to the neutral bus bar.

1.1.25.21.11

The distribution boards shall be either single pole or triple pole and neutral types and shall be equipped with means to provide over current protection to each circuit. This protection may comprise a miniature circuit breaker, which shall be removable without exposing live connections.

1.1.25.21.12

The cables feeding the distribution boards shall be connected directly to the incoming isolator or neutral bar as appropriate unless otherwise indicated by the specification.

1.1.25.21.13

Cabling to distribution boards shall generally be bottom entry. However, for indoor boards top entry may be permitted subject to the approval of the KSEBL. Cables entry to distribution boards shall be through cable glands and completely sealed after cable entry.

1.1.25.21.14

In cable compartments all live parts shall be covered after cable connection. Distribution board compartments shall be segregated from each other. Each bus section shall have coloured signalling lamps one for each of the control supplies (AC or DC) separately to indicate that these supplies are healthy.

1.1.25.21.15

Distribution boards for use on DC system shall be double pole types equipped with

adequately rated MCB's.

1.1.25.21.16

Approved type labels shall be fitted externally on the front cover of each distribution board describing its function with a suitable designation for easy identification of the equipment.

1.1.25.22 *Terminal Blocks*

1.1.25.22.1

Terminal blocks shall be mounted in an accessible position with the spacing between adjacent blocks not less than 200 mm and the space between the bottom blocks and the cable gland plate not less than 250 mm. Sufficient terminals shall be provided to allow for the connection of all incoming and outgoing cables including spare conductors and drain wires. In enclosed cubicles, the terminal blocks shall be inclined towards the door for facilitating terminations. All terminations of the Field cables or inter-equipment cables shall be terminated in the terminal block on the side facing the door for easy access. Terminal Blocks shall be logically grouped, indelibly marked and provided with removable plastic shrouds.

1.1.25.22.2

The terminals shall be of the channel mounting type and shall comprise a system of individual terminals so that terminal blocks can be formed for easy and convenient cabling consistent with the high reliability required of the circuits. Terminals for Current circuits shall be Stud Type with nuts, washers and lock nuts or lock washers.

1.1.25.22.3

The terminal blocks shall be provided with shorting links and paralleling links where applicable, and mounted identification numbers and / or letters.

1.1.25.22.4

Terminal blocks shall conform to the applicable standards. The smallest size to be used shall be designated for 2.5-sq. mm wire and not more than two conductors shall be connected under one terminal clamp.

1.1.25.22.5

Terminal identification shall be provided corresponding to wire number of connected leads.

1.1.25.22.6

415 / 240 V AC circuit terminals shall be segregated from other terminals and shall be fitted with non-inflammable transparent plastic covers to prevent contact with any live parts. Warning labels with red lettering shall be mounted thereon in a conspicuous position. Segregation of different Voltage levels within the terminal blocks shall be achieved using barriers. Voltage levels shall be clearly identified by labels. Terminal Blocks associated with external sources of supply shall be fully shrouded and fitted with a danger-warning label. All connections shall be made at the front of the terminal board and no live metal shall be exposed at the back.

1.1.25.22.7

20% of all types of terminals shall be supplied as spare.

1.1.25.23 *Panel Wiring***1.1.25.23.1**

Wire colours shall comply with relevant standard, viz.:

- Colour of Wire Circuit Particulars
- Red -Red phase connections in current and voltage transformer circuits only.
- Yellow -Yellow phase connections in current and voltage transformer circuits only.
- Blue -Blue phase connections in current and voltage transformer circuits only.
- Green / Yellow connections to earth.
- Black AC neutral connections, earthed or unearthed, connected to the secondary circuit of current and voltage transformers. AC connections other than those above and connections in AC / DC circuits.
- Grey Connections in DC circuits.

Wiring diagrams must indicate wire colours. For back-wired panels all diagrams shall be drawn as viewed from the back of panel. For front wired panels all diagrams shall be drawn as viewed from the front.

1.1.25.23.2

All wires shall be fitted with numbered ferrules of approved type at each termination, double ferrules shall be provided wherever applicable.

1.1.25.23.3

All panel wiring shall be neatly fixed on the sides of the cubicles and shall be carried out with 650 / 1100 V grade stranded tinned copper wire, PVC insulated, fire proof and suitably

lugged. Unless otherwise approved, no insulated wire shall have less than three strands and each strand shall not be less than 0.91 mm in diameter. If single conductor is approved for instrument wiring, annealed copper of circular cross section shall be used and the diameter of the copper shall not be less than 2 mm. **All instrumentation wiring shall be of screened cables.**

1.1.25.23.4

All wiring connections shall be readily accessible and removable for test or other purposes. Wiring between terminals of the various devices shall be point to point.

1.1.25.23.5

All panel wiring shall be taken to approved terminal boards. The relay and control cubicles shall be supplied complete with necessary terminal glands and end boxes for terminating the multi-core cables.

1.1.25.23.6

Electrical wiring and instruments shall be so located that leakage of oil or water cannot affect them.

1.1.25.23.7

Bus wiring between control panels etc..., shall be provided under this contract and shall be fully insulated and to be completely segregated from the main panel wiring.

1.1.25.23.8

All metallic cases of instruments, control switches relays etc..., mounted on control panels or in cubicles, steel or otherwise, shall be connected by means of bare copper conductors of not less than 4.5 mm² section to the nearest earth bar.

1.1.25.24 *Small Wiring*

1.1.25.24.1

All control panel wiring, secondary control wiring in circuit breakers, motor starters, control gear, etc..., shall be carried out in a neat and systematic manner with cables supported clear of the panels and other surfaces at all points to obtain free circulation of air.

In all cases, the sequence of the wiring terminals shall be such that the junction between multi core cables and the terminals are effected without crossover. Insulating bushes shall be provided where necessary to prevent the chafing of wiring.

1.1.25.24.2

All panel wiring shall conform to the requirements of relevant standards.

1.1.25.24.3

Except for rack-mounted equipment, each panel conductor shall be individually identified at both ends through a system providing ready and permanent identification, utilizing slip-on ferrules approved by the KSEBL. Paper ferrules are not acceptable.

1.1.25.24.4

The markers may be typed individually or made up from sets of numbers and letters firmly held in place. Open (C-Type) markers will not be accepted.

1.1.25.24.5

All wires directly connected to Trip circuits / Tripping switches etc.. shall employ markers having a red background and with the label "TRIP", engraved on it in white.

1.1.25.24.6

Sensitive control circuits shall be effectively shielded against extraneous signals and interference.

1.1.25.24.7

Wiring connections shall be readily accessible and removable for test or other purposes. Wiring between terminals of the various devices shall be point to point and shall not be jointed between terminal points.

1.1.25.24.8

Splices or tee connections are not acceptable. Wire runs shall be neatly arranged inside the panels and adequately supported by either clamping of loomed runs or in PVC wiring troughs. Trunking fill shall not exceed 75% of its capacity. Self-adhesive fixings are not acceptable. The self-supporting arrangement for wiring, if used, shall be such that they are not liable to cause permanent physical damage to the conductor or insulation. Whenever possible, unused areas of the panels shall be kept free of wiring to facilitate the installation of future equipment. With the exception of wiring direct to specific equipment, all wiring shall be located on side of the panels.

1.1.25.24.9

All wires shall be terminated with approved pin crimped terminations.

1.1.25.24.10

CT secondary shall be earthed at one point through a removable link. Each of the CT circuit shall be in separate cables.

1.1.25.25 *Bus bars, Bus ducts and Connections***1.1.25.25.1 Bus bars**

Bus bars, bus ducts and connections shall comply with relevant IEC or equivalent standards and shall be electrolytic copper, unless otherwise approved by the KSEBL.

The bus bars, assemblies and connections of equipment for service up to 11KV shall be of a type, which does not rely solely on air for insulation purposes. The covering material shall be non-deteriorating at the rated short - time maximum temperature of the bus-bars and shall have such thickness as is required to withstand rated line to line voltage between bus-bar and a conducting object on the exterior of the covering material for a period of not less than 60 seconds.

The bus-bars and bus ducts shall be capable of carrying the full rated current continuously without exceeding the maximum temperature specified in the relevant standard, under site ambient conditions.

The bus-bars and their connections, and insulation materials as appropriate shall be capable of withstanding, without damage, the thermal and mechanical effects of a through fault current equivalent to the short -time rating of the switchgear.

Facilities to the approval of the KSEBL's Engineer shall be provided to accommodate thermal expansion of the bus bars and associated components including the insulating medium if appropriate.

Bus bars shall be contained in a separate completely enclosed compartment within the general casing of switchgear. Bus-bar barriers shall be provided between switchgear equipment to prevent the spreading of ionised gases in the event of a fault. Main and auxiliary bus bars shall be covered with insulating sleeves to safely prevent internal bus bar faults and spreading of arcs. All bus-bar connections and joints shall be silver-plated.

The fixed plug-in contacts of bus bars shall be protected by automatically closing shutters if the corresponding switchgear is removed.

Access to bus bars and the connections directly connected thereto shall be gained only by the removal of covers secured by bolts or screws. Such covers shall be clearly and indelibly marked "BUS-BARS".

Bus bars shall be extensible at both ends; such extension shall entail the minimum disturbance to bus bar compartments.

Bus bars shall be of uniform cross-sectional area throughout the length of a switchboard and shall not be of a varying (tapered) section.

1.1.25.25.2 Bus ducts

Bus ducting, where it passes through walls, shall have provision for weather sealing.

Where bus ducting is located outdoors it shall be weather and dust protected to IP55.

Each bus ducting shall be equipped with a Silica Gel breather.

The Contractor is required to confirm in his tender whether or not any bus ducts included, require sun-shade due to the ambient conditions and must demonstrate that such sun - shades, where provided, are adequately supported.

Where the bus duct interconnects the transformer at one end and to the switchgear at the other end, flexible copper braids shall make such connections.

Where necessary, expansion joints shall be provided in the run of the bus ducting.

Drawing must be submitted with the tender showing the run of bus ducting, the details of the connections to the transformer, the switchgear and expansion joints.

1.1.25.25.3 Conduits

Conduit, accessories and trunking installation shall comply with the latest issue of the standards.

Exposed conduits shall be of galvanized rigid steel, and shall run parallel to the structural lines. Suitable conduit fittings and covers shall be used. Standard circular boxes or machined face heavy-duty steel adaptable boxes with machined heavy type lids shall be used throughout. For outdoor mounting all boxes shall be galvanized, weatherproof and fitted with external fixing lugs. The conduit shall be fastened using malleable iron pipe straps at spacing not greater than 500 mm. Minimum conduit size shall be 20 mm.

Supports for conduit, cables and fittings supplied under this Contract shall be removable and clamped to the building structure, wherever possible, in preference to being directly connected by bolting, screwing, welding, etc... Cable trays in the powerhouse substructure

shall be fastened to steel inserts cast into the concrete. Conduits shall be supported on heavy galvanized spacer saddles so as to stand off at least 6mm from the fixing surface.

Bends in conduit shall be made cold and the radius of bends shall not be less than nine times the conduit diameter. No bend shall be permitted to flatten the conduit. The use of running threads, solid elbows and solid tees will not be permitted.

Wherever the conduit crosses a structural expansion / contraction joint, approved expansion fittings and couplings with bonding jumpers shall be provided. Flexible metallic conduit shall be used where relative movement is required between the conduit and connected apparatus, and a separate copper connection provided to maintain earth continuity.

Where conduit is terminated so that the bare end of the conduit is exposed the conduit end shall be fitted with a brass bush. Conduit ends shall be carefully reamed to remove burrs. Draw-in boxes shall be provided at intervals not exceeding 10m in straight-through runs.

Conduit runs shall be in either the vertical or horizontal direction unless otherwise approved and shall be arranged to minimize accumulation of moisture. Provision for drainage shall be made at the lowest points of each run.

All conduits run in any circuit are to be completed before any cables are pulled in. The maximum number of cables in any conduit shall be in accordance with the latest issue of the Regulations for the Electrical Equipment of the Buildings.

1.1.25.26 *Cubicles, Desks and Control Panels*

1.1.25.26.1

Unless otherwise specified, panels, desks and cubicles, shall be of floor mounted and free standing construction and be in accordance with the specified enclosure classification. All control and instrumentation panels in any one location shall be identical in appearance and construction. Cubicle and control panel enclosures shall be of sheet steel with minimum thickness of 2.5 mm of rigid, self-supporting construction and supplied with channel bases.

1.1.25.26.2

Cubicles shall be fitted with close fitting, gasketed, hinged lift-off doors capable of being opened through 180 degrees. The doors shall be provided with integral lock and master key. Door sealing materials shall be provided suitable for the specified site conditions. Cubicles and cubicle doors shall be rigidly constructed such that, for example, door

mounted emergency trip contacts can be set so that mal-operation will not be possible due to any vibrations or impacts as may reasonably be expected under normal working conditions.

1.1.25.26.3

Cubicles and panels shall be provided with removable Steel gland plates located to provide adequate working clearance for the termination of cables (at least 250mm from the floor of the cubicle). Under no circumstances shall the floor or roof plate be used as a gland plate. The cables and wiring shall enter from bottom or top as approved or directed by the KSEBL.

1.1.25.26.4

The cubicles and panels shall be adequately ventilated, if required, by screened vents or louvers, which shall be so placed as not to detract from the appearance. All Panels, desks and cubicles shall be vermin proof. All cable entries to equipment shall be sealed against vermin as soon as possible after installation and connecting-up of the cables to the approval of the KSEBL. All cubicles, desks and panels shall be provided with a natural air circulation ventilation system. All control equipment shall be designed to operate without forced ventilation. Dust protection where appropriate shall be provided.

1.1.25.26.5

Where cubicles are split between panels for shipping, terminal blocks shall be provided on each side of the split with all necessary cable extensions across the splits. These cable extensions shall be confined within the panels with suitable internal cable ducts. For a set of panels, inter-panel bus wiring shall be routed through apertures in the sides of panels and not via external multi-core cabling looped between the panels.

1.1.25.26.6

Unless stated otherwise, cubicles and panels, whether individually mounted or forming part of a set, shall be provided with a internal ground bus with 40 mm x 5 mm copper bar extending throughout the length on to which all panel earth connection shall be made. Each end of this bus shall be drilled and provided with suitable studs or holes to the approval of KSEBL, for connecting to the main station grounding system, using cables ranging from 70 to 100 sq. mm and for possible future extension.

Earth connection between adjacent panels shall be achieved by extending the bar through the panel side and not by interconnecting external cabling.

1.1.25.26.7

The standard phase arrangement when facing the front of the motor control centres and switchboards shall be RYB from left to right, from top to bottom and front to back. All instruments, devices, buses and other equipment involving three phase circuits shall be arranged and connected in accordance with the standard phase arrangement, where possible. Electrical clearances shall conform to applicable standards and shall not require the cutting away of adjacent framework.

1.1.25.26.8

Instruments, control buttons and indicating lamps shall be flush mounted on the panels. Relays and other devices sensitive to vibration shall not be installed on doors or hinged panels, and no equipment shall be installed on rear access doors.

1.1.25.26.9

Cubicles and panels shall be securely fastened down to the floor and braced against lateral movement induced by earthquake forces. Panels shall be mounted on an approved form of anti-vibration mounting whenever necessary.

1.1.25.26.10

The instrument and control wiring including all electrical interlocks and all interconnecting wiring between sections shall be completely installed and connected to terminal blocks by the Contractor.

1.1.25.26.11

Control panels and cubicles shall be supplied with door operated interior lights, socket outlets and jacks with provision for connection to the station telephone system and is clearly labelled with the Circuit Name at front and rear, with an additional label inside the panel.

1.1.25.26.12

The arrangement of control and protection devices on the panels and the exterior finish of the panels shall be subject to the approval of the KSEBL. The interior of all cubicles and panels shall have a mat white finish unless specified otherwise. Overall height, excluding cable boxes, shall not exceed 2.5m. Operating handles and locking devices shall be located within the operating limits of 0.75m and 1.8m above floor level. The location for indicating instruments and meters shall be 1.5m above floor level, unless otherwise

specified elsewhere in the specification.

1.1.25.26.13

Panels shall be suitably designed to permit future extension wherever appropriate or specified.

1.1.25.26.14

Panel sections accommodating equipment at voltages higher than 110V shall be partitioned off and the voltage clearly labelled. Labels permanently attached to the panel and adjacent to the equipment concerned shall identify each relay and electronic card within panels. Where instruments are terminated in a plug and socket type connection both the plug and the socket shall have permanently attached identifying labels.

1.1.25.26.15

Instrument and control devices shall be easily accessible and capable of being removed from the panels for maintenance purposes. Termination, wiring and cabling shall be in accordance with relevant clauses of the specification.

1.1.25.27 *Junction and Marshalling Boxes*

1.1.25.27.1

Junction and marshalling boxes shall be of substantial sheet steel construction, having enclosure classification as specified and fitted with external fixing lugs and finished painting as specified. The boxes shall allow ample room for wiring, with particular regard to the routing of wires from the point of entry. Outdoor boxes shall be weather proof and shall have anti condensation finish and all boxes shall be designed such that any condensed water cannot affect the insulation of the terminal boards or cables. No cables shall be terminated into the top of outdoor boxes unless specifically approved by the KSEBL.

1.1.25.27.2

Each box shall be complete with suitably inscribed identification labels.

1.1.25.27.3

All necessary gland plates are to be provided. Every unused outlet shall be sealed. Unused screwed entries shall be sealed by means of a tamper proof screwed plug.

1.1.25.27.4

All box covers are to be arranged for padlocking and padlocks with keys shall be supplied.

1.1.25.27.5

All boxes shall be provided with adequate grounding bars and terminals.

1.1.25.28 *Interconnections / Contact Terminal Points***1.1.25.28.1**

The Contractor shall supply and supervise the installation of all interconnecting wiring between various items of the Work, except where otherwise specified. The Contractor shall be responsible for making all terminal connections where equipment supplied under this Contract connects with equipment existing or provided under other Contracts and the Contract includes waiting upon other contractors as may be necessary. The contract includes the termination and connection of all cables, which are supplied under this Contract.

1.1.25.28.2

Unless otherwise specified, all cables for external connections will be supplied and installed complete with cable glands by the Contractor. The Contractor shall ensure the correct functioning of related equipment and instrumentation.

1.1.25.29 *Equipment Grounding***1.1.25.29.1**

All equipment including pipe work, structural work, and non current carrying metalwork supplied under this Contract in or on which is fitted any type of electrical equipment, shall be provided with two separate grounding terminals, suitable for connection by means of copper strip or stranded copper strip or stranded copper conductor to the station grounding system. The Contractor shall supervise connection of the earthing conductors to these terminals as approved or directed by the KSEBL.

If required a suitable earth grid of copper strip shall be provided around the plant for terminating the equipment and works. The provisions for grounding are to be such that no reliance is to be placed on the conductivity of metal-to-metal joints without the use of special connectors.

VT and CT neutral or common lead shall be earthed at one place at the terminal blocks

where they enter the panel. Such earthing shall be made through links so that earthing may be removed from one group without disturbing continuity of earthing system for other groups.

1.1.25.29.2

Unless specified otherwise, earthing conductors from the station earthing bus to the equipment should be provided by the Contractor.

1.1.25.30 *Alarm Contacts*

1.1.25.30.1

All alarm contacts shall be of galvanically isolated Form C type.

1.1.25.30.2

Where required, relays should be provided as contact multipliers.

1.1.25.31 *Electronic Equipment*

All components and assemblies shall meet the requirements of the appropriate sections of the IS standards or equivalent and in particular those sections which refer to equipment stored and operated in a tropical environment.

1.1.25.31.1 *Electronic Equipment Grounding*

Electronic equipment shall be provided by specially insulated grounding bus-bar connected to a single point of the main grounding grid by two parallel conductors so that no fault current or circulating current will flow in electronic grounding system. All electronic equipment and panels shall be grounded through the electronic bus bar provided.

1.1.26 *Rating Plates, Name Plates, Labels & Signs*

The size of Rating / nameplates & labels and the height of lettering shall be suitable for the equipment, and is subject to the approval of the KSEBL.

Suitable metallic warning signs and labels shall be provided for the plant items where danger or possibility of danger exists or there is prohibition of certain action. Such warning signs shall be in red and white colour combination and shall be affixed in a clearly visible location. Where required by the KSEBL a list of precautions and procedures to be adopted when emergency or danger occurs shall be affixed. Such list shall be on a yellow coloured back ground with black coloured, lettering of minimum 6mm.

Enclosure with risk of fire or excessive heat or excessive noise shall be provided with appropriate warning signs and labels. Enclosures, which are protected with fire protection by CO₂ or Halon, shall be provided with warning labels with first aid instructions.

1.1.26.1

A rating plate of non-corrodible material and of approved size shall be permanently attached to each major and auxiliary item of Work in a conspicuous position. Major equipment nameplates shall be of stainless steel and shall be fixed to the apparatus with non-busting screws. This plate shall be permanently engraved in English with the designed full load ratings, rated voltage, temperature rise, class of insulation, frequency, serial number, type number, date of manufacture, and other identification deemed necessary to provide complete information of the plant / equipment. Where required by the KSEBL, diagram plates shall also be supplied. The English language and metric or SI units shall be used for the plates.

1.1.26.2

All items of plant shall be provided with a non-hygroscopic material nameplate or label designating the service and identification number of the equipment or device in English language. The engraving shall be of a contrast colour to the base material colour or as approved. The pumps, engines, compressors, motors, transformers, breakers, panels, etc..., shall be provided with a stainless steel rating plate (minimum 2mm thickness) engraved with details indicating all the basic parameters and circuit diagrams. The identifying inscription shall be approved by the KSEBL or conform to that designated in the appropriate sections of this Specification. Devices shall be identified by nameplates on both front and rear of all desks, panels, cubicles etc... In case of circuit breakers, starters, etc..., white transparent plastic material with lettering engraved on the back and filled with black material can also be provided. The minimum size of lettering shall be not less than 3mm high. All equipment inside cubicles, panels, boxes, etc..., must be properly labelled with their item number. This number shall be the same as indicated in the pertaining documents (wiring diagrams, equipment lists, etc...). Sticker type labelling shall not be accepted.

1.1.26.3

Nameplates or labels manufactured for indoor panels shall be of non-hygroscopic laminated plastic material with white plate and black engraving. The materials used shall

be non-fading, non-aging and suitable for tropical conditions. The minimum size of lettering shall be not less than 3mm high.

1.1.26.4

Items of the plant which are subject to handling or which are of castings such as valves etc... shall be provided with an engraved chrome plated brass / stainless steel label, 3 mm thick with the engraved lettering filled with enamel.

1.1.26.5

The proposed material of the labels, the size, the exact label inscriptions as well as proposals for the arrangement shall be submitted to the KSEBL for approval.

1.1.26.6

Labels written in English shall be provided for all instruments, relays, control switches, push buttons, indication lights, breakers, etc... In case of instruments, instrument switches and control switches, where the function is indicated on the dial plate or switch plate, no label is required.

1.1.26.7

The label must be fixed close to the instruments in such a way that easy identification is possible. Fixing on the dial glass of instrument shall not be accepted. The wordings shall conform to the wording used in engineering documents and shall be submitted for approval of the KSEBL.

1.1.26.8

All devices and components shall be identified by their identification numbers. Cubicles and similar units shall also bear this identification number on the rear side if rear access is maintained.

Warning Labels

- i. Warning labels shall be made of polycarbonate board with letters engraved in Malayalam and English. For indoor equipment such as circuit breakers, starters, etc... warning labels made of plastic material with suitably contrasting colours and engraved lettering shall be provided as described below.
- ii. LV switchboards shall have white base with 5 cm black letters reading "MAINS 415 / 240 VOLTS".

- iii. MV / LV switchboards and transformers shall have white warning labels with 7.5 cm letters reading "DANGER-11000 VOLTS or 415/240 VOLTS" in RED.

Labels for cables

- i. Each cable when completely erected shall have permanently attached to it at each end and at intermediate positions as may be considered necessary by the KSEBL, non-corrodible labels detailing identification number of the cable, voltage and conductor size.
- ii. The cable identification number shall comply with those of the cable schedule, which shall be prepared by the Contractor for the actually laid cables.
- iii. All cables in cable pits and at entry to building blocks shall be labelled utilizing the above-mentioned type of labels.

1.1.27 Packing and Transport

Each item shall be packed properly or protected for shipment and transport from manufacturer works to the site and storage on the Site. The packing or protection used shall remain serviceable for a period of at least one year at site.

Where practicable, all indoor items such as electric motors, switches and control gear, instruments and panels, machine components etc..., shall be 'cocooned' or covered in polyethylene sheeting, sealed at the joints and enclosures provided internally with an approved desiccators.

1.1.27.1

Each equipment shall be shipped completely assembled and shall be provided with lifting devices for attachment of crane slings to facilitate its handling. Components which could be damaged during shipment shall be packed separately, and shall carry complete identification. Packages shall not exceed 3 m x 3 m. Drying agent shall be included in each package and crating shall be airtight. All cases, packages etc..., shall be clearly marked on the outside to indicate the total weight, to show where the weight is bearing and the correct position of the slings and shall bear an identification mark relating them to the appropriate shipping documents. All marking shall be either of water proof material or protected by shellac or varnish to prevent obliterations in transit.

1.1.27.2

Packing shall be done for sea transport to India and shall be suitable for long term storage.

1.1.27.3

Suitable precautions shall be taken to ensure that pipe, tube and pump open ends are protected from ingress of dirt and moisture and external damage. All flanges shall be fitted with protective blanks, secured by a number of bolts not less than 50% of the number of bolts holes with a minimum of four. All rotating machines shafts and bearings shall be supported properly for protection from movement likely to occur in transit.

1.1.27.4

Spare parts or materials shall be packed in the specified manner and delivered in approved cases suitable for storing such parts and material over a period of several years.

1.1.27.5

The KSEBL's representative may inspect and approve the packing before the items are dispatched. The contractor shall inform the KSEBL when the packing is ready. Such inspection will not exonerate the Contractor from any loss or damage due to faulty packing. Equipment shall be despatched only after getting despatch clearance from the KSEBL / Engineer-in-Charge after approval of test reports submitted by the Contractor after factory acceptance tests.

1.1.27.6

After the completion of erection / installation the Contractor shall deliver all the empty packages, cases, cable drums etc... to the KSEBL's stores in an approved manner.

1.1.28 Concreting and Erection Supervision**1.1.28.1 *General Supervision Requirements During Concreting of Embedded Parts***

The Contractor shall attend concreting as required in the relevant section of the current document in addition to the following requirements:

- i. The Contractor shall supervise the placing of anchor bolts to be embedded in the foundation concrete and shall satisfy himself that these are accurately positioned, securely anchored in the concrete and are adequate to hold down the associated parts of the Work while these are being embedded in concrete. The Contractor shall carry out all measures necessary to ensure

that parts to be embedded in concrete are securely held in position and in particular will ensure that tie rods are evenly tensioned to the correct degree by means of turn-buckles and that the anchors are properly welded to form a complete ring and are not left as open hooks.

- ii. Embedded parts shall be designed to permit a concrete pouring without affecting the laid out parts.
- iii. During concrete pours, vibrators will not be allowed to touch any metal part embedded in the concrete, and the concrete will be placed evenly and neither dumped nor discharged from chutes in such a manner as to disturb the embedded parts.
- iv. Where possible, the Contractor will keep the interior of the embedded parts wet by water spray to prevent expansion by the heat of hydration. Grouting of voids will not be undertaken sooner than 7 days after concreting the embedded parts.

1.1.28.2 *General Supervision Requirements During Erection*

i. General Specifications

The Contractor shall ensure that the Work is correctly installed in accordance with the approved erection drawings and procedures, provided by him.

ii. Layout, Measurements and Datums

The Contractor shall layout basic building lines and establish datums, and shall be responsible for the proper performance of the Work.

iii. Erection Marks

All equipment and their sub-assemblies and accessories such as piping frame works, supports etc... which are to be installed at site shall be marked with distinguishing identification marks or numbers. Where the surface of the material require anti-corrosive treatment, impress marks shall be used.

iv. Erection & Checking at site

All work at site shall be carried out in such a manner as not to obstruct the operations of any other contractor or the running equipment at the site. In case of any interconnections are required with the existing plant / equipment or with the works of other contractors, the Contractor shall make the same with prior approval.

The Contractor shall obtain from the KSEBL / KSEBL's representative details of the parts, which he wishes to inspect, but such inspection shall in no way exonerate the Contractor from any of his obligations. The Contractor, if requested by the KSEBL's representative, shall open up for inspection before erection any equipment, which has been delivered to the site partly / fully assembled. Contractor shall reassemble the equipment after inspection.

The Contractor shall keep the site on which he erects or stores plant, reasonably clean.

On completion of the works, the site is to be left clean and tidy and obtain necessary clearance from the responsible KSEBL's representative. **Any damage done to the existing buildings, structures and plant or property belonging to the KSEBL shall be made good at the Contractor's expense.**

1.1.29 Inspection, Tests on Completion and Commissioning

Approval of assemblies, tests, inspections, related procedures etc... and acceptance of pertinent test and inspection certificates, or waiving of inspections or tests, shall in no way relieve the Contractor of his contractual obligations for finishing the Works in accordance with the provisions of the Specifications.

1.1.29.1 General Specifications

- i. Testing, pre-commissioning, & commissioning will involve, though not limited to these: setting / adjusting, testing, proving, trial runs, etc... of various equipment and systems installed.
- ii. During erection, commissioning and trial operation, the Contractor shall perform at suitable intervals all inspections and tests in the presence of the Engineer in order to prove the orderly execution of the works in accordance with the Contract. Unless otherwise specified, all costs for testing at site and of the works and charges associated with it shall be borne by the Contractor. This includes the measuring devices, properly calibrated, and any pertinent accessories, which shall be made available by the Contractor for the entire duration of the tests. The Contractor shall delegate his experts to perform the tests at site.
- iii. Testing and commissioning of all Work at site will be in accordance with detailed programs and procedures prepared by the Contractor and approved by the KSEBL. Such programs and procedures shall include all tests specified in this Specification.

Wherever equipment supplied under several Contracts is tested together as a unit, the KSEBL will coordinate the preparation of test programs and procedures, and the execution of the tests among the respective Contractors.

- iv. The contractor shall perform various activities during pre-commissioning, Integrated Testing, post-commissioning stages of equipment covered under this tender specification. Field testing and commissioning shall be carried out by the Contractor prior to the acceptance of the Work or part of the Work. All tests shall be witnessed by the KSEBL .
- v. The Contractor shall provide at site all experienced personnel (engineers and technicians), test equipment, instruments, wiring, tools and plant, accessories etc... required to carry out the tests and record their results in a satisfactory manner. The Contractor shall calibrate all necessary test instruments and equipment, and include calibration records in the respective test reports.
- vi. In cases where doubt exists regarding the tests, the KSEBL may request repetition of such tests.
- vii. Contractor shall earmark separate manpower for respective area of testing and shall not be disturbed / diverted for other work. The contractor's commissioning group shall work as per the instruction of KSEBL's Representative and they shall coordinate day-to-day activity with other agencies at site. The testing activity may have to be repeated till satisfactory results are obtained.
- viii. The KSEBL reserve the right to witness any tests both at factory and at site. The Contractor shall advise the KSEBL at least 10 working days prior to the start of such tests.
- ix. The Contractor shall be responsible for satisfying himself as to the correctness of the electrical and mechanical connections to all plant supplied under the Contract before such plant is brought into commission or operation.
- x. The contractor shall immediately attend to the defect noticed during tests, trial runs, pre-commissioning, commissioning such as loose components, undue noise or vibration, strain on connected equipment etc... Readjustment and realignment as called for shall be done as per KSEBL's Representative's instructions.

- xi. The contractor shall carry out any other tests as desired by KSEBL's Representative on erected equipment covered under the scope of this contract during testing, pre-commissioning and commissioning, to demonstrate the completion of any part or whole of work performed by the contractor. During this period, though KSEBL's staff will also be associated in the work, the contractor's responsibility will be to arrange for complete requirement of men and required tools and plants, consumables, scaffolding and approaches etc..., till such time the commissioned unit is taken over for operations.
- xii. The scope of testing & commissioning of electrically operated actuators for valves, dampers, gates etc..., will include but not limited to meggering, providing loop wire on actuator terminal block, adjustments of mechanical / electrical or electronic position transmitters, setting of limit / torque switches, cable checking, internal wiring checking, local / remote operation from MCC & MMI package, replacement of limit / torque switches if required.

1.1.29.2 *Commissioning Test*

- i. Commissioning acceptance tests shall be carried out, on all generating units to verify the rating characteristics of generating units and other equipment's in accordance to relevant standards. The complete field acceptance test reports shall be prepared by the Contractor and submitted to KSEBL for approval.
- ii. The test run on generating units shall be carried out as per relevant provisions of IEC standards.
- iii. Before issuing the "Taking-Over Certificate", the revised copies of the Operation and Maintenance Manual shall be submitted together with the specified number of complete sets of drawings of the Works as completed. The Works shall not be considered complete for purposes of taking over under the terms of the General Conditions of the Contract until the above documents have been supplied by the Contractor.

1.1.29.3 *Trial Run*

- i. Immediately upon completion of commissioning, the plant shall be kept on trial operation during which period all necessary adjustments shall be made while operating over the full load-range enabling the plant to be made ready for performance and guarantee tests. The plant, i.e., complete equipment, shall be on Trial operation for a period of one month. The trial operation shall be considered

successful, provided that each item of the equipment can operate continuously at the specified operating characteristics, for the period of trial operation.

- ii. For the period of trial operation, the time of operation with any load shall be counted. Minor interruptions not exceeding 3 (three) hours, at a time, caused during the continuous operation shall not affect the total duration of trial operation. However, if in the opinion of the KSEBL's Engineer, the interruption is long, the trial operation shall be prolonged for the period of interruption.
- iii. The trial operation report comprising of observations and recordings of various parameters to be measured in respect of the above trial operation shall be prepared by the Contractor. This report, besides recording the details of the various observations during trial run, shall also include the dates of start and finish of the trial operations and shall be signed by the representatives of both the parties. The report shall have sheet, recording all the details of interruptions occurred, adjustments made and any minor repairs done during the trial operation. Based on the observations, necessary modifications, repairs to the plant shall be carried out by the Contractor to the full satisfaction of the purchaser to enable the latter to accord permission to carry out the performance and guarantee tests on the plant. However, minor defects, which do not endanger the safe operation of the equipment, shall not be considered as reasons for withholding the aforesaid permission.
- iv. During the trial run the Contractor shall make familiar the Purchaser's personnel with the equipment, the operation and maintenance of the Works and its auxiliaries to such extent that thereafter the duties can be assigned to the Purchaser's trained personnel.
- v. If any defects or irregularities affecting the safety or reliability of the Works should arise during the trial run, the trial run shall be interrupted and started again after such defects or irregularities have been corrected by the Contractor at his own cost.

1.1.29.4 *Performance and Guarantee Tests*

- i. The final test as to the performance and guarantees shall be conducted at site, by the contractor, through an MNRE (Ministry of New and Renewable Energy) approved agency, in presence of the Department representative. Such tests will be commenced, within a period of 15 (fifteen) days after successful completion of Trial Operations. Any extension of time beyond the above 15 (fifteen) days shall be mutually agreed upon.
- ii. These tests shall be binding on the Contract to determine compliance of the

equipment with the performance guarantees.

- iii. The available instrumentation and control equipment will be used during such tests and the contractor will calibrate all such measuring equipment and devices as far as practicable. However, immeasurable parameters shall be taken in to account in a reasonable manner, for the requirement of these tests. The tests will be conducted at the specified load points and as near the specified cycle condition as practicable.
- iv. Any special equipment, tools and tackles required for the successful completion of the performance and guarantee tests shall be provided by the contractor.
- v. The guaranteed performance figures of the equipment shall be proved by the contractor during these performance and guarantee tests. Should the results of these tests show any decrease from the guaranteed values, the contractor shall modify the equipment as required to enable it to meet the guarantees. In such case, performance and guarantees tests shall be repeated within one month, from the date the equipment is ready for retest and all cost for modifications including labour, materials and the cost of additional testing to prove that the equipment meet the guarantees, shall be borne by the contractor.
- vi. All the costs for the pre-commissioning test, trial operation, performance and guarantee test including the consumables, arranging test set-up, test equipment and accessories, measuring devices etc... shall be borne by the contractor.

1.1.29.5 *Tests on Materials*

- i. The materials, parts and assemblies shall be tested to comply with the ASTM Standards or other standards specified and shall be in accordance with the best commercial methods applicable to the relevant type and class of work. The tests and trials shall be recorded and certified by the Contractor.
- ii. The test records for materials shall identify the component parts in which the materials are to be used and the certificate shall be prepared in such a way that it can be easily determined if the applicable Specifications or standards have been complied with.
- iii. All radio-graphs, test specimens and test records shall become the property of the KSEBL.
- iv. Load tests on crane hooks, steel wire ropes, chains and other lifting devices, etc... shall be considered as material tests.

1.1.30 *Test Reports*

- i. Test reports shall indicate the tests performed, instruments used, names of test

personnel and provide for witnesses' signatures. They shall be numbered and dated.

- ii. The Contractor shall compile records and reports on each and every test specified under this Contract and bind such test documents in the same manner as the Operation and Maintenance Manuals.

1.1.31 Operation and Maintenance Manual

1.1.31.1

For the guidance of the KSEBL's operating and maintenance staff, the Contractor shall prepare and furnish 6 copies of operation and maintenance manual for all the Work. Of these, 2 copies shall be given in advance before starting the erection works. Balance 4 copies shall be submitted after incorporating all corrections for the final as-built condition.

1.1.31.2

The manual shall include but shall not necessarily be limited to the following:

- Technical and design data;
- General description of components;
- Operating instructions;
- General information (including sequence of operations if applicable);
- Specific information (dealing with any unusual feature or safety precautions);
- Maintenance instructions fully describing all aspects of preventive and repair maintenance, including maintenance schedule and repair procedures, a detailed lubrication chart showing all lubrication points, lubricant grades required and a lubrication schedule;
- Adjustments (and assembly) including design clearances and settings where applicable;
- All drawings, diagrams, material and parts list;
- All pertinent bulletins and instructions prepared by the various manufacturers of component parts.

1.1.31.3

If the complete text is unduly bulky, then the manual shall be appropriately subdivided and produced in a multi-volume form.

1.1.31.4

Final manuals shall be reproduced as a book or books of approximately quarto size generally in the form of the title page to this document except that the references to Specification, Conditions of Contract, Drawings, etc..., will be replaced by "Operating and Maintenance Instructions". The name of the main Contractor but not that of any subcontractor may also be inscribed upon the cover after the description of the Work. A brief description of the Work is to be inscribed upon the spine of the cover and, if the instructions are contained in several books, these are to be marked with the appropriate volume number. The drawings and diagrams shall be the latest revision of the approved drawings, reproduced to a convenient size and bound into the volume. Insertion of loose drawings into cover pockets is not acceptable.

1.1.31.5

Any additional information, data or changes found necessary during commissioning should be sent to the KSEBL for insertion in the manuals.

1.1.32 Spare Parts, Special Tools and Site Consumables**A) Spare Parts**

The Contractor shall provide a list of recommended spare parts and special tools with the respective unit prices to KSEBL's approval and supply sufficient parts, as per approved list, to assure satisfactory operation for at least five years. All spare parts and accessories shall be electrically and mechanically identical to corresponding parts in the equipment supplied and shall be suitably packed and clearly marked, ready for long term indoor storage.

All spare parts to be supplied shall be interchangeable with the corresponding parts of all the Works supplied under these Specifications and shall be of the same material and workmanship. They shall be replaceable without cutting or destruction of adjacent components.

All spare parts shall be protected against corrosion and shall be marked with identification labels. The identification scheme for spares shall be sent for KSEBL's approval before dispatch of any spare.

All spare parts, tools and materials shall be delivered in marked boxes of sufficient sturdy construction to withstand long term storage.

Spare parts supplied under this contract shall not be given to the Contractor for use during erection and commissioning for replacing the defective or damaged original components of his supplies of works. The Contractor will arrange the spares required during the erection and guarantee period at his own.

The required list of spare parts has been given in Technical Specifications of respective equipment/works. The Bidders will give a separate list of spares recommend by them in addition to the list given in particular specifications and offer the price of the same separately in schedule of prices for spares. Wherever the quantity of spares is given as set / sets, it will be taken as quantity for all the generating units. Sufficient quantity of spares will be included for parts which are more prone to frequent wear and tear and can be replaced easily without involving long shutdown.

The Contractor shall provide 5%, but at least two pieces of all types of bolts, screws, nuts, washers, spanner rings and cotters. The quantity may be taken from the surplus handed over to the Purchaser after completion of the installation as described under the chapter "Fasteners." of this Section.

Mandatory Spares: All spares required during the Defects liability period, needs to be compulsorily provided by the Contractor and a list is also to be provided by the Contractor. It is also specified that any spare other than that specified in the list is necessitated during the defects liability period, the same will be deemed to have been included in the mandatory list and will have to be provided free of cost by the Contractor.

Recommended Spares: The Contractor shall provide a list of spares with unit rates that may be required for a two year period after the defects liability period. Based on the list, KSEBL may issue separate order for the needed spares, based on the rates quoted by the Contractor.

B) Tools

The scope of work shall include all customary and special tools, as well as auxiliary devices including lifting devices, ropes, etc... necessary for total assembly and disassembly of all parts of the supplied Works. Furthermore, all accessories for maintenance shall be supplied and included in the Tender. The total price for tools and devices as required by this article shall be included in the Total Tender Price.

The special lifting devices and tools designed and supplied for the project, can be

used by the Contractor during erection and will be handed over to Purchaser in good working condition without any wear and tear. However, normal tools and appliances supplied shall not be used for erection purposes by the contractor and shall be handed over in new condition. All ropes, slings, small hoists and winches etc... shall be handed over in new condition.

All lifting devices and wire ropes slings to be used at site shall be tested at works and test certificate shall be supplied to the Engineer-in-Charge.

Suitable toolboxes shall also be included in the delivery. An itemized list and description of all provided tools, auxiliary devices, etc... shall be included in the Tender. The KSEBL shall be entitled to take over from the Contractor the entire erection tools, appliances, instruments at mutually agreed conditions.

Each set of tools and appliances to be supplied under the contract shall be arranged in fitted boxes of mild steel construction, the number of boxes being determined in relation to the quantity and type of tools and appliance. If the weight of any box and its contents should be such that it cannot conveniently be carried, it shall be split into multiple boxes.

All tools and appliances shall be clearly marked outside its packing with its description, identification number and reference manual number. Each toolbox shall be painted black, fitted with a pad lock and clearly marked in white letters with the name of the item of equipment for which the tools or appliances are intended.

The Contractor shall open all the toolboxes at the Site stores for inspection by the KSEBL's representative. The Contractor shall be responsible for all such unpacking and subsequent re-labelling and re-packing.

C) Consumables

Scope of work shall include all site consumables like welding electrodes, brazing materials, insulating materials, sealants, cleaning agents, paints and varnishes, grinding wheels/discs, fasteners and raw materials etc... in fairly sufficient quantity so that erection and commissioning activity is not held up for want of these items.

For all items under this Contract, the Contractor shall deliver 5 % of the quantity of painting material, but at least one litre, in new sealed containers, for later repair works other than the Contractor's.

Lubricating oils, insulating oils and greases etc... required for first filling in the plant and equipment supplied by the Contractor under this Contract shall be supplied in quantity 10 % (ten percent) higher than the actual capacity for first filling. These items shall be supplied as per site requirement and shall not be stocked with main

equipment.

1.1.33 Safety

During erection and commissioning the Contractor shall provide all reasonable measures to ensure safety of all personnel and plant. The Contractor shall comply with all safety codes and security regulations prevailing in the KSEBL's plants and those specified in **Vol-2 – Conditions of Bid and Contract**.

All statutory requirements regarding safety provisions, where applicable, stipulated in the following Acts and rules / regulations made there under, as amended from time to time, shall be complied with:

- (a) The Electricity Act 2003.
- (b) The Building and Other Construction Workers Act, 1996 and rules made thereunder.
- (c) The Factories Act, 1948 and rules made there under.
- (d) Central Electricity Authority (Safety requirements for construction, operation and maintenance of electrical plants and electric lines) Regulations.
- (e) Central Electricity Authority (Measures relating to Safety and Electricity Supply), Regulations as and when notified by the Authority.
- (f) Central Electricity Authority (Technical Standards for construction - 2010)
- (g) Indian Electricity Rules, 1956 till Central Electricity Authority (Measures relating to Safety and Electricity Supply), Regulations are notified by the Authority.
- (h) In addition, stipulations made under following Acts and rules/regulations made thereunder, as applicable, shall also be complied with:
 - The Explosives Act, 1884
 - The Explosive Substance Act, 1908.
 - The Indian Boilers Act, 1923 and Indian Boiler Regulations, 1950
 - The Motor Vehicle Act, 1988
 - The Petroleum Act, 1934
 - The Public Liability Insurance Act, 1991
 - The Static and Mobile Pressure Vessel (unfired) Rules, 1981
 - The Workman's Compensation Act, 1923
 - The Water (Prevention and Control of Pollution) Act, 1974
 - The Air (Prevention and Control of Pollution) Act, 1981
 - The Environment Protection Act, 1986
 - Battery Management and Handling Rules, 2001
 - Bio Medical Waste (Management and Handling) Rules, 1998

- Chemical Accident (Emergency, planning, preparedness and response) Rules, 1996.
- Explosive Rules, 1983
- Gas Cylinder Rules, 1984
- Hazardous Wastes (Management and Handling) Rules 1989
- Petroleum Rules, 1976
- Manufacture, Storage and Import of Hazardous Chemicals Rules, 1989
- Ozone Depleting Substances Rules, 2000
- (i) Any other rules and regulations in this regard
- (j) Any specific approvals, permits, clearances issued by any authority under different statutes.

1.1.33.1

The operation of any items of energized Work / Plant shall be subject to a "Permit to Work" system in a form agreed between the Contractor and the KSEBL in accordance with the KSEBL's standard safety regulations for such work. While the Work / Plant is still under the control of the Contractor the permit to work shall be endorsed by the Contractor / Contractor's authorized representative. Permits to operate on Work / Plant, which has been handed over, shall be under the control of the KSEBL / KSEBL's representative.

1.1.33.2

All safety precautions have to be observed while laying the cables in the trench. After completing the work, the trench has to be cleaned and covers put back into position. The contractor, if required, shall do de-watering of trenches.

1.1.33.3

The contractor shall provide all the necessary scaffolding materials, temporary structures and necessary safety devices etc..., during pre-assembly, erection, testing and commissioning of the hydro sets.

1.1.33.4

The Contractor shall observe all statutory safety ordinances, regulations and laws, which are in effect at the Site.

1.1.34 Training of KSEBL's Personnel

The contractor shall impart training at least for a period of one month from the date of

successful commissioning of the project on operation and maintenance of the plant. The KSEBL's personnel / officers / staffs may be associated for the purpose of training right from the stage of installation of the equipment. Such training shall be imparted at free of cost to the engineer / staff / officers to enable them to make themselves conversant in the operation and maintenance of plants and equipment.

1.1.35 Taking Over of the Project

After conclusion of the training period of KSEBL's Personnel as specified in Clause 1.1.34 above, the contractor shall give due notice to the Engineer-in-Charge about successful operation of the plant and conclusion of the training period. Thereafter KSEBL shall take over the project formally subject to fulfilment of all relevant requirements in the terms of the agreement.

1.1.36 Special Notes

1.1.36.1

The Contractor shall inspect the road and ascertain the possibility of transporting heavy equipment. If necessary, the equipment shall be supplied in split up condition to suit the transport requirements.

1.1.36.2

The bidder shall include all equipment, materials, tools, consumables etc... required for the complete and satisfactory installation, testing, commissioning and operation of the units, feeders etc... even if they are not specifically mentioned in these specifications.

1.1.36.3 Deviations from Technical Specifications

All deviation from General Technical Requirements and Technical Specifications given in the following sections should be clearly brought out at one place in the "List of Deviations" from Technical Specifications clearly bringing out the financial commitment. Any deviation not clearly mentioned in the List of Deviations, but described elsewhere in the equipment description shall not be acceptable. After award of contract, the contractor has to fulfill all the requirements of technical specifications except the deviations clearly spelt out with financial commitment and accepted by the KSEBL.

Whenever a Contractor deviates from these specifications, he shall furnish the data called for in the Technical Data Schedules and give a summary of and the reasons

for all deviations in the “List of Deviations”. Failure to accomplish this may cause the rejection of his Tender, especially when a major deviation is involved.

1.2 Main Inlet Valve

1.2.1 Introduction

This section covers the KSEBL's general requirement for the design, manufacture, tests at works, supply, insurance, delivery and storing at site, erection, testing at site and commissioning of main inlet **Spherical valve** of diameter suitable for equipment being supplied for this project and suitable for the head, discharge and maximum velocity as specified in Part 2 "**Specific Requirements for the Project**", along with their operating mechanism, controls and consumables & spares for five year operation of the plant, special tools, warranty etc..., as described and detailed in the specification and other general requirements as per Part 1.1 and listed in the schedule of requirements. The equipment supplied shall conform to the requirements of this specification except as modified and or supplemented by the project related specification.

The scope of these specifications is to stipulate the basic general guidelines to the Tenderer / Contractor for the design (including the foundations / supports), manufacture, testing at manufacturer works, supply, standard and quality of workmanship, general finish of plant, compliance to the latest published edition (prior to the date of closing of tender) of the international standards and recommendations specified throughout the specifications, erection, testing, commissioning, performance and reliability confirmation, warranty confirmation of the complete **Main Inlet Valve** of **Spherical valve** type and other general requirements which are required for the plant / equipment being provided under the scope of this tender contract.

The provisions of specific and detailed technical requirements given in other project specific sections of these specifications shall take precedence over these general specifications in case of contradiction between these general specifications and other sections of the project related specifications.

It is not intended here to describe the design, arrangement or installation, or to specify each and every component required for the completeness of the plants or to select each material for safe and reliable operation of the proposed plants / equipment. In general the plant shall be complete in all respect with its equipment and accessories.

Both electrical and manual operation of the valve shall be provided. Closing of the Spherical Valve for maintenance activities is performed manually.

1.2.2 Reference Standards and Codes

The Main Inlet Valves shall be designed, manufactured, tested, installed and commissioned in accordance with the latest revision of applicable IS / IEC or equivalent standards.

The Contractor shall adhere to sound design and construction practices with regard to codes and material specifications in order to warrant operational safety and ease of maintenance of plants as well as simplicity of control and stability in plant operation.

IS 7332	Turbine Inlet Valves (Spherical) for Hydro-power Stations and Systems.
ASME	Pressure Vessel Code

1.2.2.1 Reference Sections

Section 1.1	General Technical Requirements.
Section 1.3.14	Site Installation, Field Testing and Tests on Completion.
Part - 2	Specific Requirements for the Project

1.2.3 Submittals and Approvals

The Contractor shall seek the prior approval of the KSEBL or the KSEBL's Representative at the following points of works execution using timely submittals.

- Design Calculations
- Drawings, Circuit Diagrams and Specifications
- Performance data: Graphs showing performance
- Material Test Certificates
- List of Suppliers / Manufacturers of major parts
- For the final test report of the valves at works
- Erection, Testing and Commissioning Methodology

Before delivery of equipment to site, the contractor shall submit all work test certificates for approval and obtain despatch clearance from the KSEBL / Engineer-in-Charge.

1.2.3.1 Deliverable Documents

- Drawings clearly showing the various parts / assemblies of the Main Inlet Valves of

spherical valve type and its control equipment.

- Layout drawings of power station showing the overall dimensions and layout of Main Inlet Valves of spherical valve type, clearly indicating spacing, embedded parts, foundation concreting sequences and all important elevations.
- Load diagrams and calculations: - total static and dynamic loads, including impact forces etc..., load centers and design calculations.
- Bill of materials
- Schematic drawings of electrical and hydraulic controls.
- Details of acceptance tests and methods to be adopted.
- A list of shop tests performed on finished assemblies of the equipment.
- A complete list giving details of equipment and auxiliaries.
- Operation and maintenance manual covering full details of repair procedure.

1.2.4 KSEBL's Other Requirements

The tentative layouts of the powerhouse are given in drawings appended to the specifications.

The Main Inlet Valves of the turbine shall be spherical valve type and it shall be used to shut off water to relieve pressure on the nozzles during shut down and to permit dewatering of turbines. The valves shall be designed suitable for Gross Head and discharge required for over load capacity of the turbine / generator and connecting to the existing penstock. The valve shall be suitable for all operating conditions of transient and maximum water hammer and seal properly during all operating conditions including penstock filling, extreme water pressure conditions etc... The valves shall also be capable of closing against a maximum head, including water hammer. The valve shall also be capable of closing at full turbine runaway discharge.

The valves shall normally be opened in balance conditions. The valve operating mechanism shall consist of oil / water operated servomotor. Valve is normally opened and closed by oil pressure with counter weight / penstock water pressure. The valves shall be operated by a system with a fail-safe mechanism. The fail-safe mechanism can be through oil pressure with counter-weight / penstock water pressure / any other proven method, so that valve is capable of being closed under all emergencies without the need of any external commands.

All associated equipment such as servomotors, oil pressure units, counterweights, etc..., shall be included in the offer. All pilot and control valves, limit switches and interlocks

necessary to co-ordinate the automatic operation of bye-pass valve and Main Inlet valve of spherical valve type having double seal shall be provided. Opening and closing time of the valves shall be designed by the Contractor to suit the uprated operational parameters of the system. Provision shall be made to drain the penstock and distributor. The drain valve and bypass guard valve shall be identical, to the extent possible, for easiness of swapping.

Operating servomotors shall be designed for opening the valve with minimum system oil pressure. The closing mechanism shall close the valve under the most adverse combination of hydraulic torque on valve rotor due to emergency closure at maximum turbine discharge. Oil-N₂ pressure accumulator shall be of sufficient capacity to perform minimum three operations (C-O-C) without recharging.

Suitable float switches shall be provided in the PH building on MIV floor to give closing signal to the MIV in the event of inundation of PH due to penstock rupture or leakage in penstock or for some other reasons.

All equipment shall be neatly arranged and shall be readily and easily accessible for operation and maintenance. Necessary walkways, handrails, ladders, chequered plates, platforms, necessary lifting hooks etc... required should be provided by the contractor.

The state of the spherical valve and bypass valve shall be indicated on the control board and locally. Indication and alarm shall be raised if the valves fail to close or open. All indications and alarm conditions shall be transmitted for displaying in the Plant Control room.

1.2.4.1 Scope of Work

The scope of work and the details of the equipment to be provided shall be as given in Part-2 “**Specific Requirements for the Project**”, Schedule B1 (Guaranteed Figures) & Schedule B2 (Technical Particulars) and agreed technical particulars and drawings.

Any item of work not specifically mentioned in the specifications but which are usual and / or necessary for the satisfactory operation of the Plant shall be deemed to be provided by the Contractor and included in the quoted Price. All work shall be complete in all details whether such details are mentioned in the specifications or not.

1.2.4.2 General Arrangement and Construction

All equipment shall be neatly arranged and shall be readily and easily accessible for operation and maintenance. The necessary walkways, handrails, ladders, chequered plates, platforms necessary lifting hooks etc... required shall be provided by the contractor.

1.2.4.2.1 Valve Body

The valve body shall be flanged on both ends. The body shall be of cast steel in two parts, flanged together, reinforced with ribs and complete with brackets and feet. The flanges shall match with the companion flanges of upstream and downstream sections. The body shall be accurately bored out for the door and trunnions and complete with self-lubricated bushes, bearings and seals for the trunnions. The valve body shall incorporate bracket feet supports suitable for hydraulic forces. Pads shall be provided for transmitting the vertical load to concrete foundations. Suitable foundation plates, bolts, etc... for securing the valve shall be provided. The body and the transition sections shall be so arranged that no significant weight or vertical thrust from valve, transition section etc... is applied on the penstocks. The support pads shall permit adequate movement in the upstream and downstream directions of the valve during opening and closing. The hydraulic thrust due to closure of the valve shall not be transmitted to the foundations of the valve. Body drain valve shall be provided. An air release valve shall be provided at the highest point. Mechanical locking arrangement shall be provided for open and close positions. Depending upon operating requirements, the valve shall be either fully open or fully closed and no partial opening of the valve is envisaged.

Valve fully closed and fully opened indication shall be provided.

1.2.4.2.2 Valve Door / Rotor

The valve door / rotor shall be of cast steel construction. The forged trunnions shall be bolted to it. Provision for installation of stainless steel seating rings of service and maintenance seal shall be made on the door. The trunnions bearing shall be of self-lubricating type.

1.2.4.2.3 Service Seal

The service seal comprising of a stainless steel ring sliding in machined face provided on the valve body and seating against the stainless steel seating ring fixed on the door. The service seal shall be automatically operated by penstock water pressure. It shall be operated in conjunction with the operation of MIV. This seal shall be located on downstream side of MIV. Provision shall also be made for manually operating the seal with hand pump. This seal shall be provided with position indicator. It shall be possible to replace the service seal by applying the maintenance seals without dewatering the penstock.

1.2.4.2.4 Maintenance Seal

The maintenance seal comprising of a stainless steel ring sliding in the machined face

provided on upstream side of the valve body and seating against the stainless steel seating ring on the valve door. The maintenance seal shall be manually operated by penstock water pressure. This seal shall be located on upstream of MIV. A mechanical locking device and position indicator shall also be provided.

1.2.4.2.5 Lever

The lever shall be cast / fabricated steel keyed to the trunnion and with gunmetal bush for servomotor piston rod. Manual locking device shall be provided to lock the valve in open and closed positions.

1.2.4.2.6 Servomotor

The servomotor comprising of fabricated steel cylinder with covers, cast iron piston, forged steel piston rod and complete with sealing gland, pipe connection, timing diaphragm etc...

The servomotor shall be oil operated and designed to open the valve under balanced conditions and to close from fully open position under conditions of maximum flow at all heads with minimum oil / penstock water pressure. A suitable throttling device to adjust the time of closing and opening shall be provided.

1.2.4.2.7 Inlet Pipe (Upstream Pipe)

Inlet pipe of electrically welded steel with a steel flange for connecting to the valve on the downstream side and the other side shall be edge prepared for welding to the penstock at site. Necessary connections, tappings and fittings for pressure gauge, penstock drain, bypass valve etc... shall be provided on this pipe. Sufficient excess length shall be provided as trim allowance.

1.2.4.2.8 Dismantling Joint

The dismantling joint shall be of steel and telescopic type situated on the downstream of the valve to facilitate installation and dismantling of the valve. The dismantling joint shall also permit replacement of the downstream plug seat ring without dismantling the valve. The joint shall take local thermal expansion and pressure fluctuation effects. The design shall be such that sufficient clearance is created for facilitating Main valve handling and service seal maintenance.

The valve supports shall not be designed to transmit axial hydraulic force to the foundations. Therefore, necessary anchor block on upstream of valve should be provided.

1.2.4.2.9 Bypass Assembly

The bypass arrangement shall be designed for sufficient water flow to equalise the pressure upstream and downstream of the valve. The bypass assembly shall include one hydraulic oil pressure operated bypass valve with manual and auto operating mechanism and one manual guard valve and necessary piping, fittings, etc... Manual valve shall be located upstream of hydraulic operated main bypass valve. It shall be designed to get vibration and noise free operation. Metal sealing shall be provided to have proof seal when valve is closed.

1.2.4.2.10 Valve Operating Mechanism

The operating mechanism shall consist of hydraulic cylinder, all pilot and control valves, limit switches and interlocks necessary to coordinate the automatic operation of the bypass valve and the spherical valve.

The valve shall be opened by oil pressure and closed by penstock water pressure / oil pressure with counter weight. In case of oil pressure failure, the valve shall close through either penstock water pressure or counterweight / any other method (Emergency Closure). Oil-Nitrogen pressure accumulator shall be of sufficient capacity for one opening and two closing (C-O-C) minimum without recharging of the tanks.

The valve shall normally be opened and closed by commands from the Local Control Panel / Unit Control Panel and / or through SCADA. Valve fully closed and fully opened indication shall be provided in the local control panel as well as in the Remote Control Panel including SCADA.

1.2.4.2.11 Bypass Valve and Piping

It shall comprise of hand operated sluice / wedge gate valve, bye pass valve, bye pass pipe etc... The sluice / wedge gate valve shall be provided on upstream of the bye pass valve as a guard valve. The bye pass valve shall be oil operated or electrical actuator operated with limit switches etc. for balancing pressure across the main inlet valve. The bye pass piping of suitable length joining upstream to downstream of valve with necessary flanges, fasteners and packing shall be provided. Stand by manual valve, operated manually shall also be provided. The valve shall normally be opened and closed by commands from the Local Control Panel / Unit Control Panel and / or through SCADA.

1.2.4.2.12 Air Valves

It shall be automatic operating type of valve to supply or release the air during draining off

and filling the spiral casing. It shall be mounted on downstream of valve.

1.2.4.2.13 MIV Oil Station

Each valve shall be provided with hydraulic pressure system complete with oil pumps, sump tank, valves, solenoids, piping and fittings, Oil-N₂ accumulator, safety devices etc... for operation of the spherical valves. The necessary lifting hooks required for the dismantling and routine maintenance shall be provided by the contractor.

1.2.4.2.14 Local Control Panel

A local control panel with provisions for opening and closing of the valves / seals shall be provided near to the valve. The control panel shall be provided with all controls, indicators, space heaters etc...

1.2.4.2.15 Indicators

The state of the spherical valve and bypass valve and seals shall be indicated on the control board and locally. Indication and alarm shall be raised if the valves fail to close or open. All indications and alarm conditions shall be transmitted for displaying in the Plant Control room and to SCADA.

1.2.4.3 Protective Coating

1.2.4.3.1 Internal Surfaces

No protective coating is required inside the protective valve.

1.2.4.3.2 External Surfaces

For the purpose of protective coating, the external surface shall be considered as water immersed” due to condensation problems.

Epoxy system including preparation shall conform to Indian or International Standards.

Protective coating shall be applied at the factory except the final coat, which will be applied at site after commissioning is completed and before water flow is resumed.

All bolts, nuts and washers shall be galvanized or cadmium plated.

All threads shall be coated with molybdenum disulfide to prevent seizing.

1.2.4.4 Piping

For the Bypass system and Drainage System, all valves, fittings, anchors, bolts, nuts, washers and supports shall be made of stainless steel.

1.2.4.5 Testing

The valves shall be tested on manufacture and on installation as per code referred.

1.2.4.5.1 Non-Destructive Examination

Applicable Standards

Unless otherwise requested by the Contractor and approved by the KSEBL or Engineer-in-Charge, all non-destructive testing of materials shall be carried out in accordance with the following specifications:

- Radiographic testing
 - ASME Section VIII div IUW51 (welds) .
 - ASME E446, E 186 and E 280 (castings).
- Ultrasonic testing.
 - ASME Section VIII, Appendix 12 (welds)
 - ASME A 418 and A 338 (forgings)
- Magnetic particle testing
 - ASTM E165

All inspection and non-destructive testing requirements shall be clearly specified in the drawings.

1.2.4.5.1.1 Radiographic Examination

Radiographic inspection with X-Ray machine or radioactive isotopes will be permitted. Radiographic plates will only be acceptable if they comply with the conditions specified in the ASME Code section VIII of equivalent standards.

1.2.4.5.1.2 Ultrasonic Examination

Whenever radiographic inspection of welds is not possible, such as certain angular and back-plated welds, contractor shall demonstrate the validity of Ultrasonic methods by inspecting a test sample, which has been prepared by identical methods and checked by radiography.

Inspection reports and support drawings, sketches or photographs shall be submitted to the KSEBL, together with all details needed to reproduce accurately any ultrasonic test at any time.

1.2.4.5.1.3 Complementary Examination

Complementary inspections of castings, forging and welded joints may be carried out using

Liquid Penetrant and Magnetic Particle Method. These methods shall conform to the requirements of ASTM E 709 and ASTM E 165.

These methods are only acceptable for detection of flaws on the surface of components or on welds. Striation and irregularities shall be removed before testing.

1.2.4.5.1.4 Special Examination

Weldments

For all components fabricated with segments joined by fully penetration Butt welds, the inspection requirements shall be specified in the drawing and submitted for the KSEBL's approval. The verification shall be performed by Radiographic inspection. Ultrasonic inspection shall be done when radiographic inspection cannot be performed and where the design standards allow it.

Non-destructive tests shall be performed after heat treatment.

Castings

Casting sections of all major components including all parts subjected to hydrostatic pressure shall be inspected.

1.2.4.5.2 Shop Assembly and Testing

The Spherical Valve shall be completely assembled in the shop and operated with its own servomotor. The operation test shall demonstrate that the controls and equipment perform to specified requirements.

The following tests shall be conducted in the manufacturer's shop on dates agreed with the KSEBL in the presence of KSEBL's representative:

- Hydrostatic test shall be carried out to prove the integrity of the valve body and seal at 1.5 times the maximum working pressure including water hammer for not less than 15 minutes.
- During pressure testing, the seal performance shall be verified at the pressure corresponding to the maximum static head at design pressure.
- The operating mechanism shall be tested for trouble free operation. The servomotor shall be assembled and checked at a hydraulic pressure equal to 1.5 times the design pressure. The test pressure shall be maintained for a period of 15 minutes.
- The sealing member shall be checked for water tightness at the rated pressure.

1.2.4.5.3 Erection Testing and Commissioning

All tools, test set-ups, measuring equipment, consumables etc... required for erection, site

supervision, in-progress checks, testing and commissioning shall be provided by the Contractor.

1.2.4.5.3.1 Performance Tests by the Contractor

The contractor is responsible to conduct record and document the following tests:

- **Raw materials**

Mill test Certificate for all approved materials shall be delivered to the KSEBL before fabrication starts .

- **Manufacturing**

All examinations, tests, checks and dimensional records as per approved quality plan shall be performed in due time and documented.

- **Testing and Commissioning**

The following tests shall be part of the erection Quality Plan:

- a) Radiographic test (RT) or Ultrasonic test (UT) and Magnetic Particle test (MT) of pressure parts welds.
- b) MT or Liquid Penetrant test of welds joining non-pressure parts
- c) Dimensional check
- d) Bolts torque as per approved design
- e) Flushing of hydraulic piping by approved means and procedures
- f) Pressure testing of the oil pressure system
- g) Operation of the Servomotor before connecting to MIV arm
- h) Pressure testing as per approved procedure
- i) Closing and opening repeated operation under dry condition
- j) Leakage measurement with full head applied
- k) Bypass operation
- l) Closing and opening operations following watering up
- m) Simulation of Emergency closing.

1.2.4.6 Spares and Tools

The following spares shall be supplied along with MIV separately for each type of valve:

• Limit switches of each type	-	1 set
• Bypass valve	-	1 No,
• Guard valve for the Bypass / Drain valve	-	1 No.
• Air valve	-	3 No.
• Control valves	-	1 set

- Direction valve in power pack
- Solenoid valve
- Gasket for the oil servomotor system - 1 set
- Gasket for the flanges - 4 set
- Cup seal - 1 set
- Cheveron Rings - 3 set
- Maintenance seal (both Fixed and Moving) - 1 set
- Service seal (both Fixed and Moving) - 1 set
- Pressure gauge of each type - 3 set
- Bushes of main trunnions - 1 set
- Relays of each type used in OPU - 3 No
- Sensors of each type - 2 No

In addition to the above any spares required for the smooth and trouble free operation of the Valve as recommended by the manufacturer shall also be supplied. The same shall be listed out in detail in the offer

One set of all tools and handling devices required for the erection, dismantling and routine maintenance of each type of MIV should also be supplied along with Grease and Oil for first filling with 10% extra.

1.3 Generating Units & Other Powerhouse Equipment

1.3.1 Impulse Turbine – (Pelton Wheel - Vertical)

1.3.1.1 Introduction

This section covers the KSEBL's requirement for vertical shaft impulse turbines (Pelton Wheel – 4 jet) with installed capacity as specified in Part-2 **“Specific Requirement for the Project”** at generator terminals when operating under the rated head. The Units supplied shall conform to the requirements of this specification except as modified and or supplemented by the project related specification Part-2 **“Specific Requirements for the Project”**. If the Project Specific Specification has any contradiction with the General Specification of Impulse turbine, the former shall prevail. If the contractor is having any doubts, he shall contact the KSEBL before quoting for the same.

The scope of these specifications is to stipulate the basic general guidelines to the Tenderer / Contractor for the design, manufacture, testing at manufacturer works, standard and quality of workmanship, general finish of plant, compliance to the latest published edition (prior to the date of closing of tender) of the international standards and recommendations specified throughout the specifications, supply, insurance, delivery and storing at site, erection, site testing, commissioning, performance and reliability confirmation, warranty confirmation of the complete Turbine units and other general requirements as per Part-1, which are required for the plant / equipment being provided under the scope of this tender contract.

The provisions of specific and detailed technical requirements given in other project specific sections of these specifications shall take precedence over these general specifications in case of contradiction between these general specifications and other sections of the project related specifications.

The scope of work and the details of the equipment to be provided shall be as given in Part-2 **(Specific Requirements of the Project)** of this specification, Schedule B1 (Guaranteed Figures) & Schedule B2 (Technical Particulars), and agreed technical particulars and drawings. The scope of supply shall include all parts, accessories, consumables, spares etc... which are essential for construction, erection, testing, operation and maintenance of the complete prime mover even though these are not individually or specifically stated or enumerated. Corresponding components of all the turbines and associated equipment and spares shall be of same material, dimensions and finish and

shall be inter-changeable.

It is not intended here to describe the design, arrangement or installation, or to specify each and every component required for the completeness of the plants or to select each material for safe and reliable operation of the proposed plants / equipment. In general the plant shall be complete in all respect with its equipment and accessories.

1.3.1.2 References Codes and Standards

The Turbines shall be designed, manufactured, tested, installed and commissioned in accordance with the latest revision of applicable IS / IEC or equivalent standards.

The Contractor shall adhere to sound design and construction practices with regard to codes and material specifications in order to warrant operational safety and ease of maintenance of plants as well as simplicity of control and stability in plant operation.

IS 12800 - 1993 (Part 1)	Guidelines for Selection of Turbines, Preliminary Dimensioning and Layout of Surface Hydro-electric Powerhouses – Part 1 : Medium and Large Powerhouses.
IEC 60545	Guide for commissioning, operation and maintenance of hydraulic turbines.
IEC 60193 and 60193A	International code for model acceptance tests of hydraulic turbines.
IEC 60609	Cavitation pitting evaluation in hydraulic turbines.
IEC 60041	International code for field acceptance test of hydraulic turbines.
IEC 61116	Electro-mechanical equipment guide for small hydroelectric installations.
IEC 60308	International Code for Testing of Speed Governing Systems for Hydraulic Turbines.
IEC 60994	Guide for field measurement of vibrations and pulsations in hydraulic machines (turbines, storage pumps, and pump turbines).
IEC 60995	Determination of the prototype performance from model acceptance tests of hydraulic machines with the

consideration of scale effects.

ISO 7919 Part-5

Mechanical vibrations of non-reciprocating machines- measurements on rotating shafts and evaluation criteria of machines set in hydraulic power generating and pumping plants.

IS 12837

Hydraulic Turbines for Medium and Large Power Houses – Guidelines for selection.

1.3.1.3 Reference Sections

Section 1.1	General Technical Requirements.
Section 1.3.14	Site Installation, Field Testing and Tests on Completion
Part - 2	Specific Requirements for the Project.

1.3.1.4 Submittals and Approval

The Contractor shall seek the prior approval of the KSEBL or the KSEBL's Representative at the following points of works execution using timely submittals.

- Design Calculations
- Drawings, Circuit Diagrams and Specifications
- Performance data: Graphs showing performance
- Material Test Certificates
- Quality Assurance plan
- List of Suppliers / Manufacturers
- Test Reports including Model Test reports
- Erection, Commissioning and Testing Methodology

Before delivery of equipment to site, the contractor shall submit all work test certificates for approval and obtain despatch clearance from the KSEBL / Engineer-in-Charge.

1.3.1.5 Deliverable Documents

- Drawings clearly showing the main cross section of the turbine showing the various components, parts / assemblies of the turbine to the extent possible and other auxiliary equipment.
- Plan, elevation and sections clearly showing arrangements and outline

dimensions of inlet valve, nozzle and deflector assembly, runner, turbine bearing, dismantling joints etc...

- Layout drawing of power house with transverse and longitudinal section, floor plans showing overall dimensions and general arrangement of turbine and auxiliaries.
- General arrangement as well as schematic drawings of piping systems, control systems and instrumentation.
- Foundation details and loads including unbalanced forces, their point of application under various normal and most abnormal operating conditions.
- Graphs / curves showing the performance characteristics of turbines.
- Schematic drawings of electrical and hydraulic controls including piping system, control system and instrumentation.
- Charts / Curve showing performances and cavitation characteristics of the turbine.
- Model test reports of the turbines.
- Details of acceptance tests and methods to be adopted.
- A list of tests to be performed at site on sub-assemblies and equipment.
- A list of shop tests performed on casting, forging materials, and welded structures and on finished assemblies of the equipment.
- A complete list giving details of equipment and auxiliaries.
- Operation and maintenance manual covering full details of repair procedure.

Any additional document not specified above but required to ascertain suitability of design and provisions of this specification shall also be submitted.

1.3.1.6 KSEBL's Other Requirements

Turbine Characteristics

Type	- Vertical shaft 4 jet impulse turbine (Pelton Wheel)
Rated head	- Please refer Part-2 "Specific Requirement of the Project"
Rated output	- Please refer Part-2 "Specific Requirement of the Project"
Frequency	- 50Hz.
Speed of turbine	- Please refer Part-2 "Specific Requirement of the Project"

The turbine shall be of vertical shaft 4 jet impulse turbine suitable for coupling to vertical shaft synchronous generators with installed capacity as specified in Part-2 "Specific Requirement for the Project" at generator terminals when operating under the rated head.

The turbine shall have adequate capacity commensurate with the continuous capacity of the generators. The turbines shall be capable of giving outputs higher than rated output to match with the 10% continuous overload capability of the generators. The turbine shall also be capable of delivering an output higher than the rated output continuously when operating at heads higher than the rated head. The maximum output both at maximum and minimum heads shall be stated in the offer.

The rated speed for the Unit to be provided shall be as given in Part-2 "Specific Requirements for the Project". The specific speed of the turbine shall be as per the best modern practice and of proven design and operation. The direction of rotation shall be Anti-Clock-wise when looking from the Drive end.

The turbine guide bearing shall be self lubricated type. The bearing housing shall be made in two or more sections to facilitate dismantling. The turbines shall be so constructed as to allow all the removable parts to be dismantled conventionally. The design shall also permit vertical movement of runner shaft by an amount sufficient for adjustment of bearings and for cleaning the joint at the coupling of the turbine and generator.

The tenderer / contractor shall ensure that the turbine manufacturer co-ordinates with the generator supplier so that the generator to be coupled to the turbine is matched in respect of speed, run-away speed, moment of inertia, overload capacities, coupling and other relevant requirements.

The maximum runaway speed of the unit resulting from various operating conditions and reservoir and tail race levels shall be stated by the supplier. The turbine shall be capable of running safely at maximum runaway speed with cooling water supply and without damage to any part for a period of 15 minutes.

The existing layouts of the powerhouse are given in drawings appended to the specifications.

The bidder shall provide the optimum design to get the maximum efficiency and the most cost effective design.

All equipment shall be neatly arranged and shall be readily and easily accessible for operation and maintenance. Necessary walkways, handrails, ladders, chequered plates, platforms, necessary lifting hooks etc... required shall be provided by the contractor.

Each turbine assembly shall comprise of the following equipment:

- One set of turbine housing.
- Four sets of needle injector assembly to suit the existing retained distributor pipes.
- Four sets of nozzle with servomotor and four sets of deflectors with common servomotor assembly.
- Replace existing brake jet system with hydraulically operated brake jet valve complete with water supply piping, brake nozzle with servomotor, guard valve and local and remote automatic controls from turbine floor and control room.
- One set of impulse runner and necessary fasteners.
- One set of rails for runner removing.
- One forged carbon steel turbine shaft with coupling bolts.
- One set of turbine guide bearings complete with oil coolers, necessary valves, sight level indicators-cum-relay, temperature measurement and signalling device.
- Turbine labyrinth seal which forms the part of turbine housing shall be provided.
- One set of piping system for bearing cooling, shaft seal etc...
- One set of all equipment, tools, and instruments devices etc... for conducting performance and efficiency tests on the turbine.
- One set of all tools and handling devices for erection and dismantling of turbines and its routine maintenance.
- Suitable instrumentation devices:
 - For measurement of pressure at various points.
 - For measurement of cooling water flow, temperature and pressure for turbine bearing, measurement of oil and pad temperature of turbine bearing.
 - For shaft and bracket vibration monitoring devices
 - For mechanical over speed protection independent of electrical devices (mechanically operated).
- Grease and Oil for first filling with 10% extra.
- One set of all spare parts necessary for 5 years of operation.

1.3.1.7 Output and Efficiency Guarantees and Penalties

1.3.1.7.1 Output and Efficiency Guarantees

The rated output of the turbine at rated head during independent operation shall be stated and guaranteed. The efficiency of turbine at rated head for 100 percent, 80 percent and 60 percent rated output shall also be guaranteed. These figures shall be applicable for purpose of penalties, rejection limits and bid evaluation as defined in the following clauses 1.3.1.7.2, 1.3.1.7.3 and 1.3.1.7.4. In addition, the output of turbine at the Maximum head, at the Minimum head (heads as given in Part-2 Specific Requirements of the Project) shall also be stated in the tender.

1.3.1.7.2 Penalties

1.3.1.7.2.1 Penalty for shortfall in Weighted Average Efficiency & Output

For any shortfall in the tested values of rated output and weighted average efficiency (as determined on the basis described in Clause 1.3.1.7.3) from the guaranteed values, penalty shall be applied at the rate of 0.5 (half) percent of ex-works contract price on pro-rata basis for each of the turbine having shortfall for every 0.1 percent by which test figures is less than the corresponding guaranteed figure. The penalties for output and efficiency shall be computed separately and the total amount of penalty shall be the sum of these two. No tolerance shall be permissible over the test figures of rated output. In case of efficiency, tolerance will be allowed as per appropriate IEC test code. If the shortfall is more than 2% of this, the turbine will be rejected.

1.3.1.7.2.2 Rejection Limit

The purchaser has the right to reject the turbine if the test value of either weighted average efficiency or the rated output is less than the corresponding guaranteed values by 2 (two) percent or more after allowing tolerance in computation of efficiency.

1.3.1.7.3 Weighted Average Efficiency

The weighted average efficiency of the prototype turbine shall be determined from the field test or the model test values of efficiency at the rated head specified in Part-2 "Specific Requirements for the Project" in accordance with the following formula for purpose of penalty, rejection limit and bid evaluation.

$$T_{\eta_{av}} = 0.1 \times T_{\eta_{110}} + 0.5 \times T_{\eta_{100}} + 0.3 \times T_{\eta_{90}} + 0.1 \times T_{\eta_{80}}$$

where $T_{\eta_{av}}$ = weighted average efficiency of the turbine and $T_{\eta_{110}}$, $T_{\eta_{100}}$, $T_{\eta_{90}}$, $T_{\eta_{80}}$ are efficiencies of turbine at 110 percent, 100 percent, 90 percent and 80 percent rated output

at rated head respectively.

1.3.1.7.4 Rectification to Meet Guarantees

The contractor shall be given 4 months or mutually agreed time to improve / modify the design of turbine or carry out rectifications, etc... as may be required so that the guarantees are met, in case the tests prove unsuccessful in meeting the guarantees. If the second attempt is also unsuccessful, penalty or rejection of the equipment as the case may be, shall be applied. However, no delays in the original delivery schedule shall be allowed if the model test results do not meet the guarantees and rectifications are made by the contractor thereafter within the period of 4 months or mutually agreed period as stated above.

1.3.1.8 Cavitation Guarantees

The tenderer shall guarantee the runner and other hydraulic passages against excessive pitting caused by cavitation for 18 months from the date of commissioning or 8000 hours of operation whichever is earlier. For the purpose of this guarantee, excessive pitting shall be defined as the removal of metal from the runner and other hydraulic passages of a weight of $W=0.15D^2$ per 1000 hrs. of operation, where D is the pitch circle diameter of the runner in metre and W is the weight in kg. If the 18 months of guarantee period expires before completion of 8000 hrs operation, the guarantee shall apply to the actual hours of operation proportionately.

In case of cavitation pitting exceeding the guarantee, the turbine supplier shall, at his cost, take corrective measures such as modification of design, finish, replacement, repair, etc..., and the turbine after modification etc..., shall be subject to cavitation guarantee as for the original equipment. In determining whether or not excessive pitting has occurred, metal removal by erosion, corrosion or by the presence of injurious elements in water etc..., shall be excluded.

1.3.1.9 Speed Rise and Runaway Speed

The moment of inertia of the unit and the normal nozzle closing and deflector application time shall be so adjusted that the maximum momentary speed rise of the unit shall not exceed the lower half of the range of limit as stipulated in relevant IS and the maximum pressure rise in the penstock shall not exceed the lower half of the range of limit as stipulated in relevant IS under any condition of operation, including 10% overload. The turbine manufacturer shall coordinate with the generator manufacturer to achieve the desired flywheel effect for limiting the speed and pressure rise values. The maximum

runaway speed of the unit under any combination of head and load conditions shall be stated by the tenderer in the tender. The turbine (all rotating parts and bearings) shall be capable of withstanding continuously the runaway speed attained with nozzle fully open and the generator disconnected and unexcited and with gross maximum head on turbine, without any damage to its parts for every such occurrence with the cooling water supply on and functional and for 30 minutes without cooling water. (The turbine shall be capable of withstanding maximum runaway speed for 15 minutes with cooling water supply and same shall be substantiated with supporting calculations. However, capability of bearings shall be to withstand for (1) runaway speed with cooling water = 15 minutes, (2) rated speed without cooling water = 30 minutes.) The calculated first critical speed shall be at least 25% higher than the maximum runaway speed.

1.3.1.10 *Vibration and Noise Level*

The turbine design shall ensure smooth and quiet operation with low vibrations, pressure pulsation, power fluctuation and noise.

The vibration amplitude at shaft shall not exceed the values specified in ISO-7919 (part-I) and ISO-3945 or VDI 2056 and VDI 2059 when measured with instrument with 1 Hz cut off frequency.

Maximum noise level resulting from any of the operating conditions shall not exceed 90 dB (A) at any place 1.0 m away from any operating equipment in the machine hall.

1.3.1.11 *Stresses and Factor of Safety*

All parts of turbine shall be designed and constructed to safely withstand the maximum stresses during normal running, runaway and short circuit conditions, out of phase synchronizing and brake application. The maximum unit stresses of the rotating parts shall not exceed two third of the yield point of the material. For other parts the factor of safety based on yield point shall not be less than 3 at normal conditions. For overload and short circuit conditions, a factor of safety of 1.5 on yield point shall be permitted.

1.3.1.12 *Bid Evaluation*

For comparison of tenders, the equalization on account of differences in the efficiencies of various offers will be made on the basis of weighted average efficiency as calculated by the formula given below:

$$T_{\eta_{av}} = 0.1 \times T_{\eta_{110}} + 0.5 \times T_{\eta_{100}} + 0.3 \times T_{\eta_{90}} + 0.1 \times T_{\eta_{80}}$$

where $T_{\eta_{av}}$ = weighted average efficiency of the turbine and $T_{\eta_{110}}$, $T_{\eta_{100}}$, $T_{\eta_{90}}$, $T_{\eta_{80}}$ are efficiencies of turbine at 110 percent, 100 percent, 90 percent and 80 percent rated output

at rated head respectively. The highest weighted average efficiency will be the basis for comparison. Prices of turbines with lower efficiencies will be loaded at the rate of 0.5 (half) percent of their ex-works contract prices for each 0.1 percent difference in weighted average efficiency as compared with the highest weighted average efficiency.

Note:- The weighted average efficiency of the turbine will be multiplied by the efficiency of the gear box (if provided) for obtaining overall weighted average efficiency which will be used for bid evaluation. If gear box is provided, the efficiency of the same shall be stated in the tender.

The basis for selection of the offers will be the overall economy to the purchaser considering powerhouse civil works, monetised values of efficiencies, prices of matching generator, prices of powerhouse crane required, etc... The speed and setting of the turbine and its design shall be such as to result in the installation of the best generating unit at the least cost.

1.3.1.13 *Model Test*

The Purchaser shall have the option to get the model test performed by the contractor at an extra cost after the award of the contract. For this purpose, the Bidder shall quote charges for conducting the model test in his laboratory or in an independent approved laboratory in the presence of Purchaser's Engineers. In that event, the manufacture of any part of the prototype turbine shall be started only after the efficiency and other guarantees and requirements of the turbine are established and fulfilled on the basis of model tests. In case the contractor has already performed model test on homologous models, the Purchaser may, at his discretion, permit the contractor to proceed with the manufacture after approval by the purchaser of the model test report, copy of which is furnished by the contractor within one month of award of contract. The bidder should provide sufficient details of model test to the KSEBL in the bid so as to ensure surety that such test has been carried out.

The performance of the model test either afresh or that had been done earlier shall be as per IEC 60193 and 60193A / relevant IS in all respects. Hydraulic performance tests shall be made to determine the machine characteristics including regimes of safe operation, zones of cavitation and vibration etc... The phenomenon of cavitation and vibration shall be specially investigated. These tests shall include determination of capacity, cavitation limit, hydraulic thrust, runaway speed, etc... and such other details as covered in IEC 60193 and 60193A / relevant IS. Prototype efficiencies shall be derived from model tests by the step-up formula as applicable for the type of turbine contained in IEC 60193 / relevant IS. Model

tests shall simulate all possible normal operating conditions of the prototype for entire range of reservoir levels.

The tenderer shall clearly mention the time within which the model tests including manufacture of a new model, if required, will be complete. The delivery schedule given by the tenderer shall be reckoned from the date of approval of model tests or model test report or from the time of permission to proceed with the prototype manufacture. If the model test report is already available, this shall be submitted within one month after the award of contract.

If the model test has been carried out in a foreign country, and if the Model test report is in any language other than English, the same shall be translated to English and duly notarized before attestation by the Indian Embassy / Consulate in the foreign country.

1.3.1.14 General Arrangement and Construction

The overall design shall be in such a way to use the existing turbine housing. The existing distributor pipe embedded in concrete shall be retained with necessary refurbishment. The nozzle injector assembly, runner etc... shall suit the retained parts. The existing checker plates and supports inside the runner pit shall be replaced with new ones.

All equipment shall be neatly arranged and shall be readily and easily accessible for operation and maintenance. The necessary walkways, handrails, ladders, chequered plates, platforms etc... required shall be provided by the contractor.

1.3.1.14.1 Runner

The runner shall be of 13/4, chromium-nickel stainless steel with integrally cast buckets. The runner manufactured by forged method is also acceptable. The composition of the material and the source of runner casting shall be stated in the tender. All surfaces of runner in contact with moving water shall be smoothly finished by grinding to templates and polished and shall be free from hollows, depressions, cracks or protrusions etc... The runner shall be designed and constructed to withstand safely to stresses developed due to unit operating at runaway speed under conditions of maximum head. The finished runner shall be statically balanced at works before despatch. Bolted flanged connections shall be provided for attaching the runner to the generator shaft. Jacking screws shall be provided to separate the runner from shaft during dismantling of runner. A single forged steel shaft of suitable length to accommodate in the powerhouse for connecting to generator and runner shall be provided.

1.3.1.14.2 Shaft and Coupling

The turbine shaft shall be of forged carbon steel or alloy steel conforming to IS or other equivalent international standards. Wherever the flanges are integral with the shaft, the same should conform to ANSI-49.1, 1967. The turbine shaft shall be connected to the runner on one side and to generator shaft on the other side. It shall be of ample size to transmit the torque at rated speed without excessive vibration or any distortion.

The turbine manufacturer shall co-ordinate and co-operate with the generator manufacturer for proper design and construction. The final alignment of the shaft at site shall be the responsibility of the generator manufacturer.

1.3.1.14.3 labyrinth Seal

To prevent leakage a labyrinth seal which forms the part of turbine housing shall be provided.

1.3.1.14.4 Sets of Nozzle and Deflector Assembly

Nozzles shall be operated by single acting servomotor fed by regulated oil supply from governor. The design should ensure that upon oil pressure becoming ineffective, the nozzle shall close by spring force or manifold water pressure thus eliminating a chance of over-speeding. The nozzles shall be designed to be maintenance free for long periods. The dismantling and repair of worn-out nozzle shall be made possible without disturbing any adjacent parts like the runner.

The nozzles shall be provided with continuously movable deflectors (not on-off type) with highest possible speed of operation. All oil pipes related to the nozzle and deflector shall be well protected from water spray. Mixing of oil and water shall be eliminated meticulously.

Each set comprising of:

- Nozzle Inlet / Spider

Shall be of cast / fabricated steel with suitable flanged connection for bolting on to the respective inlet wye branch of distributor.

- Nozzle Tip and Nozzle Tip Liner

Nozzle tip shall be of cast steel bolted on to the nozzle inlet, accurately shaped and polished for compact and streamlined jet and fitted with accurately shaped and polished nozzle tip liner of stainless steel. Nozzle tip liner shall be replaceable type. Integrally cast bosses for mounting the deflector shaft guide bearing shall be

provided. Suitable baffle / hood arrangement shall be provided for taking the complete thrust of the deflector jet, thereby protecting the nozzle assembly.

- Jet Deflector

Jet Deflector shall be of cast steel complete with operating shaft carried in suitable brass bush / roller needle bearing mounted on the nozzle tip. The deflector rod is keyed to the deflector lever and is operated by deflector servomotor. The bearing shall be self-lubricated.

- Needle and Needle Stem

Needle consists of needle stem of forged steel fitted with removable needle tips of stainless steel.

- Needle Servomotor

Needle servomotor shall be provided outside. The servomotor shall be single acting oil operated type against spring tension. The servomotor shall comprise of cast / fabricated steel cylinder and cast iron piston. The servomotor cylinder shall be provided with connections for oil piping and stuffing box to prevent leakage of oil and water along the piston rod. Suitable provision shall be made for the governor restoring mechanism. A suitable indicator to indicate the nozzle opening shall be provided. Suitable means shall be provided for adjustment of the rate of movement of needle in closing / opening direction, so as to limit pressure rise / drop in the penstock.

1.3.1.14.5 Deflector Operating Gear

Each consists of the following:

- Deflector Servomotor

The servomotor actuating the deflector shall comprise of cast steel body complete with end cover and assembly flange, a steel housing mounted to the body with seals for connecting rod. The servomotor shall be single acting type. It shall be opened by oil pressure and closed by spring tension. The supply of oil / withdrawal of oil is achieved by distribution valve. The servomotor shall be mounted on nozzle body / spider / distributor flange.

The servomotor cylinder shall be accurately bored and shall be provided with flanges for connecting oil piping and stuffing boxes to prevent leakage of oil along

the piston rod. Suitable arrangement to indicate the deflector opening shall be provided.

1.3.1.14.6 Needle Control Mechanism

It shall consist of electronic feed back type needle control mechanism. This will also indicate the needle position of each nozzle.

1.3.1.14.7 Guide Bearings

The turbine bearing shall be Pad / Journal type as applicable with babbitt lined, oil lubricated or self-lubrication type.

These bearings shall be guaranteed for a minimum continuous operation of 100,000 (one hundred thousand) hours and the design and performances shall be well proven and established.

The turbine shall be provided with adequate number of bearings. The bearings shall be designed to withstand operation at maximum runaway conditions as per Clause 1.3.1.9 above. The bearing shall be provided with a dial type or resistance type thermometer with provision for alarm annunciation and shutdown on excessive bearing temperatures.

The bearing shall be capable of being operated continuously without injuring, at any speed from rated speed up to runaway speed. The normal bearing temperature at rated output shall be below 60°C. The maximum temperature of the bearing shall not exceed 70°C.

Moisture detector shall be provided in the bearing support to detect any ingress of water from oil coolers. External bearing coolers are preferred with main and standby oil circulating pumps.

The number and type of bearings shall be stated in the tender.

1.3.1.14.8 Turbine Platform, Walkways, Hand Rails, Lifting Hooks etc..

The contractor shall provide necessary platforms, walkways, handrails, chequered plates, ladders, lifting hooks etc..., wherever necessary.

1.3.1.15 Shop Assembly and Tests

The following assemblies and tests shall be carried out on the turbine and associated equipment at the manufacturer's works before despatch in the presence of the purchaser's representatives if desired by the purchaser and test certificates shall be submitted whether or not the tests were witnessed by the purchaser.

1. Major components of turbine be match marked to ensure correct assembly and alignment in the field.
2. The deflector and needle servomotors and guide bearing coolers shall be pressure tested at 150% of the maximum working pressure.
3. Static balancing of runner.
4. Oil pumping units for complete operation.
5. Leakage test for servomotors.
6. Routine tests on hydro-mechanical governor.
7. Routine tests on electrical cabinet of governor.
8. Testing of all valves and pressure switches.

Bidder shall submit quality assurance plan indicating test to be performed and witnessed by the KSEBL and their acceptance criteria for KSEBL's approval. Quality Assurance Plan should essentially include the following:

- Static balancing of runner.
- Hydrostatic testing at 1.5 times the maximum working pressure including water hammer for not less than 15 minutes for the main inlet valve, servomotors, etc...
- Non destructive test of welded joints.
- Performance test for individual auxiliary equipment.
- All motors, pumps, compressors to be tested as per relevant Indian Standards.
- Routine test reports of all bought out items shall be furnished before dispatch for approval.
- Hydraulic testing of servomotors, stroke checking, oil leakage checking.
- Material test of important components such as runner, turbine shaft, guide pads, bushes, piston rods and other components shall be carried out as per agreed plan.

1.3.1.16 Commissioning Tests

All applicable tests listed in IEC guide for commissioning operation and maintenance of hydraulic turbines (Publication 60545) shall be carried out in accordance with specified procedures. Pre-start tests and checks shall be carried out before filling of water ways as per approved procedure. After filling waterways, necessary checks shall be made before initial run.

The commissioning tests shall include but not limited to the following:

- Bearing run test to determine temperature rise of bearing to determine maximum bearing temperature at no load, full load and maximum overload condition.

- Load rejection test at 25, 50, 75 and 100 percent rated load and at 110% overload to verify speed rise and pressure rise.
- Unit starting, stopping, breaking, no load, no excitation run test, part load, full load and overload operational test to ensure performance as per specifications.
- Measurement of noise / vibrations during various operating conditions.
- Stalling time from 100% speed to 30% speed.
- Turbine safety and signal devices.
- Main inlet valve closing with unit on full load.
- The contractor shall carry out the commissioning tests in accordance with IEC 45. The turbine, after continuous operation for 72 hours, shall be free from problems of leakages, overheating, failure, damage etc... The machine will be handed over to purchaser thereafter.

1.3.1.17 Performance Test

If nothing unusual has been observed in load run and load rejection tests, the test service period of 72 hours shall follow. During this test service period, the unit must operate continuously at rated condition without any interruption, except of those beyond the control of the contractor. However, such interrupted period shall not be counted for in the test service period.

The contractor shall be responsible for the equipment during test service and also for the way it is operated. However, purchaser's personnel will operate the equipment under the contractor's guidance during the test service period.

1.3.1.18 Field Acceptance Test

All field acceptance tests in accordance with provision in IEC 60041 - 1991 shall be conducted at site before acceptance of the turbine by the purchaser. Output and efficiency test shall be conducted at different heads on the turbine to determine guaranteed efficiency parameters.

Efficiency shall be measured by ultrasonic or other acceptable methods prescribed in IEC. The contractor shall furnish details of tests methods, agency which will conduct tests, provision for field testing, calibration of instruments, for purposes of test and all other relevant details for approval. The arrangements for these tests will be made, including the testing devices, by the contractor. The Purchaser reserves the right to appoint an

independent agency for repeating these tests at his own costs.

1.3.1.19 Design Calculation

The contractor shall submit the design calculation covering at least the following, for approval:

- Structural and stress analysis of bearings, servomotors, etc...
- Structural and stress analysis of runner.
- GD^2 calculation.
- Hydraulic transient analysis including speed and pressure rise.
- Natural frequency of the unit.
- Critical speed of the combined turbine & generator and generator rotating parts.

The contractor shall also provide other calculations as required by the Engineer in charge for his approval of the contractor's design.

1.3.1.20 Spares for Turbine

The spare parts for the turbine and associated equipment considered necessary for 5 years operation of the generating units shall be supplied by the contractor. Spares list shall consist but not limited to the following:

1. Nozzle and deflector assembly (full set)	-	1 Set
2. Shaft seal packings	-	1 Set
3. Guide Bearing Pads	-	1 Set
4. Gaskets and packings	-	1 Set
5. Piston rings for servomotor	-	1 Set
6. Piston ring, limit switches for air inlet valve	-	1 Set
7. Bushes for servomotor piston rod	-	1 Set
8. Pressure / vacuum gauges	-	3 No. of each type
9. Turbine guide bearing coolers (for plug-in type coolers) -		2 Nos
10. Complete runner	-	1 No.
11. Dial type thermometer with sensing bulbs	-	3 No.
12. Limit Switches of each type	-	3 Set
13. Needle tip	-	4 No.
14. Nozzle seal ring	-	4 No.

15. Deflector knife

- 4 No.

Any other spares recommended by the manufacturer as essential for the satisfactory and trouble free operation of the equipment as per Clause 1.1.32 of this specification. The price for the above shall be indicated in the bid.

1.3.2 Governors

1.3.2.1 Introduction

This section covers the KSEBL's requirements for turbine governors complete with all necessary devices for complete automatic and remote / manual control, synchronising, load / frequency control, start / stop and emergency stop of the generating units in the powerhouse. The equipment supplied shall conform to the requirements of this specification except as modified and or supplemented by the project related specification.

The scope of these specifications is to stipulate the basic general guidelines to the Tenderer / Contractor for the design, manufacture, testing at manufacturer works, standard and quality of workmanship, general finish of plant, compliance to the latest published edition (prior to the date of closing of tender) of the international standards and recommendations specified throughout the specifications, supply, insurance, delivery and storing at site, erection, site testing, commissioning, performance and reliability confirmation, warranty confirmation of the complete **Governor** units and other general requirements as per Part-1, which are required for the plant / equipment being provided under the scope of this tender / contract.

The provisions of specific and detailed technical requirements given in other project specific sections of these specifications shall take precedence over these general specifications in case of contradiction between these general specifications and other sections of the project related specifications.

It is not intended here to describe the design, arrangement or installation, or to specify each and every component required for the completeness of the plants or to select each material for safe and reliable operation of the proposed plants / equipment. In general the plant shall be complete in all respect with its equipment and accessories.

1.3.2.2 Reference Standards and Codes

The Governors shall be designed, manufactured, tested, installed and commissioned in accordance with the latest revision of applicable IS / IEC or equivalent standards.

The Contractor shall adhere to sound design and construction practices with regard to codes and material specifications in order to warrant operational safety and ease of maintenance of plants as well as simplicity of control and stability in plant operation.

IEC 60308

Hydraulic turbines - Testing of control systems.

IEEE 125-2007	IEEE Recommended Practice for Preparation of Equipment Specifications for Speed-Governing of Hydraulic Turbines Intended to Drive Electric Generators.
IEEE C37.90.1:2012	IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus.
IEEE 472	Surge Withstand Capability (SWC) Tests For Relays And Relay Systems Associated With Electric Power Apparatus.
ASME Performance Test Code 29	Acceptance test of governor

1.3.2.3 Reference Sections

Section 1.1	General Technical Requirements
Section 1.3.14	Site Installation, Field Testing and Tests on Completion
Part - 2	Specific Requirements for the Project

1.3.2.4 Submittals and Approvals

The Contractor shall seek the prior approval of the KSEBL or the KSEBL's Representative at the following points of works execution using timely submittals.

- Design Calculations
- Drawings, Circuit Diagrams and Specifications
- Graphs showing performance
- Material Test Certificates
- Quality Assurance Plan
- List of Suppliers / Manufacturers
- Test Reports
- Erection, Testing and Commissioning Methodology

Before delivery of equipment to site, the contractor shall submit all work test certificates for approval and obtain despatch clearance from the KSEBL's representative.

1.3.2.5 Deliverable Documents

- Drawings clearly showing the various parts / assemblies of the governor.
- Layout drawings of power station showing the overall dimensions and layout of

Governor units, clearly indicating unit spacing, foundation concreting details and all important elevations.

- General Arrangement drawings of Cubicles.
- Load diagrams and calculations: - total static and dynamic loads, including impact forces etc..., load centers and design calculations (as applicable).
- Graphs / curves showing the performance characteristics.
- Physical and schematic drawings and descriptive literature on the governor and governor mechanism including electrical and hydraulic controls.
- Diagrams and drawings of the speed governing system together with written description.
- External connection diagrams showing the details of all wires connected to user's equipment including equipment grounding details.
- User Guides and specifications of individual devices and components.
- Hierarchical list of software, including revision level.
- Program design standards.
- Configuration control methodology.
- Program descriptions with flow chart.
- Original / final program / ladder drawing.
- Acceptance test procedures and test reports.
- Software installation, maintenance and user guides, including User Interface guide.
- Step-by-Step trouble shooting / Diagnostics procedures.
- Erection, Testing & Commissioning methodology.
- Operation and maintenance manual describing the construction, recommended procedure for assembling, dismantling and maintenance and information (including ordering information) on all electronic parts used.
- A list of shop tests performed on finished assemblies of the equipment.
- Details of acceptance tests and methods to be adopted.
- A complete list giving details of equipment and auxiliaries.
- A complete and detailed description of governor operation explaining various safety, protective and regulation features.

1.3.2.6 KSEBL's Other Requirements

Other technical requirements shall be as given in Part-2 “**Specific Requirements for the Project**”.

The existing layout of the powerhouse is given in drawings appended to the specifications.

The governor system for each unit shall essentially consist of the following:

- Electronic digital governor suitable for Impulse turbines (Pelton Wheel) consisting of a hydro-mechanical cubicle and one set of duplicating instruments (balance indicator, Electro tachometer, Deflector opening, Needle opening and limit indicator and speed setting indicator).
- Manual and auto control valves.
- Emergency shutdown valve with its solenoid operated valve.
- Emergency shutdown pilot valve for shutdown on mechanical over-speed.
- Oil pumping unit for governing system consisting of one oil sump tank, two oil screw pumps with motors, safety and idler valves, oil level gauge, air breather, manhole lid, pressure switches, isolating valves, low oil alarm device and manhole for oil sump and fittings.
- Oil pressure accumulator (nitrogen filled) complete with pressure gauge, oil level gauge, arrangement for manual replenishment or release of Nitrogen.
- Oil pumps shall be vertically mounted.
- Feedback connection and other accessories.
- Oil pipelines for interconnecting oil pressure unit, emergency slide valve, pressure vessel, tank and servomotors.
- Oil for first filling and 10% extra.
- One set spare parts necessary for 5 years operations.

The governor shall be provided with PID (digital) system of control. The Governor shall also have provision for Manual Control in the absence or failure of Automatic / digital control and also during maintenance operations.

All equipment shall be neatly arranged and shall be readily and easily accessible for operation and maintenance. Necessary walkways, handrails, ladders, chequered plates, platforms, etc... required should be provided by the contractor.

All governor panels shall be enclosed in dust proof air-conditioned cabinet.

The governor shall be capable of interfacing with automatic synchronizing equipment and be adaptable for Automatic Generation Control (AGC) through direct interaction with the SCADA system.

1.3.2.6.1 Scope of Work

The scope of work and the details of the equipment to be provided shall be as given in Part-2 “**Specific Requirements for the Project**” of this specification, Schedule B1 (Guaranteed Figures) & Schedule B2 (Technical Particulars) and agreed technical particulars and drawings.

Any item of work not specifically mentioned in the specifications but which are usual and / or necessary for the satisfactory operation of the Plant shall be deemed to be provided by the Contractor and included in the quoted Price. All work shall be complete in all details whether such details are mentioned in the specifications or not.

1.3.2.6.2 Description of Equipment

The electronic governor shall be of microprocessor based with manually operated backup system for integrated unit and plant control. The governor shall be of proven design controlling the turbine by speed sense. The governor should provide flexibility in control, alarming, sequence of event recording and providing graphic display. The PLC should be of standard make, open architectural system allowing expansion. The governing system shall be complete with actuator unit comprising of hydraulic pressure system, water level sensor, restoring mechanism, load adjustment with level, load limiting device, start stop capability and emergency closure. The hydraulic pressure system shall comprise of two motors driven pumping unit, pressure tank, sump tank and piping etc... The construction shall be with the components of governor and its associated equipment mounted in a totally enclosed and vermin proof sheet steel cabinet with access doors for maintenance and repairs. All hydraulic and electrical circuits, devices, components and indicators shall form part of the cabinet and the cabinet may be installed on the turbine floor but the essential instruments and controls required for starting, stopping and running of the turbine shall be provided on the turbine control cubicle in machine floor and on the control desk in main control room. The governor shall be of suitable design to enable the generator to work satisfactorily in parallel, without hunting, with other machines in the same station and with those connected to the National grid, especially the Southern grid.

Electronic governor shall provide following control:

- a) Speed / Frequency Control
- b) Unit Control
- c) Load / Needle opening set point control

- d) RGMO / FGMO control.
- e) Joint power control with other generating units in the power station
- f) Automatic Starting / Stopping by single command
- g) Suitability for Isolated Operation
- h) Suitability for Parallel operation
- i) Suitability for Grid Operation
- j) Control from remote Supervisory Control And Data Acquisition (SCADA) / DCS
- k) Transfer selector switch for Manual / Auto changeover of Governor Controls
- l) Manual backup control with provision for setting the following manually:
 - i. Temporary droop percent
 - ii. Permanent droop
 - iii. Frequency dead-band
 - iv. Sensitivity

In the absence of any signal to adjust frequency or power, the servomotor piston rod shall not be adjusted to oscillations whose amplitude is greater than $\pm 0.5\text{mm}$ with respect to their average position.

Following a sudden variation of an external signal, involving a steady state change of 10% of the normal load, the change in generator output shall achieve 6.2% of the normal power within 20 seconds for a permanent droop of 5%. This check shall be made at approximately 90% of normal power. The governor dead time shall not exceed 0.2 second for a load change of 10% or greater.

For a condition of constant frequency, the sensitivity of power regulation shall be better than 0.02%.

The behaviour of the governor during the start-up, emergency closure, during return to speed no load following a load rejection and / or following any other manoeuvre shall be silent, rapid and without vibrations. The exact momentary variation in speed and time within which steady speed is regained shall be stated in the bid. The maximum speed rise on load rejection shall not exceed the lower half of the range of limit as stipulated in relevant IS.

Each governor shall be supplied with a mechanical as well as electronic load limiter to

prevent the jet opening beyond a predetermined limit when operating in parallel with other plants. The load limiter shall operate on 110 V DC. Two remote load limit indicators and two switches for operating the limiter have to be supplied. One indicator and switch shall be mounted on the turbine control cubicle and the other indicator and switch shall be mounted on the control desk (if provided). Operation of the Load limiter from the SCADA system shall also be provided along with indication.

The speed droop shall be adjustable from 0 to 10%.

The hydraulic circuit shall include the mechanical over speed device which will operate in the event of over speed even in the absence of control signal and governor pressure.

Governor shall be fail safe on the failure of the speed sensing element, loss of oil pressure or defects in actuating system, so that under any of these conditions, the machine shall be automatically shut down with alarm and indication.

The regulator and governor control will be fed from the powerhouse batteries at normal voltage of 110V DC ($\pm 10\%$).

The governor shall be designed for independently adjusting the opening and closing rates of movement of turbine wicket gates for full gate opening or closing stroke. A secure and rigid means shall be provided for locking the rate of adjustment.

The governor shall be provided with a set of the restoring mechanism of transmitting deflector servomotor movement to the distributor valve and the connecting linkage shall be as short as possible.

Speed adjustment over the range of 85% to 115% of the rated speed along with the indicator shall be provided.

The Governor shall be provided with an automatic shut down device for complete closure of needles and deflector. The operating solenoid shall be of self-latching type with the provision of electrical reset.

Device for automatic locking out of the governor and gate control mechanism and manually operated from the governor cubicles shall be provided along with indicating lamps for showing the position of locking mechanism.

Emergency shutdown manually operated from the governor cubicles, unit control panel and control desk / SCADA shall be provided. Indicating lamps shall be provided showing the position of shut down mechanism i.e. whether operated manually or electrically shall be provided on the governor cubicles as well as on the unit control panel and control desk.

Indication should be configured in SCADA also.

Manually operated control device allowing opening or closing of deflectors shall be provided. A change over switch for automatic to manual control and vice versa shall be provided along with the indicating lamps.

A speed signal generator shall also be supplied. The speed sensing device shall be provided with the requisite redundancy. Electric polarised speed switches shall be installed in the cabinet of the unit for 0, 10, 20, 30, 90, 98 and 105 percent of speed.

Provision shall be made on the governor for starting, running, running in condenser mode (for 50MW and above units) and shutting down the turbine manually by energising the manual control solenoid valve and it shall be possible to smoothly change over from the manual control to automatic control and vice versa.

Provision shall be made to drain out the servomotors, oil pipelines etc... to the leakage oil sump for carrying out maintenance works. Clean oil supply to devices like servo valves etc... must be ensured by providing filters with generous capacity and redundancy with high maintainability.

The performance requirements of the governing system shall be governed by relevant IS / IEC standards.

1.3.2.6.2.1 Type and Description

The governor shall be Microprocessor based electronic-hydraulic type suitable for automatic control. It shall be complete with control cabinet, sensors, electro-hydraulic transducers, oil hydraulic system and all parts and accessories required to make a complete unit for regulating the speed and controlling the needles and deflectors of the turbine in accordance with the performance characteristics specified below:

1.3.2.6.2.2 Specification of Electronic Controller

The electronic controller shall be Microprocessor based Proportional-Integral-Differential (PID) controller. The PID controls shall be implemented through the software program.

The electronic controller shall be modular in construction and easy for mounting the control cabinet. The electronic controller should have a minimum of the following Input / Output capacity. The electronic controller should have sufficient Input / Output capacity plus 20% unused spare channels.

It should be possible to increase the I/O capacity of the electronic controller, if required, by plugging in additional modules.

Each digital inputs and outputs should be galvanically isolated from the field.

For the purpose of user interface, suitable display unit with keyboard or a touch screen shall be provided on the front panel.

The electronic control should be capable of working on 110V DC.

There should be a provision to interface to a communication network of the plant automation system.

All governing parameters shall be made programmable from the display unit / touch screen.

There should be a PC interface software to monitor and program the governor parameters. Final program, relevant communication cables, PC interface software etc... shall be handed over. If the program has locking corresponding key / passwords, the same also shall be handed over. Hardware locking is not preferred.

Suitable indication shall be available on the front facias of individual modules indicating the health of the module.

1.3.2.6.2.3 Working Requirement of the Governing System

The governing system should have facility to adjust the closing and opening time of the needles and deflectors to regulate the speed rise and pressure rise in the penstock.

The speed dead band at the rated speed should not exceed 0.02% of the rated speed. For a sudden change of more than 10% of the rated load, the governor dead time should not exceed 0.2 second.

The governor shall provide stable operation free from hunting or instability in the following conditions of operation:

- No load
- Isolated load
- Synchronised to grid

The governor shall be suitable for manual control from the turbine control cabinet.

The governor shall be capable of initiating the shutdown in case of any malfunction in the interfacing sensors and with in its own hardware and software.

An overriding automatic shutdown device shall be provided which will ensure safe closure of the turbine in case of any fault in the electronic controller. Once tripped, it has to be reset before restarting the unit.

The electronic controller should give relay output for corresponding speed switch, which activates at different speed levels of the turbine. Additionally five relay contacts should be available which can be set to operate between 0-200% of rated speed for further use in turbine operating interlocks.

A provision should be available to operate the needles and deflectors in manual mode. Suitable Auto-Manual transfer valve will be provided in the governor hydraulic system.

1.3.2.6.2.4 Following control facilities shall be provided

Speed adjustment control range of 85% to 115% of the rated speed.

Individually adjustable Off-load, On-load stabilizing controls with automatic transfer between modes such as No load to grid synchronous mode

Load set-point mode, speed / frequency set-point mode, RGMO and FGMO modes of operation.

Adjustment of speed droop from 0% to 10%.

Adjustment of nozzle opening limit within 0% to 100% opening.

Adjustment of no load nozzle opening limit.

Isolated network operation and dead-bus synchronisation option.

1.3.2.6.2.5 Field interface

The turbine generator speed shall be sensed as a pulse input from a toothed wheel and a pick up as well as by sensing the generator remnant voltage or network frequency for the purpose of redundancy.

The position of the needles and deflectors will be sensed by individual contactless position sensor.

The status of the circuit breaker will be sensed as a potential free contact for automatic change over from Speed No load mode to Grid Synchronous mode and vice versa.

Sufficient metering outputs will be provided for local indication of the needle position, deflector position, Unit speed, speed set point and nozzle opening limit.

Interface for the following commands from the control cabinet shall be provided.

- Speed / Load adjust – Rise / Lower
- Needle limit setting

- Speed droop setting

Suitable interface with the electro-hydraulic transducer shall be provided.

1.3.2.6.2.6 Conditions of service

The electronic controller must be designed to the following limiting ambient conditions.

- Temperature 50° C
- Relative Humidity 95%
- Pressure Atmosphere
- Atmosphere Dusty

1.3.2.6.2.7 Conformance to standards

- Protection against electrostatic discharge according to IEC 801-2 for power supplies, digital modules and communication interfaces, min. 5kV.
- Noise immunity against electromagnetic irradiation according to IEC 801-3 min. 3 V/m
- Immunity against current transients according to IEC 801-4 min. Class III
- Electromagnetic devices, own irradiation within the limits set forth in VDE 0871. Class A

1.3.2.6.2.8 Shop tests

The electronic controller will be factory tested by the customer to ensure that all equipment, sub-systems and modules can perform as per the requirements of this specification. The vendor shall maintain proper records duly signed by authorized quality assurance personnel regarding all stage inspections, tests on individual equipment or subsystem.

1.3.2.6.2.9 Hydraulic Supply System

The hydraulic supply system includes high-pressure oil system and Nitrogen system. The requirements for some components of the above system can be briefly described as follows:

1.3.2.6.2.9.1 Oil Pressure System

The turbine shall be provided with suitable oil pressure system for operation of the turbine.

The capacity should be sufficient for 10 minutes operation with oil pumps failed. Piston

type accumulator with nitrogen bottles shall be used for pressure more than 60kg/cm². Separate oil pressure systems shall be used for the control of turbine and the control of MIV.

1.3.2.6.2.10 Oil Sump Tank

It shall be of electrically welded steel plates having sufficient capacity to hold all the oil in the governing system. The tank shall be totally enclosed, semi buried type and shall be provided with a manhole, oil level gauge, switches for high and low level alarms and water-in-oil detector with alarm contact. The sump will have a pair of valves for connecting to an oil filter unit in service.

The sizes of various components of oil sump tank and pressure receiver shall be calculated as per the relevant IS / IEEE standards. The oil volume below its machine shutdown level shall be sufficient to perform 3 full operations of the servomotor viz. Close-Open-Close with oil pumps being out of operation.

1.3.2.6.2.11 Oil Pump Motor Set

Governor shall be provided with independent motor driven oil pumps, of sufficient capacities to fulfill the requirements of the governor oil pressure system with a stand by governor oil pump. (Two sets shall be mounted on the sump tank, one as main and other as standby and either units shall be selectable as main / standby). It should have sufficient capacity to supply all the pressure oil requirements of the governor and all servomotors even in their worn out condition.

The two pumps shall be interconnected so that they can be operated independently or together. The governor oil pump shall be self priming, under the minimum oil pressure and shall be driven by motors of continuous duty.

Each pumping unit shall be provided with unloader valves, check valves, safety valves, suitable number of hand operated valves, fitting and interconnecting pipes etc..., so as to make the pumping unit complete in all respects and shall have tolerable noise level. The loading / unloading of the motors shall be done automatically using pressure switches having redundancy and electrically operated valves.

1.3.2.6.2.12 Emergency Shutdown Slide Valve with Electromagnet (110V DC)

The emergency slide valve is intended for closing the turbine servomotors under all emergency conditions of the hydro set, bypassing the governor. Its action should be fail-safe, ie, the valve is normally kept activated with 110V DC and on an emergency it

deactivates to close the servos by draining oil with indication and alarm.

1.3.2.6.2.13 Oil Pressure Accumulator

It shall be of fabricated construction and shall withstand the maximum working pressure and shall be of sufficient capacity to meet the requirements of the servomotors. The accumulator shall be provided with two nos. of alarm and trip facility and one electrically operated (110 V DC) isolation valve with automatic closing when oil level is very low.

Hand shut off valves at the bottom of the tank and automatic arrangement for shutting of oil and N₂ discharges shall be provided.

The oil pressure unit shall be provided with the following safety / control / operation switches:

- a) Pressure switches for automatic starting & stopping of oil pumps and for alarm and trip the units under low and low – low load, low pressure conditions respectively.
- b) Level switches / differential pressure switches for giving alarm and shutting down the machine when oil level falls below predetermined level.
- c) Level switches / differential pressure switch for giving alarm when oil level rises above a predetermined level.

The oil pressure unit shall be equipped with an oil level gauge with automatic valves at the ends for preventing N₂ and oil loss in case glass breaks.

The oil pressure unit shall be complete with N₂ inlet, relief valve (safety valve), pressure gauge, oil drain connection with valves, manholes etc...

1.3.2.6.2.14 Feedback Connection

A suitable feedback arrangement shall be provided.

1.3.2.6.2.15 Piping and Valves

One set of piping and valves with flanges, bolting materials, gaskets, packing etc... as required for connecting the pressure receiver, pumping set, governor and deflector & needle servo motor shall be supplied.

1.3.2.6.2.16 Oil-Pressure System using Nitrogen Accumulator

Nitrogen accumulators of sufficient capacity shall be provided for maintaining the required pressure in the governor oil pressure system. Design calculation of oil pressure system shall be furnished.

A complete set of all necessary tools shall be supplied

Acceptance tests shall be as per American standard test code or equivalent. Electronic circuits shall be tested in accordance with IEEE standard or equivalent.

1.3.2.7 Spares for Governor

- Oil pressure pumping unit (Pump with motor) complete - 1 Set
- Hydraulic amplifier - 1 No.
- Transducers - 1 No. of each type
- Main feedback mechanism - 1 No.
- Control valve - 1 No. of Each Type
- Oil filter - 1 No.
- Electronic Controller - 1 No.
- Display unit with keypad / Touch screen display - 1 No.
- Speed measurement device - 1 No. of Each Type
- Meters & gauges - 1 No. of Each Type
- Sealing rings - 1 Set
- 'O' ring of each type - 1 Set
- Coil for each solenoid - 1 Set
- Electronic printed circuit - 1 No. of Each Type
- Auto-Manual transfer valve - 1 No.
- Speed switches (relay) - 1 No.
- Mechanical over speed device - 1 No.
- Speed signal generator - 1 No.
- Power supply unit of each type - 1 No.
- Proportional control valve assembly - 1 set of each type

Any other spares recommended by the manufacturer as essential for the satisfactory and trouble free operation of the equipment as per Clause 1.1.32. The price for the above shall be indicated in the bid.

1.3.2.8 Tools and Instruments

The contractor shall supply special tools, customary tools and devices required for installation, repair and maintenance of the turbine and its list shall be stated in the tender.

A complete set of tools and instruments for the satisfactory erection, adjustment,

maintenance and testing of the governing system shall be supplied. These will cover meters and oscilloscopes, Fault Analysers etc...

Software required for the configuration, setting change, maintenance, trouble shooting, retrieval and display of stored data etc... of the Governor system shall be provided in CD along with a Laptop (with pre-installed software's required as above) and any other interfaces / converters / connecting cables etc... required for communicating with the system. As commissioned final program in disk also shall be handed over.

Necessary manuals giving complete information on installing, configuring, adjusting settings, trouble shooting etc... of the software (including data retrieval / display) and the governing system shall also be provided.

1.3.3 Generators

1.3.3.1 Introduction & Scope of Supply

This section of the specifications covers the KSEBL's requirements for the design, manufacture, test at works, supply, insurance, delivery and storage at site, installation & supervision of erection, testing at site and commissioning of vertical AC Generators complete with excitation system, voltage regulating equipment, neutral grounding and generator terminal equipment including CT's, PT's, Surge protection equipment, etc... and auxiliaries such as CO₂ generator firefighting equipment (as required), lubrication system (as required), oil, water and air piping with valves and fittings, instrumentation, controls and safety devices (as required), warranty, spares for 5 years operation of the plant, special tools and testing devices as described and detailed in the specifications and in the annexed schedule of requirements. The scope of supply shall include all parts, accessories, spares etc..., which are essential for construction, operation and maintenance of the complete generator even though these are not individually or specifically stated or enumerated. Corresponding components of all the generators and associated equipment and the spares shall be of the same material, dimensions and finish and shall be interchangeable.

The generator manufacturer shall co-ordinate with the turbine supplier so that the turbine to be coupled to the generator is matched in respect of speed, runaway speed, moment of inertia, overload capacities, coupling and other relevant requirements.

The generator first critical speed should be greater than 125% of the runaway speed.

The weighted average efficiency of the generator shall not be less than 98%.

1.3.3.2 Reference Standards and Codes

IEEE Test Code 115	Test Code of Synchronous Generator
ANSI Standard C.501	Synchronous Generator
IEC 60034 all parts	Rotating Electrical Machines
ANSI Standard B49-1	Generator Shaft Coupling
IS 5422	Turbine Type Generator
IS 4722	Rotating Electrical Machines – Specification.
IS 7132	Guide for Testing Synchronous Machines
IS 4728	Terminal Marking for Rotating Electrical

	Machines.
NEMA MG1	Motors and Generators
IEC 34-1:1983	Electric Motor Handbook

1.3.3.3 Reference Sections

Section 1.1	General Technical Requirements.
Section 1.3.5	Control and Monitoring
Section 1.3.6	Protection.
Section 1.3.14	Power Plant Field Testing and Tests on Completion.
Part - 2	Specific Requirements for the Project.

1.3.3.4 Submittals and Approvals

The Contractor shall seek the prior approval of the KSEBL or the KSEBL's Representative at the following points of work execution using timely submittals.

- Design Calculations
- Drawings (General and sectional arrangements, lifting arrangements, Stator slot layout, Thrust bearing assembly, guide bearing assembly, cooler assembly, rotor assembly etc...), Circuit Diagrams, schematics (Schematics of HS lubrication, Brake & Jack, cooling lines, fire protection etc...) and Specifications / details of thrust and guide bearings, coolers, brake jacks, stator, rotor, shaft, brackets, bearing oil, special instruments etc...
- Performance data, Graphs showing performance (Characteristic curve, Capability curve, V curve, Negative sequence curve, No Load Harmonics curve etc...).
- Material certificates, painting specification, Quality Assurance plan
- List of Suppliers / Manufacturers
- Test Reports / Data
- Erection / Testing / Commissioning Methodology

Before delivery of equipment to site, the contractor shall submit all work test certificates for approval and obtain despatch clearance from the KSEBL / Engineer-in-Charge.

1.3.3.5 Deliverable Documents

- General arrangement and overall dimensions of generator, showing position of main

and neutral leads, important elevations etc...

- Design calculation for Foundation loads.
- Design calculation for GD^2 calculations.
- Design calculation for Runaway speed, Critical speeds.
- Drawings showing thrust bearing, guide bearing assemblies etc...
- Drawings showing arrangement of air cooler, air ducts etc...
- Graphs showing predicted characteristics of the generator (capability curve) with an engraved copy for display in control room.
- General layout showing overall dimensions and layout and relative position of all auxiliaries, ducts, spaces for cable, piping and cooling water system etc...
- Design calculation for Maximum stresses / loads during normal operation, runaway speed conditions.
- Design calculation for Strength of all rotating parts to withstand run away speed and vibration.
- Calculations supporting selection of Neutral grounding resistor.
- Diagrams of cooling system, lubricating system, braking / jacking system.
- Details of fire protection schematic diagram, literature etc...
- Operation and Maintenance Manual.

1.3.3.6 KSEBL's Other Requirements

1.3.3.6.1 Generator Type and Ratings

The generator shall be of vertical shaft water wheel driven alternating current type. The direction of the rotation shall be clock-wise / anti-clock-wise when viewed from top / turbine end. Rating, tests and characteristics shall be in accordance with latest IEC / IEEE standards ANSI C 50.12 and IEEE No 115. The generator shall be designed in accordance with best international practice, with liberal factor of safety and for continuous operation at 100% rated MVA at rated voltage, power factor and frequency. The rating and other specific details of the generator are detailed in Part-2 **“Specific Requirements for the Project”**.

The generator shall be capable of delivering maximum continuous output of 110 percent of the rated output at rated power factor. The Tenderer / Contractor may offer his nearest standard design. The generator will be connected to the turbine directly. Each generator

terminal shall be brought out of the stator frame for insertion of current transformers for protection, metering and surge protection apparatus. The generator neutral shall be grounded suitably and the generators shall be designed to safely withstand any mechanical / magnetic stresses resulting from either a three phase or a single phase fault.

The synchronous generators shall be capable of delivering the guaranteed output under the stated conditions as mentioned in Part-2 **“Specific Requirements for the Project”**.

The requirements of reactive power capability shall be specified as per requirement of Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations, 2007. Generating Units located near load centre, shall be capable of operating at rated output for power factor varying between 0.85 lagging (over-excited) to 0.95 leading (under-excited) and Generating Units located far from load centers shall be capable of operating at rated output for power factor varying between 0.9 lagging (over-excited) to 0.95 leading (under-excited).

The above performance shall also be achieved with voltage variation of $\pm 5\%$ of nominal, frequency variation of $+3\%$ and -5% and combined voltage and frequency variation of $\pm 5\%$.

The units shall be capable of withstanding the thermal and dynamic stresses at rated speed and at runaway speed. All parts of the generating unit shall be designed to mechanically withstand all electrical, mechanical and other stresses, which may be experienced during the operation of the unit, including short circuit, faulty synchronising and over speed conditions. The generator shall be capable of safely withstanding the maximum stresses during normal operation, run-away speed conditions, two phase and three phase short circuit conditions, single phase earth fault, 180 degree and 120 degree out of phase synchronization, magnetic unbalance with 50% of the poles short circuited within the speed range of 1.3 times the rated speed, brake application, etc...

The design of the unit including the relative location of the rotor, generator thrust and guide bearings and the turbine bearing shall be such as to cause no abnormal vibration or resonant conditions. The rotor poles and stator coils shall be possible to be taken out or in without removal of the whole rotor and without disturbing UGB. The rotor poles shall be interchangeable.

Each generator shall be designed and constructed so as to be capable of running for a continuous period of 15 minutes at the maximum possible runaway speed of the unit. The maximum runaway speed shall be stated and guaranteed by the supplier. All rotating parts and bearings shall be capable of with standing the forces and stresses occurring during runaway speed for at least 15 minutes without any damage to any part. The guide bearing

and guide cum thrust bearing shall be capable to withstand runaway speed for 15 minutes with supply of cooling water and at rated speed without supply of cooling water 30 minutes continuously without abnormal temperature rise and increase of vibration. All parts of each generator and other equipment shall successfully and safely withstand the stresses resulting from the operation. The moment of inertia of the generator together with the moment of inertia of the turbine and flywheel (if any) shall be such that the maximum momentary speed rise shall be limited to a safe percentage of the rated speed. The generator manufacturer shall co-ordinate with the turbine manufacturer to limit the speed rise to this value.

The inertia of the machine shall be adequate to meet the transient stability requirements imposed by the interconnected electrical power system to limit speed rise and shall not have such a value which will cause the machine natural frequency to be in resonance with the expected frequency of hydraulic surges. A margin of approximately 25% shall be provided for this.

The critical speed of the unit shall be at least 25% above the runaway speed.

The generator shall operate satisfactorily in parallel with each other and with other machines connected to the grid.

1.3.3.6.2 Insulation and Guaranteed Temperature Rise

Insulation shall be of thermal class F for the stator and the rotor windings with temperature rises limited to that of thermal Class B as per relevant IS / IEC standards. Insulation shall have high basic insulation level suitable to withstand system surges on account of switching surges and lightning surges.

Insulation shall be provided as follows:

- a) Stator winding material corresponding to class F,
- b) Rotor winding material corresponding to class F,

The generator shall be capable of delivering rated output continuously at any voltage and frequency in the operating range at rated power factor without exceeding the following values of temperature rise over cooled air temperature not exceeding 45⁰C with temperature of cooling water as 32⁰C

- a) Rotor winding - 90⁰C
- b) Stator winding (as measured by resistance method):
 - a) Single layer - 90⁰C
 - b) Multilayer - 80⁰C

The maximum temperature rise when the generator is delivering maximum output corresponding to continuous overload capacity for conditions stated above shall not exceed the following:

- a) Rotor winding - 100⁰C
- b) Stator winding:
 - a) Single layer - 110⁰C
 - a) Multilayer - 100⁰C

Stator winding shall be insulated with thermosetting type epoxy resin mica paper corresponding to class-F insulation. Rotor winding shall be insulated with thermosetting type epoxy impregnated NOMAX paper corresponding to class-F insulation.

The temperature at various points of the stator core shall be uniform to the extent that the difference between any two points shall not at any time exceed 5°C. The temperature of the collector rings shall not exceed 100°C at rated MVA and power factor 0.9 lagging.

The temperature rises shall be guaranteed and shall be measured at site in accordance with IEC 34 or relevant Indian Standard.

The Generator shall be capable of delivering 110% rated output continuously at any voltage and frequency in the operating range at rated power factor without exceeding temperature values applicable for B class of insulation of temperature rise over ambient temp. of 40°C (For ambient air temperature higher than 40°C the temperature rises shall be adjusted correspondingly).

This temperature rise limit is to be restricted to class-B insulation with 10% overload capacity. The temperature of the stator winding will be determined by means of embedded resistance type temperature detector located in stator winding in accordance with 5.2 of and NSI standard. The temperature of field winding will be determined by resistance method. The temperature of stator core shall be determined by temperature detector (RTD) method.

1.3.3.6.3 Output and Efficiency Guarantees

Output Guarantee

The generators shall be guaranteed to give its rated output without exceeding the temperature rise specified. Within the limit of temperature rises specified above, the rated continuous output of the generator shall be guaranteed under penalty with a rejection limit of minus 2% for the rated terminal conditions.

For any short fall in the test value of output from guaranteed figures, the penalty shall be @ 0.5% of ex-works contract price for every 0.1% fall by which test figure is less than the guaranteed figures.

Efficiency Guarantee

The efficiencies of the generator shall be guaranteed when delivering 60%, 80% and 100% rated output at the rated voltage of and rated power factor of 0.9 lagging, without exceeding the temperature limits specified.

The efficiencies shall be determined by summation of losses method as specified in the latest edition of IEC publication No. 34-2 / IS 4889 or equivalent standard.

Determination of efficiencies

For the above purpose, the weighted average efficiency will be determined from the efficiency figures at the three loads specified below:

$$G\eta_{av} = 0.1 \times G\eta_{110} + 0.5 \times G\eta_{100} + 0.3 \times G\eta_{90} + 0.1 \times G\eta_{80}$$

Where, $G\eta_{av}$ is the weighted average efficiency, $G\eta_{110}$, $G\eta_{100}$, $G\eta_{90}$ and $G\eta_{80}$ are the efficiencies of the generator at 110%, 100%, 90%, and 80% rated output. The η values furnished shall be supported with performance curve at rated voltage at 0.9pf lag. The η values shall be indicated in the curve.

For every shortfall of 0.1% in the weighted average efficiency after taking into account IEC tolerance, a penalty @ of 0.5% of ex-works contract price on a pro-rata basis for each of the generator having shortfall will be levied. If the short fall is 2.0% or more, the generator will be rejected.

The penalty for output and efficiency shall be computed separately and the total amount of penalty shall be sum of two. The ceiling on the total amount of penalty on account of shortfall in the weighted average efficiency and output will be 10% of the total contract price.

No tolerance would be permitted over test figures of output. Tolerance in determination of efficiency shall be as per relevant IEC / Indian Standard.

1.3.3.6.4 Bid Evaluation

For the purpose of comparison of tenders, the equalization on account of difference in the weighted average efficiencies between various offers will be made on the same basis as indicated for penalties, i.e., the prices of Generators with lower efficiencies will be loaded at

the rate of 0.5 percent of ex-works contract prices for each 0.1 percent difference in weighted average efficiency as compared with the highest weighted average efficiency.

1.3.3.6.5 Speed Rise and Runaway Speed

The moment of inertia of the generator together with the moment of inertia of the turbine and flywheel (if any) shall be such that the maximum speed rise shall be as low as possible and shall not exceed the designed, guaranteed and specified speed rise of the turbine to avoid excessive stress in the generator. The Generator parts shall be so designed to withstand a maximum runaway speed without damage to its parts for 15 minutes for every occurrence with supply of cooling water for its bearings and same shall be substantiated with supporting calculations. The value of maximum runaway speed and the duration of the same with reference to the needle / deflector closing time as recommended by the turbine manufacturer shall be stated in the tender. The generator manufacturer shall coordinate with the turbine manufacturer to limit the speed rise. The critical speed shall be at least 25% higher than the maximum runaway speed.

Each generator shall be designed and constructed so as to be capable of running at maximum runaway speed for a period of 30 minutes duration. Over speed test at runaway speed may be conducted after the temperature rise test. After over speed operation, bearings, any contact of the stator with rotor, cooling fan, binding wires and other tightening parts shall be examined and no injury shall appear. The runaway speed test shall be considered successful if after undergoing the test, "no injury" is apparent.

1.3.3.6.6 Noise Level

The noise level shall not exceed **90 dB (A)** when measured at a distance of 1.0 m (one metre) from any component of the generator. Any vibration caused by the machine should not be in resonance with any part of the equipment delivered. The frequency band shall be indicated by manufacturer and high vent noise shall be avoided.

1.3.3.6.7 Short-circuit Ratio

The Short-Circuit Ratio (SCR) for generators shall be as per IEC-34. The short circuit ratio will be established by the reactance characteristics of the machine. The short circuit ratio shall be such as to ensure stable operation under all operating conditions and it shall not be less than 0.8.

1.3.3.6.8 Short-circuit Requirement

The generator shall be capable of withstanding without damage, a 30 second three phase short circuit at its terminals when operating at rated MVA and power factor, at 5% over voltage with fixed excitation in accordance with ANSI C 50.12 or NEMA MG1 (Reference Standard according to the rating of the Generator).

The excitation system and AVR offered shall have the necessary features to overcome the disadvantage due to low short circuit ratio from stability considerations such that the units operate stable under all conditions when connected to a large grid.

1.3.3.6.9 Performance Curves

The Contractor shall submit performance curves of the generator for rated voltage and power factors of:

1. Zero lag
2. Zero lead
3. 0.8 lag
4. 0.8 lead
5. 0.9 lag
6. 0.9 lead
7. 1.0

1.3.3.6.10 Construction

Stator

The stator will consist of frame, core and winding. The current flowing in stator slot shall be limited to 3000-6000 Amperes with current through individual coil being limited to approximately 3000 Amperes.

Stator frame

The stator frame shall be in two or more segments. The stator frame shall be of cast iron or fabricated steel construction with bolted and dowelled joints between the segments. The frame shall be designed to withstand bending stresses and deflections due to its self weight and weight of the complete core to be supported by it. Ventilating ducts of suitable dimensions with wire mesh shall be provided on outer periphery of the frame. The frame shall have its own foundation plate.

The bidder shall coordinate with turbine supplier for details of centre line of stator frame to be kept. Necessary suitable fabricated structure to be provided to fix the generator sole

plates on the foundations.

Stator core

Stator core material shall be of high quality Electro technical sheets of grade 50C 270 as per IS 648 and not subject to significant ageing due to any cause and shall be thoroughly insulated from each other with insulating material or coating capable of withstanding temperature of 130°C without deterioration. Core punching may be in one piece or in segments. Punching shall be degreased cleaned & dried before varnishing. Core plate varnish with class 'F' properties shall be applied and over dried. Both side thickness of the varnish shall be restricted to 6-7 microns. Insulation resistance shall be measured and recorded. The segments shall be assembled in stator frame with the help of wedges. In case punching are in segments these shall be staggered in alternate layers. The punching shall be pressed between pressing plates welded with fingers as per bidders shop specifications. However, no looseness in core assembly shall be permitted. Bidders shall ensure monolithic stator core frame inside to outside. Assembled core shall be tested for core losses & hot spots if any. Proper record shall be kept for the test procedures & observations. After completion of core loss test, stator slot portion shall be painted with conducting varnish.

The core laminations shall be punched from high-grade magnetic steel coated with baked insulating enamel and piled on dovetail key ribs accurately and securely fastened to the stator frame. The core shall be ventilated by means of radial air ducts throughout the stack length. The stator core shall be clamped by means of flange and finger assemblies at both ends of the core.

Resistance temperature detector (RTD) / Thermo couple or any other type of temperature sensor at suitable locations along with Temperature indicators shall be provided for temperature monitoring of Stator core. 6 numbers embedded temperature detectors shall be symmetrically provided in the core for the measurement of core temperature. Sufficient numbers spare Temperature detectors shall be embedded symmetrically in the core for core temperature measurement for future use. Temperature scanner shall be interfaced with machine SCADA system.

Stator Windings

Windings shall be multi turn with tip to tip class 'F' insulation system, manufactured by VPI system or Resin rich Resi-flex insulation systems. The copper for elementary conductors shall be ETP as per IS 191. The section shall be rectangular in shape. The self insulation of elementary conductor shall be glass braiding with class 'F' varnish. Other insulation details

like liners, packers & slot wedges shall also be of class 'F' material. Over hang portion of the winding on both sides shall be supported on suitable binding rings and lashed properly with packers of suitable thickness to provide adequate rigidity to the overhanging portion against dynamic forces. The stator winding shall be star connected with both ends of conductors of each phase brought out of the stator. The neutral leads shall be brought out in a suitable manner to enable installation of current transformer for split phase protection and shall terminate at the neutral grounding cubicle.

For each generator, a minimum of twelve (18) numbers - (six numbers (4 + 2 spare) resistor elements per phase) embedded temperature detectors of resistance type (PT 100 RTDs) shall be provided for stator windings, located symmetrically. The connections on the resistor elements shall be well insulated and extended to a connection box on the outside of stator frame. All detectors including spares shall be terminated in the marshalling kiosk and shall be tested.

It should be possible to replace windings at site and the insulation system slots and winding arrangement shall be designed to this end. Full details of method, equipment and components required for replacing coils shall be included in operation and maintenance manual and outlined in the bid.

1.3.3.6.11 Generator Neutral Earthing

Neutral point of the star connected stator of each generator shall be grounded either directly through a Neutral Grounding resistor or a single phase, dry type distribution transformer of suitable ratio, as mentioned in Part-2 "**Specific Requirements for the Project**", and with a loading resistor of adequate rating connected across the secondary winding. Calculations supporting the selection of resistor shall be submitted for approval. Suitable terminal arrangement with neutral isolating switch shall be provided. The isolating switch shall be of manually operated type with external indication of position, and auxiliary switch with required number of contacts for interlock shall be provided. All the above neutral grounding equipment shall be housed in a drip proof enclosure. The generator ground protection should cover 100 % of the stator winding.

1.3.3.6.12 Rotor

The design and construction of the rotor shall be in accordance with the best modern practice. The factor of safety at maximum runaway speed based on yield point of material shall not be less than 1.5.

Shaft & Spider

The generator shaft shall be made of the best quality carbon steel forging properly heat-treated. The shaft shall be of adequate size to operate at all speeds including maximum runaway speed and shall be able to withstand short circuit stresses without any vibrations or distortion. The generator shaft shall be accurately machined all over and polished where it passes through the bearings and accessible points for alignment checks. Generator shaft shall have suitable provision for coupling to turbine. The main shaft shall have an integrally forged flange for connection to turbine shaft flange. All coupling dimensions shall be agreed upon by the turbine and generator manufacturer and shall essentially conform to IEEE 810 "IEEE standard for hydraulic turbine and generator integrally forged shaft coupling and shaft run out tolerances" or an equivalent approved standard.

The rotor Spider shall be of fabricated type with central bush to be shrink fitted on the shaft. The spider shall have adequate tangential and vertical rigidity to prevent undue deformation, to ensure centering of the rim and the poles, and to blow enough cooling air to the rim, if the design of the cooling system uses radial (rim) ventilation. Suitable arrangements shall be provided to fix the poles on the rotor body.

If any additional flywheel is required excluding generator rotor effect, it shall also be mounted on the generator shaft.

Alternatively Generator shaft shall be of forged steel in one piece including extension for mounting the turbine runner. The shaft shall be heat-treated & accurately machined. Generator supplier shall coordinate with turbine manufacturer for mounting the turbine runner on the extended portion of the generator shaft and flywheel required for turbine governing.

Winding

The rotor winding shall be insulated with class-F insulation. Field windings shall be made of copper bends on edges. Fabricated type is also acceptable. The body of the poles shall be isolated with glass insulation. Pole coil connections shall be soldered with suitable grade of material. The design of the rotor shall be such as to permit removal and replacement of field poles easily without removal of rotor. Special epoxy impregnated Nomax paper of suitable thickness and of class 'F' properties shall be used for insulation between turns of field winding and glass laminations for insulation to ground. Damper winding shall be provided on field winding to improve stability.

The collector ring shall be properly insulated with pure hard mica. Brake ring shall be provided beneath the rotor surface with easily removable and renewable segmented wearing surface. The collector rings shall be made of suitable alloy well insulated with pure

hard mica and designed for use with carbon brushes. The number of brushes and their design and arrangement shall be such that the brushes can be renewed while the generator is on load. The carbon dust shall be prevented from entering the winding by providing a properly designed carbon dust extraction system for sucking and collection of carbon produced by the brushes and the dust duct shall be exhausted outside the powerhouse building to prevent pollution inside the powerhouse.

Provision shall be made for the determination of field winding temperature by measuring its resistance. Two insulated brush holders and copper brushes shall be provided with each generator rotor for measuring the voltage across the slip rings during operation and leads shall be brought out in a conduit from the insulated brush holders to the generator terminal box. A suitable temperature indicator shall be provided in the unit control board.

Any special lifting gear such as beams or special slings supports which are necessary to remove or replace the rotor shall be provided. The proposed method of rotor removal shall be described by the bidder in the bid.

Poles

The field poles shall be laminated from stamped sheets of suitable thickness, and fixed between iron plates and fitted to the rotor rim / spider / rotor body. The form of pole shoe shall be such that sine wave of voltage at no load performance of the generator is achieved. Field windings shall be made of copper bends on edges. The subsequent turns shall be insulated with pre-treated Nomex paper of suitable thickness of class 'F' properties. The body of the poles shall be isolated with glass insulation. Pole coil connections shall be soldered with suitable grade of material.

Main Shaft

The main shaft shall be of best quality forged steel finish, turned and polished all over and shall be of ample size to operate at any speed upto runaway speed without vibration or distortion. It shall be hollow bored, with proper finish to permit ultrasonic examinations of the interior surface. The shaft shall be ultrasonically tested throughout its full volume.

The shaft shall be provided with easily accessible machined surfaces at top and bottom for measurement of shaft eccentricity when in service. The contractor shall provide suitable device for measuring the eccentricity of the shaft.

The contractor shall supply a complete set of test reports covering the metallurgical strength and ultrasonic tests performed on each of the shafts during various stages of manufacturing as also the complete specifications of the shaft material forging and its

design parameters such as stress and critical speed. The test coupons of forging material shall also be furnished in accordance with ASTM specification.

Coupling

The generator shaft coupling shall be designed in accordance with ANSI standard B49.1. The face of the coupling shall be at the minimum distance below the generator compatible with accessibility. The generator shaft coupling shall be forged integral with the shaft.

The generator manufacturer shall co-operate with the turbine manufacturer in regard to detailed design of the coupling in accordance with ANSI specification B49.1. The generator shaft female half coupling shall be recessed to match a spigot to be machined on the turbine shaft male half coupling. The turbine manufacturer will be responsible for the final boring of the coupling bolt holes in the turbine shaft when assembled with the generator shaft at site and will finish the coupling bolts and nuts. The generator manufacturer shall provide a cover for the coupling bolt on the generator side of the coupling. The coupling bolts shall be provided with locking devices. Taper bolts shall not be used.

After the shaft has been coupled to the generator rotor shaft, the generator manufacturer shall make such adjustments to the guide and thrust bearings and other parts of the generator as necessary in order that the unit is in correct alignment within the tolerances specified and to the approval of the KSEBL.

Cooling System

In the case of horizontal generators, the unit shall be self-ventilating, its own fanning action being utilised to force air through the winding ducts etc...

In the case of vertical generators, the generator shall be totally enclosed. Each generator shall be provided with a cooling water system based on the closed circuit air circulation principle, complete with frame mounted air coolers, cooling water pipes, valves, alarms and indicating devices, flow relays and all other accessories. Baffles shall be provided for separation of the generator air-cooling system from the turbine pit. **The air coolers shall have sufficient capacity to maintain air temperature at less than 45°C at the unit even when one cooler is out of service and the unit is operating at rated output, rated power factor and rated voltage.** The air cooler shall be equipped with all necessary valves for reversal of flow arrangement.

A humidity measurement system shall be provided to detect cooler leaks.

The generator shall be provided with screen protected enclosure for open ventilated type machines. It is necessary to prevent dust and rubbish entering the machine when it is shut

down, the air outlets shall be fitted with self opening louvred ventilators or equivalent.

1.3.3.6.13 Bearings

- The generator bearings shall be preferably anti friction ball / roller bearings oil or grease lubricated. In case pedestal type bearing are supplied these shall be pad type or sleeve type with Babbitt metal lined with oil lubrication. These bearings shall be guaranteed for minimum continuous working for 1,50,000 (one lakh fifty thousand) hours and shall be of proven design and performance and shall require minimum maintenance. The detailed drawings and dimensions shall be supplied by the bidder with the offer.

Bearings shall be adequately insulated to prevent any harmful circulating currents. The Drive End bearing shall be of thrust cum journal bearing and Non Drive End bearing shall be journal bearing. The thrust bearing shall be suitable to take axial thrust in both directions. The bearing shall be designed to withstand any damage, if machine is operated on runaway speed with cooling water for 15 minutes and at rated speed without cooling water for 30 minutes.

The oil used for generator bearing lubrication, may be of the same type as used for turbine governing system and bearing to the extent possible. Thermometers, moisture detector for bearing oil etc... as required shall be provided.

Each of the bearings shall be provided with dial type thermometer and also provided with two sets of contacts for annunciation and trip of the machine. The bearings shall also be provided with RTDs. Wires shall be run from thermometer and RTDs to the instruments and the junction box mounted on the outside of the stator frame.

The temperature of the bearing at continuous full load should not exceed 70°C and adequate cooling shall be provided for the bearing to ensure that the bearing temperature does not exceed 70°C which shall be measured by the RTD's.

Cooling arrangement having an ample supply of cooling water to the bearing complete with water flow indicators and flow meters with local indication shall be provided. These indicators and flow meters shall be interfaced with the machine SCADA system. The bearing shall be complete with necessary valves, oil level indicator and temperature indicator with alarm for low / high oil level in oil sump, temperature high / very high protective devices and other accessories.

- Forced lubrication type bearing

These are provided with oil pump motor set. The pumping unit shall be complete with oil tank necessary piping, isolating valves, duplex filter, filter blocking device level indicator, level switches, thermometers, pressure switches or oil flow failure switch.

These should have following provisions also:

- a) The required operation of the protection device is to automatically operate the DC pump on AC pump failure and initiate the shutdown of the system.
- b) Means shall be provided to operate DC motor with automatic change over to AC motor for black start conditions (if specified).
- Combined thrust and upper guide bearing mounted on a top bearing bracket above the rotor and lower guide bearing below the rotor shall generally be used for small diameter, long core, high speed machines. For medium to high capacity machines having low speed, combined thrust and guide bearing mounted on a separate bearing bracket located below the rotor and an upper guide bearing installed above the rotor on a separate, light-weight bracket mounted on the top of the stator frame shall be provided. The arrangement of combined thrust and guide bearing mounted on a separate bearing bracket located below the rotor shall be used for low to medium capacity machines having low speed.
- The horizontal mounted hydro-electric machines shall be provided with the journal type bearings. The number of journal bearings shall vary depending upon the machine output, speed, diameter, core length, etc...

1.3.3.6.13.1 Thrust Bearing

The vertical generators shall be of suspended type with the thrust bearing and a guide bearing located above the rotor supported on the upper brackets and a guide bearing located in the lower bracket. The thrust bearing and upper guide bearing bracket shall be capable of carrying the additional load of turbine shaft and runner and also the maximum hydraulic thrust in addition to the weight of generator rotating parts or other loads on the generator. Suitable platforms, walkways, stairs, hand rails and inspection doors in the generator housing shall be provided for inspection and maintenance of its bearings, slip rings, coolers etc...

The thrust bearing shall be of adequate design and shall carry the weight of the rotating portion of generator, turbine and the downward hydraulic thrust of the turbine under all conditions of operation.

The thrust bearing shall be provided with pump driven high-pressure oil system to inject oil at high pressure between its bearing surfaces during starting and stopping of the machine. The bearing oil shall be cooled using cooling coils placed in the oil reservoirs with 150 percent cooling capacity and back flushing features. The bearing shall be self-lubricating and self-pumping. Starting at normal operating temperature, the bearing shall be capable of being operated at normal speed and load without cooling water for at least half an hour. The bearing shall be equipped with all necessary indicating and control devices. The bearing shall be capable of shutdown even without high pressure oil pump in service. Moisture detector shall be provided in the oil sump to detect leakage of water from coolers.

1.3.3.6.13.2 Guide Bearing

The generator shall be provided with guide bearings, on either side of the generator. The guide bearings shall be capable of withstanding all stresses incidental to the normal operation of the unit and to the specified maximum runaway speed. The bearing shall be capable to withstand forces due to earthquake of magnitude 0.3g in both the directions. The bearings shall be cooled by circulating oil coolers mounted in the oil bath. However, external heat exchanges are preferred. Suitable temperature measuring devices with two contacts shall be provided for measurement of bearing metal temperature. Suitable flow relays in water flow system with alarm & tripping for low water supply shall also be provided. Adequate provision shall be made for preventing oil or oil vapour from entering the generator cooling system. For this properly designed Oil vapour extraction and collection system is to be provided for upper guide bearing and lower guide bearing.

The guide bearing shall be of oil immersed self-oiling type. The cooling coils for the lower guide bearing shall be similar to that of the thrust bearing.

All bearings shall be adequately insulated, where necessary, to prevent the flow of circulating currents through the bearings. The operating temperature of the thrust and guide bearings at rated output shall be 60°C and 50°C respectively. The maximum temperature of the bearing in worst operating conditions shall not exceed 70°C. All the bearings shall be provided with moisture detectors to detect leakage of water from coolers.

1.3.3.6.13.3 Bearing Oil Coolers

Coolers shall be manufactured with cupro-nickel tubes grade Cu Ni 30 as per IS 1545. Adequate surface shall be provided to evacuate the bearing losses. External coolers are preferred with main and standby oil pumps. Necessary cooling water flow arrangement

shall be provided for oil cooling.

1.3.3.6.13.4 Bearing Temperature Indication

Dial type thermometers complete with two independent settable contacts making for alarm and trip temperatures and hand resetting of maximum temperature indicator shall be provided for each bearing and shall measure bearing shell or pad temperatures as close to the lining to journal or thrust ring interface as practicable. Water cooled bearings shall have high or low water level trip contracts.

1.3.3.6.14 Generator Winding Termination

Generator phase and neutral terminals shall be taken out and terminated at separate locations for connecting to 11kV bus and generator neutral grounding system respectively. Provision shall be provided for isolating the phase and neutral connections for testing purposes. All terminals shall be properly covered for electrical safety as per standards.

1.3.3.6.15 Cooling System

Cooling water system for the generator shall be based on closed circuit air circulation principle complete with frame mounted air coolers, cooling water pipes, valves, alarms and indicating devices, flow relays and all other accessories.

The air coolers shall have sufficient capacity to maintain air temperature at less than 40°C at the unit when one cooler is out of service and the unit is operating at rated output, rated power factor and rated voltage. The air cooler shall be equipped with all necessary valves for reversal of flow arrangement.

1.3.3.6.16 Creep Detector

A suitable creep detector shall be provided for the generator and arranged to give an alarm, to apply brakes and to start high pressure oil pump of thrust bearing.

1.3.3.6.17 Anti-condensation Heaters

Low temperature heaters with hygrostat and thermostat control shall be provided in the generator housing to prevent condensation of moisture on the winding when the unit is under shutdown. The temperature to be maintained shall be 5°C above the ambient temperature. The heaters shall be suitable for operation on 415V, 3-phase, 50 Hz supply. The heaters shall be automatically disconnected when the units starts. The heater control gear shall be mounted in a panel to be located outside the generator enclosure.

1.3.3.6.18 Earth Terminal

Two Nos. of Earth terminals shall be provided. The earth terminals shall be designed to terminate Galvanized Iron conductors. The size shall be as specified IEC 34-1.

1.3.3.6.19 Vibration Monitor

All rotating parts shall be designed to operate without undue vibration. Special precaution is to be taken to run the machines smoothly. The vibration level of the machines shall be within the limits specified in the relevant IS specifications (IS: 14773 / ISO 7919) or equivalent. The preferred vibration level is maximum 1.8 mm / s (Peak value).

Fine balancing shall be carried out at site to bring down vibration level to acceptable limits.

A vibration monitor for continuous online monitoring of shaft and body vibration during the operation of the unit and suitable device to detect excessive vibration and give an alarm shall be supplied.

1.3.3.6.20 Brakes and Jacks

The unit is to perform braking operation automatically / manually. For stopping the generating units quickly, each Generator shall be provided with conventional air brakes. Brakes shall be provided with reliable limit position switches in order to indicate the position of the brakes.

Brakes shall be provided for bringing the rotor to rest after the turbine nozzles are closed, excitation is removed, and the speed reduced to approximately 20% of the rated speed. The brakes shall be liberally designed for a braking duty associated with the normal shutdown of the unit. Provision for manual operation of brakes shall be made.

The air brakes shall be suitable for use as oil-lift hydraulic jacks, capable of lifting the complete rotating elements of the unit for a sufficient height. One portable motorised high-pressure oil pumping system shall be provided for jacking the rotor.

Provision shall be made for mechanically locking the rotor in the fully raised position. The locking device shall form an integral part of the brakes and shall be such that it shall not be necessary to maintain hydraulic pressure on the jacks while the rotor is in raised and locked position. Provision shall be made to indicate and interlock brake ON / OFF position. Brake shoes shall be provided with suitable moulded material for friction wearing surfaces. A brake dust extraction system shall be provided for sucking and collection of brake dust produced during braking operation of unit. The brake dust collection unit shall have suitable collecting bins for collecting heavy dust and light dust collection shall be through properly

designed fabric based filter.

1.3.3.6.21 Lubricating Oil for Bearings

The successful bidder / contractor shall indicate this requirement and give his recommendations with detailed specifications regarding type of oil to be used for lubrication of generator bearings. The oil for generator bearing lubrication, etc..., may be identical with that used for the pressure oil system of governor and Turbine guide bearing to the extent possible. The generator and turbine manufacturers shall cooperate to ensure that their recommendations regarding oil are identical. The first filling of oil with 10% extra shall be supplied along with the generator.

1.3.3.6.22 Continuous On-line Machine Condition Monitoring System

The following monitoring equipment / systems for prediction of abnormality and preventive action shall be provided for the generating units rated for **100MW and above**. The same shall be provided for units of lesser ratings if specifically mentioned in Part-2 "Specific Requirements for the Project".

i. Partial discharge monitoring (PDM)

A partial discharge analyzer (PDA) shall monitor the partial discharge activity of the machine winding, indicating the condition of winding insulation systems. The system shall consist of permanently mounted partial discharge sensors (capacitive couplers) on the line and neutral windings and portable or permanently installed test equipment.

ii. Air gap monitoring

In order to provide high degree of dimensional stability, online air gap monitoring system shall be provided. A uniform air gap under all the conditions of operation below a tolerance of $\pm 10\%$ shall be maintained.

iii. Vibration monitoring

The displacement of the bearings while the units are running shall be monitored by using on-line vibration monitoring equipment for replicating the forces acting on the rotor. A vibration monitor for continuous monitoring of vibrations (on-line monitoring) at TGB, LGB, UGB and Thrust bearing during the operation of the unit and suitable devices to detect excessive vibration and give an alarm and trip shall be supplied.

1.3.3.6.23 Oil Level Gauges and Oil Level Relays

Oil level gauges shall be float gauge type and shall be fitted with appropriate protection cover for preventing damages. They shall be so controlled that there is no oil leakage. The gauges shall be fixed at locations convenient for inspection even during operation. They shall be installed in convenient positions to enable easy inspection and checking of operation and shall be provided with suitable air release valves. The relays shall be provided with 2 sets of normally open contacts in lower and upper oils levels respectively.

1.3.3.6.24 Fire Protection System

Either water based or CO₂ type of fire suppression system shall be provided. A water based system shall be adopted in underground power stations because release of CO₂ gas in an underground installation shall be hazardous

An automatic CO₂ fire protection system common for all the generators comprising of two banks of connected CO₂ cylinders i.e., one as main and other as reserve, ring headers, piping, discharge nozzles, thermostat, temperature detectors, fittings, directional valves etc..., shall be supplied. The temperature detectors shall be of the rate of the rise of temperature type.

Each bank shall consist of CO₂ cylinders both for initial as well as for delayed discharge and complete with pipes and valves. Both the initial discharge and the delayed discharge shall commence discharging at once, the initial discharge within 2 minutes while the extended discharge shall maintain the concentration of above 25% for 30 minutes. Extended discharge shall be maintained by restriction of diameter of pipes and nozzles.

Automatic control shall be arranged to discharge CO₂ into the generator in the event of operation of temperature detector or *of the differential relay of the generator (latter, if specifically required)*. Provision for manual release of CO₂ to individual machines from control room shall be provided.

The CO₂ cylinder bank provided for the fire protection of Generator shall be self weighing type and should give alarm during weight loss.

A fire alarm panel with required number of heat, smoke sensors etc... shall be provided as per standards. There should be provision for interfacing the fire protection system with the plant operating system such as SCADA or DCS.

1.3.3.6.25 Insulation against Stray Currents

The generator shall be insulated against stray currents set up by the field of the generator, which may cause injury to the generator or turbine bearings or shafts. This insulation shall be arranged to break the possible paths of such currents in not less than two places in series so that positive tests for ground currents can readily be made.

1.3.3.6.26 Shaft Current Measuring Device

A suitable shaft current detector with relay shall be provided and wired to give an alarm and to provide necessary control / trip functions and the same shall be time stamped in the SCADA system. The generator shaft shall be earthed through a brush to avoid leakage currents flowing into bearing pads.

1.3.3.6.27 Speed Signal Generator and Speed Switches

There shall be provision for mounting speed signal generator (inductive pick up), speed switches and any necessary timing or metering pulse device on the top of the generator housing or around the main shaft above coupling flange. The speed signal generator leads and all speed switches shall be wired to terminals in the generator terminal box.

1.3.3.6.28 Speed Relay, Toothed Wheel & Mechanical Over-speed

A toothed wheel arrangement is to be mounted on the shaft of the generator and a photo interceptive pick up has to be mounted on a bracket and connected to speed relay mounted on turbine control panel through a special screened cable. Further, a mechanical over-speed device shall also be provided to stop the unit during over-speed and this should directly act on the oil pressure system to stop the machine.

1.3.3.6.29 Temperature Indication

Provision for suitable temperature indication, recording and initialisation of trip and alarm signals shall be made. Multi channel temperature scanners shall be provided in the control panel.

Resistance temperature detectors (RTD) / thermocouples or any other type of temperature sensors at suitable locations for temperature monitoring of stator core, stator winding and bearings shall be provided. Suitable arrangement for rotor winding temperature monitoring shall also be provided.

The temperature detectors shall conform to relevant Indian standards.

1.3.3.6.30 Tests

The tests on generators and associated auxiliary equipment shall be carried out in accordance with the detailed schedule to be approved by the KSEBL based on applicable standards. During manufacture, all necessary tests shall be made to the satisfaction of the KSEBL so as to ensure the quality of materials, workmanship and adequacy of design and test reports / data shall be furnished for approval of the KSEBL.

On completion of work at site, all equipment shall be tested to the satisfaction of the KSEBL to demonstrate that the plant complies in every way with the specification, that all guarantees have been met with, and that the equipment is suitable for commercial operation.

The Contractor shall provide all the instruments / equipment and apparatus required for conducting the testing at site. The Contractor shall transport all the required testing equipment and instruments to site and back at his own cost and shall carry out the test. A detailed list of the devices and instruments shall be submitted with the tender.

The Contractor shall intimate the time of tests at works sufficiently in advance so that the tests may be witnessed by the KSEBL or its authorised representative. The witnessing of tests shall, however, not relieve the Contractor of his responsibilities to fully meet the requirements of specifications and guarantees.

Test reports shall be supplied to the KSEBL as per the procedure described elsewhere in the specifications. No shipment / despatch of any portion of the equipment shall be made till the test certificates for the tests at factory are approved by the KSEBL in writing.

1.3.3.6.30.1 Shop Assembly and Tests**1.3.3.6.30.1.1 Routine Tests**

Following routing tests / checks (but not limited to) on major components and accessories shall be carried out on each generator as per the relevant IEC / IS standards:

1. HV tests on stator coils and stator sections
2. Impedance and voltage tests on field coils
3. Calibration of over-speed devices
4. Hydrostatic tests on all oil and air coolers and associated pipe works
5. Hydraulic tests on brakes / jacks
6. Insulation resistance test for stator and rotor windings, bearings and embedded detectors
7. Tests for accuracy of RTDs and DTTs

8. Tests on excitation and regulation equipment:
 - a. Measurement of resistances
 - b. Measurement of insulation resistance
 - c. Visual inspection and wiring check
 - d. Checking of control and relay logic
 - e. Functional checks of electronic modules
9. Hydrostatic tests on duplex strainer
10. Testing of all electromagnetic valves and pressure switches
11. Additional tests, if any, required for judging the performance of generator and auxiliaries
12. Measurement of DC resistance of armature and field winding
13. Tangent delta 'Tip-up' measurement at 0.2 p.u. and 1.0 p.u. of line-to-ground voltage (value should be less than 0.5%)
14. Phase sequence test
15. Type test on panels for IP:55 protection as per IS:13947. After this test, insulation resistance (1.5 kVrms for 1 min) and functional test on control devices shall be conducted
16. In addition to the above, tests shall be carried out on relays etc... and all other auxiliaries, and all equipment commissioned to the satisfaction of KSEBL as certified by the KSEBL's Engineer.

Further to the above, each mechanical and electrical sub-assembly shall be tested for its functioning and continuity of electrical circuits. The Contractor shall furnish a list of the proposed shop assemblies for the generator and associated equipment for the approval of the KSEBL

The KSEBL or its authorised representative shall have access to the manufacturer's works for all purposes of witnessing the manufacture, inspection of assembly, match marking etc... for testing of all components. The equipment shall be assembled and shop tested in the presence of the KSEBL or its authorised representative prior to the shipment. Any work found defective or unsatisfactory shall be rejected.

1.3.3.6.30.2 Tests at Site for each Generator

After delivery and installation of the generators at site, following tests on generators as per IS, IEC or equivalent standards shall be carried out during commissioning:

1. Measurement of air gap length
2. Measurement of stator winding resistance and rotor winding resistance
3. Measurement of stator and rotor winding insulation resistance

4. Alignment of generator and turbine runner and shaft system
5. Balancing of rotor
6. Drying out of stator winding, if necessary (turbine used as prime mover, generator terminals short circuited and field winding supplied with DC supply)
7. Adjustment of AVR
8. Relay test
9. Shaft voltage measurement
10. Phase sequence tests
11. Automatic start and stop tests
12. Synchronizing test
13. Line charging test
14. Load acceptance test
15. Quick and emergency stop test
16. Oil lift operation test
17. Braking test for verifying stoppage time
18. Open circuit characteristic curves
19. Short circuit characteristic curves
20. Potential drop and polarity of field coils
21. Recording of field currents at different operating conditions of load and power factor.
22. Load throw-off at 110%, 100%, 75%, 50% and 25% rated output and measurement of speed rise and pressure rise
23. Record thrust bearing and upper bracket deflection at dead load and operating loads
24. Checking and commissioning of various other auxiliary equipment
25. Hydrostatic pressure testing on each surface cooler and each bearing cooler
26. Checking / testing of various other auxiliary equipment.
27. Any other tests specifically required by the KSEBL's site / testing personnel

1.3.3.6.30.3 Acceptance Tests

The following acceptance tests at site shall be conducted by the Contractor, after erection and commissioning of the units.

1. Efficiency tests (by calorimetric method)
2. Temperature rise tests of Stator and Rotor winding and other parts, Stabilized temperature of bearings etc...
3. Vibration measurement tests
4. Any other test specified by the KSEBL's representative.

The Contractor shall carry out the acceptance tests of CTs and excitation transformers, which shall be witnessed by the KSEBL or its representative. However, KSEBL, at its cost, reserves the right to call on any third party to make the field test to determine whether any of the generators purchased under this Contract meets the specification, guarantee of efficiency, temperature rise, output etc... In such case, the Contractor shall cooperate with by providing all assistance for the conduct of tests and shall assume full responsibilities for the operation and safety of their equipment during such tests.

1.3.3.6.30.4 Output Tests

Load test shall be carried out at site for seventy two hours to show rated output including overload on generator in complete auto mode before releasing for commercial operation.

1.3.3.7 Requirement of Generator Spares

The following spares shall be supplied for generators:

1. Stator winding complete with insulation materials, binding materials and wedges of one generator	- half set
2. Slip rings	- 1 set
3. Brushes for slip rings	- 2 sets
4. Brush holder	- 1 set
5. Field poles each suitable for north or south polarity (universal type)	- 2 Nos
6. Thrust bearing pads	- 1 set
7. Guide bearing pads	- 2 sets of each type
8. Air cooler with water chamber	- 2 Nos
9. Thrust / upper guide bearing coolers (for plug-in type coolers)	- 2 Nos
10. Lower guide bearing coolers (for plug-in type coolers)	- 2 Nos
11. Thermometers for air circuits, bearing and bearing oil system	- 20%
12. RTDs used for air circuits, bearing and bearing oil system	- 20%
13. Heat exchanger & motor pumpset (for external type coolers)	- 1 No each for each type

Any other spares recommended by the manufacturer as essential for the satisfactory and trouble free operation of the equipment as per Clause 1.1.32 of this specification. The price

for the above shall be indicated in the bid.

1.3.3.8 Special Tools and Tackles

All special tools and tackles required for the O&M of Generator such as pole lifting, machine balancing tools etc... shall be supplied.

1.3.4 Excitation Systems

1.3.4.1 Introduction

This section of the specifications covers the KSEBL's requirements for the design, manufacture, test at works, supply, insurance, delivery and storing at site, installation, supervision of erection, testing at site and commissioning of Excitation system and related equipment for the AC Generators complete with instrumentation, controls and safety devices (as required), warranty, spares for 5 years operation of the plant, special tools and testing devices as described and detailed in the specifications and in the annexed schedule of requirements. The scope of supply shall include all parts, accessories, spares etc..., which are essential for construction, operation and maintenance of the complete Excitation system even though these are not individually or specifically stated or enumerated. Corresponding components of all the Excitation system and associated equipment and the spares shall be of the same material, dimensions and finish and shall be interchangeable.

1.3.4.2 Reference Standards and Codes

- IEEE 421 - Standard definitions for excitation systems of synchronous machines
- NEMA TR 27 – Dry type transformer
- IEC 726 - Specification for dry type power transformer
- IS 11171 - Dry type power transformer
- IEEE 115 - Test procedures for synchronous machines

1.3.4.3 Reference Sections

Section 1.1 General Technical Requirements.

Section 1.3.5 Control and Monitoring

Section 1.3.6 Protection.

Section 1.3.14 Power Plant Field Testing and Tests on completion.

Part - 2 Specific Requirements for the Project

1.3.4.4 Submittals and Approvals

The Contractor shall seek the prior approval of the KSEBL or the KSEBL's Representative at the following points of work execution using timely submittals.

- Design Calculations
- Drawings, Circuit, Diagrams and Specifications
- Graphs showing performance

- Material certificates, Quality Assurance Plan
- List of Suppliers / Manufacturers
- Test reports / Data
- Erection, Testing and Commissioning Methodology

Before delivery of equipment to site, the contractor shall submit all work test certificates for approval and obtain despatch clearance from the KSEBL / Engineer-in-Charge.

1.3.4.5 Deliverable Documents

- Physical and schematic drawings of excitation system, automatic voltage regulating equipment, field discharge equipment and descriptive literature.
- Design calculations
- Drawings, Circuit Diagrams and Specifications
- General Arrangement drawings of Cubicles
- External connection diagrams showing the details of all wires connected to other related equipment including equipment grounding details.
- User Guides and specifications of individual devices
- Hierarchical list of software, including revision level
- Program design standards
- Configuration control methodology
- Program descriptions
- Hard copy of As Commissioned Program / Ladder
- Acceptance test procedures and test reports
- Software installation, maintenance and user guides, including User Interface guide.
- Step-by-Step trouble shooting / Diagnostics procedures
- Erection, Testing & Commissioning methodology
- Operation and maintenance manual

1.3.4.6 KSEBL's other Requirements

1.3.4.6.1 General

- a) The generator shall be provided with an Excitation System along with 'Automatic Voltage Regulator' to meet the requirement specified herein. The excitation system offered shall be of proven design and conform to latest design and applicable standard. It should have a satisfactory field service record on machines of similar

size and construction incorporating the type of excitation. References for the type offered shall be provided.

- b) If required by the KSEBL, Stability studies, both dynamic (long duration, transient) and steady state, shall be carried out to evaluate various parameters of the excitation system, e.g. response time, response ratio, ceiling voltage, loop gains, power system stabilizer (PSS) parameters etc..., so as to meet the operational requirements of the grid particularly on loading side as often the power station is connected to the grid by long transmission lines.
- c) The necessary inputs and interface equipment shall be provided with Generator Excitation and Automatic Voltage Regulator for hooking up with Turbine Automatic Run-up system and Electro Hydraulic Governing System.
- d) The excitation system provided shall be of simple construction and suitable for isolated and parallel operation of machine. The excitation system shall have matching characteristics suitable for satisfactory parallel operation with other generators in the plant. It should have manual voltage regulator for proper synchronization with other generator or grid and network.
- e) All necessary equipment for complete system as well as any field flashing equipment shall be supplied.
- f) Excitation system should be well protected against any damage in case of main field opening or short circuiting.
- g) The excitation system shall be complete with devices for trouble free and efficient operation including indication, protection alarm and control devices even though some of the items may not be described.
- h) Generator excitation system shall be capable of controlling the terminal voltage from 0% to 110% on test mode.

1.3.4.6.2 Design and Construction

- a) When the generator is subjected to a sudden loss of rated output at rated power factor, the system shall be capable of restoring the voltage within 2% of the nominal preset value within negligible time.
- b) Generally, the excitation system shall have 2x100% channels including independent AVRs, power converters and controls. The redundancy shall have the following options:
 - 1. Channel 1 to Converter 1 only
 - 2. Channel 1 to Converter 2 only
 - 3. Channel 2 to Converter 1 only

4. Channel 2 to Converter 2 only

In addition to the above, bridge sharing option shall be provided. The controls shall have two independent controllers, one for each channel with hot stand-by facility. Each shall be equipped for Auto Operation with the facility for selecting either channel in Auto or Manual mode. Each excitation system channel shall be designed to continuously carry at least 110% of the rated machine excitation current at the rated output of the machine and higher currents for short time duty. Short time duty as mentioned above shall be on MCR base as per Clause 1.14 of part III in VDE 530. The rated voltage shall be at least 110% of the machine excitation voltage.

- c) Excitation system response time shall be less than 0.5 sec as per IEEE 421 A.
- d) Excitation response ratio shall be greater than 2.
- e) Excitation system ceiling voltage shall be greater than 1.8 times rated load excitation voltage.
- f) Each excitation system channel shall be capable of supplying without damage to any of the components, the field forcing voltage and current of the system for a period of 10 seconds without exceeding the limits of temperature for rectifier junction and sink, when the equipment starts at normal operating temperature.
- g) Rectifier transformer overload protection shall be provided in case of static excitation system.

Excitation system may be any of the following two types as specified in Part-2 “**Specific Requirements for the Project**”.

- Static Excitation System
- Brushless Excitation System

1.3.4.6.2.1 Static Excitation System – Technical Requirements

1.3.4.6.2.1.1 General

The excitation system of static type consisting of high performance fully controlled solid state converter bridge, dry type excitation transformer of suitable capacity, static voltage regulator, field breaker, field flashing unit, field discharge resistor, etc..., conforming to acceptable relevant international standards may be supplied. The AC supply for excitation shall be taken directly from the generator output leads / generator bus connected to a high performance dry type excitation transformer. The DC output of the power rectifier bridges shall be controlled by a digital voltage regulator and consequently regulate the excitation to the main generator field. The equipment shall have sufficient capacity to provide ceiling voltage and current required by the generator.

The excitation system shall have two independent channels namely "Manual" and "Auto" so that in case of failure of auto channel, the unit can be run on manual channel. An auto-manual balance indicator and automatic follow up of manual channel with auto channel shall be provided for smooth changeover.

The system shall include all necessary devices and be able to control the generator terminal voltage under all operating conditions and shall be equipped with facilities for joint control with the other units in the station. The voltage regulator shall be a one panel cubicle in which functional units are combined in such a manner that suitable firing pulses can be supplied to a matched excitation system required for optimum operation of the generator for control of the terminal voltage and limits. Every voltage deviation, positive or negative, shall cause an instantaneous reaction on the static excitation system in the appropriate direction so that the sudden voltage deviation caused by load changes in the system is quickly compensated.

The excitation system to be provided with the following:

- Rectifier transformer
- Thyristor convertor along with gate firing circuits
- Voltage Regulator (Auto, Manual)
- Field Flashing system along with transformer and rectifier
- Field Circuit Breaker along with field discharge resistor
- Interconnecting cables / busbars between different equipment / panels of the system.

1.3.4.6.2.1.2 Rectifier Transformer

The excitation transformer shall be of indoor, naturally ventilated air-cooled epoxy moulded dry type, enclosed, separately mounted unit conforming to NEMA TR27 or equivalent standard for dry type transformers.

The transformer shall have at least Class-H insulation and shall be epoxy-insulated type and complete with flanges and terminal lugs for connection to the generator terminals through bus ducts or UG cable as required in Part-2 "Specific Requirements for the Project". The transformer shall withstand without damage induced field currents resulting from generator short circuits. The bushings and winding shall have a BIL as per relevant standards or as specified in Part-2.

Temperature rise - 75 °C over an ambient temperature of 45 °C.

Fault rating - Withstand through fault current for the time duration equal to de-excitation time of the generator field current for such faults under AVR / manual operation.

Housing - Sheet steel cubicle.

Protection - A set of CT's shall be provided in the primary of rectifier transformer for overload protection. Hot spot temperature measurement in each limb of the transformer along with indication as well as alarm and trip contacts shall be provided.

1.3.4.6.2.1.3 Power Rectifier Components

Power rectifier bridges shall consist of 3-phase, 6-pulse, fully controlled power rectifier bridges and associated firing circuits facilitating fast and high ceiling performance complete with power fuse (ultra high speed) in series with each thyristor for selectively protecting against over-loads, gate pulse transformer and status light across each thyristor. Suitable lamps indication shall also be provided to indicate the defective 'thyristor'. The equipment shall be capable of supplying the maximum continuous current of the excitation system even if one rectifier bridge is out of service. Current sharing between bridges shall not vary more than $\pm 5\%$ of the average current of the bridges. Conduction monitors shall be provided in each leg of the bridges. With the failure of the second bridge, it shall be possible to continue operation at reduced load. The rectifier PIV (peak inverse voltage) rating shall not be less than four times the maximum RMS voltage of the input. The equipment shall be mounted in draw-out trays of modular construction. Two bridges shall be taken as failed only if identical legs have failed in both (Applicable only in the bridge sharing condition). It shall be suitable to ensure trouble free service of the cells under all fault conditions.

Gate Firing Circuit – The thyristor gating circuits shall have gated solid-state components mounted in plug-in printed circuit cards. The circuit shall be basically of the anode voltage controlled, short pulse type, which shall provide pulse train lasting only as long as necessary to cause the thyristor to conduct. Gate pulse rise time shall be very fast.

The firing circuit shall have the following essential features:

- It shall produce a gate pulse for every thyristor once in a cycle.
- It shall be able to shift the gate pulse in the time over a range of about 150 electrical degrees under a signal from the regulator.
- It shall provide a linear relationship between the regulating inputs volts and rectifier

output.

- Firing circuit shall have negligible time lag.
- It shall fire the thyristors correctly for any situation of input voltage, depression or unbalance coupled with high or low field currents.

Pulse Transformer - There shall be a pulse transformer between the individual gates of the parallel connected thyristors and between the main current circuit and the control circuit. Their amplitudes shall be depending upon the trigger characteristics, approximately (+) 3 to (+) 20V peak against cathode.

1.3.4.6.2.1.4 Field Flashing

The initial field flashing during starting of the generator shall be accomplished by flashing the field from the 110V DC station battery and 400V auxiliary station AC service voltage. Normal field flashing shall be from station AC supply and DC field flashing shall be used only in emergency. Suitable rectifier filters, etc... required for converting this AC supply to the required DC supply shall be housed in the excitation system cubicle. Suitable protection interlock with desired time delay shall be provided so that when the AC terminal voltage of the generator is built up to the required level for the main excitation rectifier system to take over, the field flashing circuit is switched off. After the machine is brought to a speed of 95%, a 2-pole contactor shall connect the source to the field through a blocking diode and a current limit resistor. When the generator voltage reaches about 40% of the rated value, the flashing contactor shall be opened and the exciter shall take over from the field-flashing source.

In case the main excitation system fails to take over after a predetermined time of field flashing, the field breaker should trip automatically. An annunciation for field flashing failure / main field breaker trip due to field flashing failure shall be incorporated.

All the components of field flashing system shall be continuously rated irrespective of its short time duty requirement so as to guard against any failure in case of it's prolonged mal-operation.

1.3.4.6.2.1.5 Field Application and Suppression

The field circuit breaker discharge contacts, discharge resistors, or other equipment shall be mounted together to form a self-supporting assembly of the excitation control equipment of each generator. A suitable hinged door, locking handle, inspection windows, foundation bolts etc..., shall be provided with each excitation cubicle.

Field breaker:- The generator field breaker shall be of DC, multi pole air break type, suitable for operation from local panel and also from Station SCADA / OWS (Operator Work Station). The field breaker shall be tripped on fault condition both in Local and Remote modes. The totally enclosed field breaker shall be electrically operated and shall operate on 110V DC shunt tripping device and auxiliary switch with manual-reversible electrically separated contacts of sufficient capacity for operation on 110V DC circuit. Rated maximum interrupting voltage shall be 3 times the rated voltage of the breaker. The breaker shall have arc quenching arrangement for both the main poles as well as the discharge contacts. Breaker shall be designed to carry currents for continuous as well as short time duty of the excitation system.

The Breaker shall be capable of breaking, without generating dangerous over voltage, the maximum field current that can occur under conditions of normal operation or when interrupting the transient D.C. component of the field current due to a three-phase fault at generator terminals.

Breaking current capacity of the breaker shall match with the fault level at the output DC bus. Discharge contacts shall be rated to discharge the field energy corresponding to the highest field current which may come during its entire operating range. The breaker shall be complete with control switches, indication lamps, local / remote selector switch, etc...

The field circuit breaker shall be suitable for both manual and electrical operation.

Discharge resistor:- Non-inductive for quick discharge of inductive energy and thereby controlling the voltage across the field. The generator field discharge non-linear resistor shall be able to limit machine damage during faults with fast action. Under such conditions, the field current shall be zero in about one second.

Option: - Separate breakers for field application and suppression may also be considered if it is manufacturer's standard arrangement.

Interlocks:- Suitable interlock shall be provided to prevent closing of the field breaker unless the regulator reference signal is at / near the minimum setting and minimum machine speed of 95% is attained. Adequate number of normally open and normally closed field circuit breaker auxiliary contact for remote position indication and interlocking with generator and field flashing circuit shall be provided.

Following minimum indications / alarms shall be displayed locally and remotely including SCADA:

- automatic mode of operation of a regulator

- manual mode of operation of a regulator
- failure of excitation system (breakdown of the power thyristor converter elements, breakdown of the power transistor of a regulator, loss of the excitation, the raised voltage on the stator etc...).

1.3.4.6.2.1.6 Pole Slip Protection

As there is always possibility of the synchronous machine pulling out of step and slipping poles, a path has to be provided for induced current with a field shorting thyristor (crowbar) or a non-linear thyristor such as thyrite. The impedance of the crowbar or thyrite must be low enough to pass induced current and hold field voltage sufficiently low to avoid damage to the exciter. The thyristor shall be gated to respond to an over voltage condition that is created by the induced current through the field discharge resistor.

1.3.4.6.2.2 Brushless Excitation System – Technical Requirements

1.3.4.6.2.2.1 General

Brushless digital excitation system having AC exciter with rotating Rectifier Bridge mounted on the shaft complete with diodes, surge suppressor, AVR & APFC conforming to acceptable relevant international standards may be supplied. Power for AVR is provided by main generator terminals. In this system, diode rectifiers that rectify exciter output are mounted on the generator shaft and their output is directly connected to the field of the alternator thus eliminating brushes & slip rings. The stationary field system of the main exciter may be fed from PMG through a voltage regulator.

The system shall have fully rated redundant diodes with indicating fuses and shall permit full load operation even with a diode out of service. A strobe light shall be furnished with the unit to view the indicating fuses and determine diode failure. Peak Inverse Voltage (PIV) of the exciter diodes must be 800V or 8 times the maximum exciter armature operating voltage, whichever is higher. At nominal speed, the excitation system must produce sufficient residual voltage in order to ensure self excitation.

Field ground indication may be provided without slip rings by means of a transmitter mounted on the diode wheel assembly. A light signal may be sent across the air gap to a stationary receiver and relay to indicate presence of a ground.

The current carrying studs in the excitation systems shall have insulation made of thermosetting resin rich mica paper machined to exact diameter of ring bored holes and bonded to the studs itself.

The excitation system shall have two independent channels namely "Manual" and "Auto" so that in case of failure of auto channel, the unit can be run on manual channel. An auto-manual balance indicator and automatic follow up of manual channel with auto channel shall be provided for smooth changeover.

The system shall include all necessary devices and be able to control the generator terminal voltage under all operating conditions and shall be equipped with facilities for joint control with the other units in the station.

Every voltage deviation, positive or negative, shall cause an instantaneous reaction on the brushless excitation system in the appropriate direction so that the sudden voltage deviation caused by load changes in the system is quickly compensated.

The complete equipment shall be mounted on a bed plate and enclosed by suitable exciter cover. The system shall consist of:

- Permanent Magnet Generator (PMG) type pilot exciter
- Voltage Regulator (AVR, MVR along with rectifier bridges for PMG)
- Field Circuit Breaker along with field discharge resistor
- Rotating rectifier bridges
- Brushless AC Main Exciter
- Complete instrumentation and protection system
- Inter-connecting cables between different components of the system

The generator shall be provided with Brushless Excitation System with 'High Initial Response' as described by IEEE Std 421 (standard criteria and definitions for excitation system) with a response ratio of 1.5, capable of continuously carrying the required excitation current at 40°C ambient temperature when the generator is delivering 100% rated kVA at rated power factor, rated frequency and 100% rated voltage. It shall also be capable of carrying short circuit current for 30 seconds after reaching rated temperature when the generator is delivering 100% rated kVA at rated power factor and 100% rated voltage. AC exciter and generator shall be electrically connected to one another. The exciter shall be of rotating armature and stationary field type to be coupled with a salient pole, rotating field type stationary armature generator. A diode wheel consisting of six diodes and selenium surge suppressor shall be mounted on the shaft. The diodes shall be easily accessible for replacement without dismantling the rotor.

A digital voltage regulator shall sense the armature voltage and control the DC supply to exciter field, under varying load conditions to maintain the voltage very near to preset value.

The excitation system shall be suitable for maintaining the voltage for a grid voltage variation of $\pm 10\%$ & for a frequency variation of $\pm 3\%$.

1.3.4.6.2.2.2 Pilot Excitation System

The pilot exciter shall be revolving field, rectifier assembly and excitation control equipment. The rotor shall be magnetized and stabilized by the Manufacturer to give stable magnetisation characteristic during operation.

The stator winding shall be of class-155(F) insulation or better, suitable for operation at 50°C ambient temperature. The machine shall be fitted with fans for self ventilation.

Converter Assembly of pilot excitation system, thyristor gate firing system and pulse transformer etc... shall be of similar design as specified under static excitation system.

1.3.4.6.2.2.3 Brushless AC Main Exciter

Armature: This shall be of rotating armature, 3-phases, star connected, feeding current to the rotating diodes mounted on the exciter shaft.

Armature core: The armature core shall be made from silicon sheet lamination to reduce eddy losses and shall be suitably varnished on both sides.

Exciter enclosure and support: The exciter shall be totally enclosed, self ventilated, frame supported on the generator foundation having journal bearings.

Heat exchanger: Integrally mounted air to water heat exchangers. Sizing criteria for the heat exchanger shall be similar as for generator mounted hydrogen cooler.

Insulation: The stator and rotor winding insulation shall be of class-155 (F) with the temperature rise limited to class-130 (B) limits of IEC-60034.

Overhang conductor: The armature conductor in the overhang portion shall be adequately held to withstand the electro-dynamic forces during field forcing condition. Rotor winding retaining ring shall be made up of stress corrosion resistant material.

1.3.4.6.2.2.4 Rotating Rectifier Assembly

The rectifier assembly made of silicon diodes shall be arranged as two distinct rings with opposite polarity diodes on respective rings.

The diodes shall be connected in a conventional three arm full wave rectifier bridge.

Rectifier assembly shall have one complete bridge as redundant. Alternatively a single three phase Rectifier Bridge having at least one redundant parallel branch in each of the six arms of the bridge may also be considered.

Rectifier assembly shall have same requirements as regards the component features and rating as detailed out for the thyristor assembly.

Diodes shall be cooled by forced air circulation by means of fans mounted on the main exciter. Each diode shall be provided with a fuse together with visual indication in the event of diode failure.

The output from the rectifier shall be fed to the generator field through the bore of the rotor shaft and necessary plug in type of shaft connection. The axial copper connector shall be designed such that it shall be possible to disconnect this connector at the point where the exciter shaft couples to the generator so that, if necessary, the generator and exciter can be tested individually.

1.3.4.6.2.2.5 Field Application and Suppression Arrangement

As detailed out in 'Static Excitation System'

1.3.4.6.2.2.6 Instrumentation and Protection

The system shall generally include, but not be limited to, the following:

- Suitable twin resistance temperature detectors for measuring hot and cold air temperature of exciter with necessary provisions for protection tripping / interlock.
- Dial type thermometers for measuring the inlet and outlet temperature of water to the air coolers.
- Pressure gauges at the inlet and outlet of water to air coolers.
- Instruments and devices for the measurement of rotor winding temperature.
- Stroboscope or suitable alternative device for detection of faulty rotating diode element.
- Suitable arrangement for exciter field suppression.

A pair of auxiliary slip rings shall be provided to give access to the rotor circuit allowing an earth fault detector circuit to be connected.

For all alarms in the system, contact shall be taken from the pressure switches temperature switches etc... provided at suitable points. The system shall be provided with transmitters

for the indicators / recorders.

Following minimum indications / alarms shall be displayed locally and remotely including SCADA:

- automatic mode of operation of a regulator
- manual mode of operation of a regulator
- failure of excitation system (breakdown of the diode of the rotating rectifier, breakdown of the power transistor of a regulator, loss of the excitation, the raised voltage on the stator etc...).

1.3.4.6.2.3 Technical Requirements Common for Both Systems

The capacity of the excitation system shall be adequate to supply continuously 1.1 times the excitation current and voltage required by the generator at its 100% rated output and 100% rated voltage and also for supplying twice the excitation current required by the machine at its 100 % rated output and 110% rated voltage for a duration of one minute.

The excitation system while operating at its maximum output, terminal voltage, power factor and speed shall be capable of changing from rated field voltage to 90 percent of ceiling voltage within 25 milliseconds for a sustained drop in generator terminal voltage of 5 percent.

The excitation system shall be able to produce negative ceiling voltage to the limit of zero field current in order to reduce rapidly the generator excitation following over voltage and loss of load.

The excitation system shall be capable of changing the generator field voltage from normal to ceiling within 100 milliseconds from the time of a drop in Generator terminal voltage 50% or less. The excitation system shall maintain the generator terminal voltage within $\pm 0.5\%$ of set value from no load to full load and at 90 to 120 % of normal frequency.

The excitation system shall incorporate the following features and facilities:

- a) Manual voltage setting rheostat.
- b) Protection against AVR failure (e.g. over / under excitation combined with over / under voltage).
- c) Each fault monitoring unit shall be provided with contacts for indication of the alarm / annunciation on AVR and excitation panel and SCADA.

1.3.4.6.3 Automatic Voltage Regulator

Each digital automatic voltage regulator (AVR) shall be provided with two channels for working at constant excitation voltage / constant excitation current i.e., one in operation and one as hot standby for automatically coming into operation in case of failure of the first channel in operation. Over the electronically controlled current loop control manual mode the motorized Auto-transformer (variac) controlled manual mode is preferred. The manual control shall be simple and shall not need expert personnel for maintenance and trouble shooting. Facility for transferring from manual to auto-control and vice-versa without the risk of sudden change of excitation level at the instant of change over shall be provided.

The AVR shall be sensitive to the change of $\pm 0.5\%$ of normal voltage (average of 3 phases) of the Generator when operating under steady load conditions for any load or excitation within operating range and shall initiate corrective action without hunting. After the initial maximum voltage following any load rejection up to 110% of rated load, the AVR shall restore the terminal voltage to a value not more than 5% above or below the voltage being held before load rejection and shall maintain the voltage within these limits throughout the period of generator over speed. The voltage regulator shall be provided with cross current compensating devices for parallel operation of generators. The range of the voltage control shall extend from 90% to 110% of rated voltage of the generator.

The digital AVR shall be of proven quality, based on latest technology, and high availability with short commissioning time and requiring little maintenance during operation.

The AVR shall be continuously acting, microprocessor based, containing the voltage regulator function together with limiters and other control circuits. The voltage regulator shall be anti-hunting. The voltage regulator shall be capable of maintaining the generator terminal voltage at any pre-set value and at the same time sharing the reactive MVA of the load between the other similar units.

The AVR shall be suitable for operating with automatic synchronizing equipment.

The AVR shall be capable of preventing an excessive over voltage during over speed conditions following loss of load. The voltage shall not rise above 115% of normal after shedding full rated MW load at the rated power factor with normal speed rise. This may be achieved by an over voltage relay tripping the field switch.

During change over from auto to manual and vice versa there should be no dip in generator voltage.

If an exciter output over voltage condition persists for sufficient time such condition shall be

able to initiate the following action:

- The generator lockout relay shall be tripping to shut down and lock out the generator along with excitation system.
- Provide annunciation.

The AVR shall have the following minimum functions:

- Dual channel automatic voltage regulator with additional control and limiter circuits. There shall be two controllers with 1 AVR + 1 MCR in each of the controllers. i.e., Controller 1 (AVR 1+MCR 1), Controller 2 (AVR 2+ MCR 2).
- Manual control facility (field current regulator) as an alternative to automatic voltage regulator.
- Independent manual back up channel field current regulator, thyristor pulse generators and a second over-current protection as an additional redundancy.
- A local control and display unit and service panel for local man-machine communication.
- Follow up function between auto and manual control and vice versa.
- Follow up function between auto and backup controller.
- Soft start with adjustable gradient time.
- Limit voltage rise in case of load rejections to a maximum of 5%.

Limiters:

- Field current limitation, instantaneous and delayed acting with inverse time characteristics.
- P / Q based under excitation limitation, instantaneous acting.
- Stator current limitation, delayed acting with inverse time characteristics in the over excited and instantaneous acting in under excited operation period.
- Over fluxing limitation (V / Hz limiter).

Monitoring / Protection

- Over excitation current protection, instantaneous and inverse time acting.
- Loss of excitation.

- PT failure monitoring and protection.
- V/Hz protection.
- Temperature monitoring of excitation transformer.
- Monitoring of field flashing time.
- Self test of the electronics (watch dog).
- Bridge disabled condition.
- Rotor ground protection with online monitoring / alarm.

The following will be general specifications:

- Auto mode can have three / two phases sensing. Voltage regulation at zero droop setting shall be better than 1%.
- Quadrature droop adjustability will be up to 8% at rated reactive load.
- Manual mode will constantly follow auto mode and in case of failure of auto mode or if desired by operator, through a push button command, change over to Manual mode bumplessly.
- Manual mode to Auto mode changeover shall be possible through a null-balance mechanism. Null-balance may be done between control signals or between final convertor outputs depending upon design.
- All components for Auto and Manual including Power Convertors and Power Transformers shall be separate, ensuring 100% redundancy.
- Auto mode shall have Power factor controller for parallel operation with grid.
- There will be Reactive current export and import limits, which will give raise lower Commands to both Auto and Manual.
- Auto mode voltage set point shall be adjustable to suit worst system conditions.
- Manual mode shall be capable of supplying zero to 120% of rated excitation.
- AVR shall have rotating rectifier failure indication and two Changeover contacts for trip and remote annunciation.
- AVR voltage sensitivity shall be better than 0.5%.
- Meters giving Excitation parameters are to be provided on AVR panel with provision

for remote metering. AVR panel will also have a voltmeter showing Generator voltage.

- AVR panel will have provision for self start on receiving signal from speed switch.
- AVR shall have frequency ROLL-OFF function, to ensure no over excitation under low speed operations.

Note:-

Generators of 100MW rating and above shall have Automatic Voltage Regulator with digital control and two separate channels having independent inputs and automatic changeover; and the Automatic Voltage Regulator of generator of 100 MW and above shall include Power System Stabilizer (PSS).

The excitation system shall be designed in such a manner that due to any fault in AVR firing circuit pulse transformer, rectifying elements in any channel etc... excitation system shall be available with its full capacity. All rectifying elements shall have over voltage and short circuit protection.

Two numbers fully equipped automatic channels having independent inputs and automatic changeover shall be provided. Either channel shall be capable of being the main or standby. Either channel shall be capable of being selected as manual also. In the event of failure of auto channels, manual control shall be possible.

At least 100% redundancy shall be provided for the converters including power supply. In case of brushless excitation system, rectifier assembly shall be provided with either complete bridge as redundant or at least one redundant parallel branch in each of the six arms of the bridge.

Automatic voltage regulators shall be either of solid state based type or microprocessor / PLC based as per manufacturer's standard and having negligible time delay suitable for a large interconnected system.

Input to AVR shall be through current transformer secondary 5A and voltage transformer secondary 110V phase to phase.

Characteristics:

- Auto control range of generator operation shall be suitable for worst grid conditions.
- Frequency range of operation shall be 47.5Hz to 51.5Hz.
- Accuracy at which generator voltage to be held shall be better than 0.5% generator

terminal voltage.

- Range of transformer drop compensation shall be 0 to 15%.
- There shall be no dip in generation voltage when AVR is transferred from auto to manual and vice versa under all conditions of excitation.
- Manual control range shall be 70% of no load to 110% full load excitation.

Technical features

The AVR shall be provided with minimum following features:

- Maximum and minimum excitation limiter, to keep field excitation within the specified limit.
- Channel reference control. Either motorized rheostats or microprocessor control.
- Ramp generation circuit, to enable gradual rise of reference signal applied to the comparator circuit to avoid sudden voltage build up.
- Rotor earth fault detection. Two stage rotor earth fault unit for continuous online monitoring facilities along with alarm and trip contacts.
- Transformer drop compensation. Suitable feedback proportional to transformer drop to be provided for compensation.
- Rotor angle limiter. A rotor angle limiter shall be incorporated in the system. This shall enable to keep the angle between the direct axis of the machine and network vector within the set reference value as determined by stability, by adjusting the excitation.
- Stator current limiter. The stator current limiter shall act immediately in under-excited range. The time delay in over-excited range shall enable a temporary overloading of the machine.
- Rotor Current limiter. The regulator shall act with time delay, so that the regulation dynamics are not impaired in case of a fault.
- Voltage / frequency (V/F) limiter. To limit the ratio of generator voltage and frequency at all operating conditions to such a value that the maximum generator transformer core flux density does not exceed the value specified.
- Automatic change-over from Auto-1 to Auto-2 or vice versa. To be possible in case of trouble in the running channel.

- Automatic change-over from Auto to Manual.
- Automatic change over shall be possible from Auto to Manual in case of:
 - Generator protection circuit operation i.e. after field forcing and over excitation condition with a time delay.
 - Loss of terminal voltage feedback by way of any of the VT fuse blowing up.
 - Faulty over excitation condition.
 - Loss of automatic channel reference signal.
 - Power supply failure in the automatic channel.
 - Manual intervention.

1.3.4.6.4 Power System Stabiliser (PSS)

The excitation system shall be provided with power system stabilizer for achieving the dynamic stability of the system under most stringent conditions of operation in the phase of disturbance created by short circuits conditions, load rejections, switching on / off of transmission lines.

The power system stabilizer should have adoptable settings, which should automatically adjust to system reactance. In other words the system should provide automatic and continuous measurement of system reactance and power system stabilizer setting must continually adjust itself for any changes in the system reactance so as to provide required dynamic stability margins.

1.3.4.6.5 Joint VAR Control

Provision for joint VAR control shall be made to permit each machine to take its share of the total station VARs. For parallel operation with a network of other generators, a current dependent regulation characteristic is desired.

1.3.4.6.6 Control, Protection, Alarms and Metering

The equipment shall include all protective relays, all control equipment, measuring instruments and illuminated Annunciator panel.

1.3.4.6.6.1 Controls

All equipment shall be automatically and electrically controlled in order that the system may

be operated from the main control centre of the powerhouse. Provision shall be made for supervisory control and monitoring of all systems from a remote Load Despatch Centre. The equipment shall include necessary relays and contactors for performing the automatic transfer of the generator field current from field flashing unit or station battery source to the normal supply source (rectifiers), when the generator terminal voltage has attained a sufficient value.

Manual start / stop may be included in excitation scheme. It is, however, preferred not to use manual control during normal start / stop operations. Manual operation will be resorted to during failure of automatic system and / or during maintenance.

1.3.4.6.6.2 Protection

All protective relays and controls shall be flush mounting type. Each relay shall be provided with two electrically separated normally open contacts for trip and annunciation. The equipment shall include the following items:

- V / Hz relay
- Generator field ground protection
- Instantaneous and time over-current protection on the rectifier supply transformer and winding temperature indicator with alarm and trip provision
- LT breakers, fuses etc... for protecting the equipment against overloads and short circuits
- Surge voltage suppressing equipment
- Slip ring short circuit protection
- A method of freewheeling of rectifier bridges to de-excite the field in the event of failure of the field breaker to open.

1.3.4.6.6.3 Annunciation

Visual annunciation shall be provided on each rectifier excitation equipment. It is intended that operation of each protection alarm will operate a point on an Annunciator in the control room. A fuse monitoring circuit may also be provided to annunciate remotely when a fuse has failed. Control / protection DC fail shall be annunciated in control room for which a pair of contacts shall be provided.

1.3.4.6.6.4 Metering

An ammeter working with DC CT to measure the field current and a voltmeter for measuring exciter voltage shall be included. A transducer type current transformer and potential measuring device shall be supplied, installed and connected to the main field leads in the main breaker cubicle. These shall also feed ammeter and voltmeter provided in the main control panel.

For Brushless excitation systems, Generator field current indication may be provided by provision of quadrature axis coil in brushless exciter.

1.3.4.6.7 Cooling

The equipment shall be cooled by forced air under positive pressure or by natural convection. In the case of forced air-cooling, dual redundant air blowers shall be provided to increase cooling system reliability. It is desirable that the hot air be thrown out of the powerhouse via ducting. The control system shall permit manual selection of either blower unit for standby operation.

All excitation panels shall be enclosed in dust proof air-conditioned cabinet.

1.3.4.6.8 Connections

The Contractor shall provide the following items:

- Power cables required for connection between rectifiers and generator field. All cables to be used inside the generator shall be of fire resistant type. Only copper cables shall be used for connection between the rectifiers and field.
- All interconnecting cables for the static excitation system, between the rectifier transformer and the control cubicle.
- All components emitting heat such as inductors, resistors etc... shall be insulated with heat resisting material and shall be suitable for operation under conditions specified in a tropical atmosphere.
- 11 kV CTs, control cables, relays etc... for the excitation transformer.

1.3.4.7 Tests**1.3.4.7.1 Type Tests**

Tests on static excitation and regulator equipment shall be as follows:

- Open circuit saturation curve
- Heat run to determine the maximum temperature rise at rated and maximum output
- Excess current test at rated full load
- Adjustment and checking overload computation
- Tests to determine speed response
- Tests to determine ceiling voltage
- Tooth ripple voltage test
- Exciter loss, efficiency, regulation and determination of characteristics and corresponding characteristic curves
- Tests on regulating devices to determine its ability to give requisite performance and also to restrict the generator voltage to a safe value under all conditions of operation of the machine.

1.3.4.7.2 Tests at Site

- Voltage build up test on auto control
- Steady state accuracy of voltage control from no load to full load
- Test to determine the range of voltage adjustment on auto control and manual control
- Load rejection test to determine maximum voltage rise under AVR control
- Minimum excitation limiter test
- Tests to determine the field current under the following conditions:
 - Rated kVA, rated power factor and 110% voltage
 - 110% rated kVA, rated power factor and 110% voltage
 - Dielectric test for rectifier transformer.

1.3.4.8 Requirement of Exciter Spares

The following spare parts shall be supplied for each unit depending upon the type of excitation system being offered:

1. All plug in units, printed circuits cards, power supply units, protection devices, Rotor Earth Fault relays and transducers for the static excitation equipment and/ including digital voltage regulator (DVR) - 2 Sets.
2. Set of Thyristors complete with fuses - 6 Sets.
3. Rectifier cooling fan complete with motor, air flow meter and accessories - 1 Set.
4. DC Field circuit breaker - 1 No
5. Discharge resistors - 2 Sets.
6. Relays, circuit breakers, contactors, switches, fuses, indication instruments etc... - 1 Set.
7. Small parts, subject to wear and tear such as gaskets, valve components etc... - 2 Set.
8. Field flashing circuit breaker - 1 No
9. Field cables - 1 No

Any other spares recommended by the manufacturer as essential for the satisfactory and trouble free operation of the equipment as per Clause 1.1.32 of this specification. The price for the above shall be indicated in the bid.

1.3.5 Control and Monitoring

1.3.5.1 Introduction

This section of the specifications covers the KSEBL's requirements for the detailed design and engineering, manufacture, quality assurance, quality control, shop assembly, shop testing, transportation, delivery at site, site storage and preservation, erection, testing and commissioning, performance testing, field acceptance testing, training of the KSEBL's personnel, handing over of protection, metering, indication, control equipment & other devices as required by the specific design offered to complete the system in all respects, including spares for 5 years operation of the plant, warranty, special tools and testing devices as described and detailed in the specifications and in the annexed schedule of requirements. The scope of supply shall include all parts, accessories, spares etc..., which are essential for construction, operation and maintenance of the complete system even though these are not individually or specifically stated or enumerated.

The control system shall be built in such a way that in case of a fault in any equipment, others are not affected and systems continue to function effectively. If the control system mentioned in the awarded contract becomes obsolete at the time of supply, the contractor shall offer the latest model without any extra cost to the Purchaser. Corresponding components of the supplied equipment and the spares shall be of the same material, dimensions and finish and shall be interchangeable.

The SCADA system shall be a state of art technology product based on distributed control system for monitoring the Plant and shall have a HMI for Man-Machine Interface. The visual indications on the PC screen shall provide complete relevant information about the Plant to the operators.

The purpose of the computerized control system is to provide Supervision, Control and Data Acquisition for the generating units, their associated transformers and auxiliaries, switch-yard including Bay control Breakers and common station auxiliaries from a single control location for automatic operation of the entire power plant in an efficient and cost effective way without compromising safety.

The Control system shall also be expandable for future addition of any generating units envisaged (if mentioned in Part - 2 "Specific Requirements for the Project"). It shall also be capable for providing control and supervision of any future feeder bays as indicated in Part - 2 "Specific Requirements for the Project".

The design of the system shall be such as to optimise control and monitoring of the Plant concerned utilising the functions implemented. It shall ensure personnel and operational safety at all times.

Standard systems shall be supplied utilising standard hardware and software, so as to assure support from the Manufacturer as much as possible. The equipment shall be from manufacturers with a proven record of both continuously enhancing their products and maintaining them upwardly compatible.

Most of the plant operations shall have state of the art control system with minimum operator intervention. All the operations shall be automatically controlled from the dedicated local SCADA and the local system provided shall be capable of connecting to the existing SCADA network through IEC 60870-5-104 or latest protocol for connecting to the Control Centre.

Any item of work not specifically mentioned in the specifications but which are usual and / or necessary for the satisfactory operation of the equipment / system shall be deemed to be provided by the Contractor and included in the quoted Price. All work shall be complete in all details whether such details are mentioned in the specifications or not.

1.3.5.2 Reference Standards and Codes

- IEC 62270 Hydroelectric power plant automation - Guide for computer based control.
- IEC 61850 Substation Automation
- IS 1554 PVC insulated cables upto and including 1100 volts
- IS 6875 Control switches (LV switching devices for control and auxiliary circuits)
- IEEE 1046 IEEE Guide for Distributed Digital Control and Monitoring for Power Plants (ANSI)
- IEEE 1249-1996 Guide for Computer-Based Control for Hydroelectric Power Plants.
- IEEE Std C37.1-1994 IEEE Standard Definition, Specification, and Analysis of Systems Used for Supervisory Control, Data Acquisition, and Automation Control (ANSI).

The codes / standards referred shall govern the specifications and mean the latest

revisions, amendments, changes adopted and published by the relevant agencies.

1.3.5.3 Reference Sections

Section 1.1	General Technical Requirements.
Section 1.3.3	Generators
Section 1.3.4	Excitation System
Section 1.3.14	Site Installation, Field Testing & Tests on Completion.
Section 1.4.2	GSU Transformer & Station Auxiliary Transformer
Section 1.4.3	Switch-yard equipment
Part - 2	Specific Requirements for the Project.

1.3.5.4 Submittals and Approvals

The Contractor shall seek the prior approval of the KSEBL or the KSEBL's representative at the following points of work execution using timely submittal.

- The design and drawings of Complete Architecture of the control system shall be submitted for approval of the KSEBL along with specification of devices employed.
- Design / setting calculations
- General Arrangement / Layout Drawings, Foundation Details, Schematic / Circuit diagrams and Specifications.
- Interlocking / Inter Trip Matrix, Trip Logic diagrams, Synchronising Logic.
- Bill of Materials (including type, make and ratings)
- Graphs showing performance.
- Calculations supporting CT sizing / selection.
- Alarm List and Annunciator Facia / Window Inscription Details.
- List of suppliers / manufacturers supported with Brochures / Catalogue of Equipment for Vendor approval along with QAP.
- Relay setting calculations and data.
- Test protocols and test reports / data.
- Inspection & Test Protocol (IT&P) of equipment.

- Method Statement for Erection, Testing & Commissioning.

1.3.5.5 Deliverable Documents

Documentation should be provided that adequately describes the system such that the design can be verified. Documentation should also be provided such that it can be used to support installation, testing, system activation, hardware operations and maintenance, and software maintenance and development. The following are typical of the documents to be furnished to meet this requirement.

- Equipment specifications.
- Single line diagrams and Connecting / circuit diagrams.
- Logic diagrams and flow charts.
- Schematic diagrams.
- Equipment drawings.
- Control room layout.
- Detailed dimensional drawings of control and relay panels / desks showing all equipment mounted on them with complete lists of name plates.
- Contact development drawings of all switches, relays etc...
- Outline drawings and internal wiring diagrams of the panels such as instruments, relays, meters, Annunciator and other equipment showing external wiring terminations.
- Complete AC and DC schematic drawings of all elements of control and relay boards.
- Complete schematic drawings for annunciation system.
- Cable interconnection drawings indicating terminal block numbers of cores, instruments / panels at which cable is to be connected etc...
- Details of protection schemes and annunciation system offered.
- Literature describing the instruments, relays and their characteristics, technical details, relay-setting calculations etc...
- Commissioning, operating and maintenance instruction manual for each relay.

- System Architecture showing nomenclature, equipment types, model numbers, input / output provisions etc...
- General Arrangement drawings of Cubicles.
- External connection diagrams showing the details of all wires connected to user's equipment including equipment grounding details.
- User Guides and specifications of individual devices.
- Cable list.
- Inputs / Outputs list.
- List and settings of protections.
- Acceptance test procedures and test reports.
- Software installation, maintenance and user guides, including User Interface guide.
- Step-by-Step Troubleshooting / Diagnostics procedures.
- Erection, Testing & Commissioning methodology.
- Operation and maintenance manual.
- Test Report / Data.
- Factory Acceptance Test, Site Acceptance Test and Site Integration Test Methodology and Reports.
- Other drawings considered necessary in addition to the drawing stated above
- Program description and flow charts.
- Source code and source key.

The extent of the documentation to be furnished shall be to the satisfaction of the KSEBL.

Before delivery of equipment to site, the contractor shall submit all work test certificates for approval and obtain despatch clearance from the KSEBL / Engineer-in-Charge.

1.3.5.6 KSEBL's Other Requirements

1.3.5.6.1 Station Control & Monitoring

Depending upon the requirements specified in Part 2 "Specific Requirements for the

Project”, either PLC with HMI / Computerized control (SCADA) desk shall be provided for the control and monitoring of the Units, Switch-yard equipment, Auxiliary systems etc...

Any ratings, protection requirements etc..., if mentioned, are indicative only and are a minimum for giving a base line. The Bidder should ensure that the ratings / protection requirements etc... of the various equipment are sufficient to take care of the design requirements of the equipment offered for the concerned project. Any increase in rating / upward change in protection requirements during detailed engineering stage will not entitle the Successful Bidder / Contractor for any extra charges. The Contractor should submit for approval the calculations for arriving at the ratings of the various equipment.

Notes:

- i. The control equipment offered should have been in successful operation for 2 years in at least 2 power stations in India under similar operating conditions. Certificates to this effect from the users shall be submitted by the bidder.
- ii. The UPS (redundant) required for the Automation system and the batteries needed for the UPS for 1 hour (for PLC with HMI only) / 6 hour (for PLC with SCADA) backup shall also be supplied by the contractor as given in 1.3.8.6.2.6 of “Auxiliary Electrical Equipment” shall also be supplied by the contractor.
- iii. Calculation for kVA rating of the UPS and battery sizing along with specifications shall be submitted by the bidder for purchaser’s consideration.

1.3.5.6.1.1 PLC / Computerized Control

PLC with HMI / Computerized control if intended for the station, will comprise the following:

- Redundant PLC system with duplicate control provided in the control room and local unit control Board in the machine floor.
- Provision for controlling all the Units, MIV, Station auxiliaries, Switchyard etc... from the above PLC / Computerized control system in the Control room.
- Provision for manually controlling all the units, MIV, station auxiliaries, Switchyard etc... in case of failure or malfunction of the above PLC system.

The control system design shall also take into consideration any future additions of new units envisaged in the station.

Control Room Process Computer System

A redundant process computer system and the necessary peripherals are necessary for

controlling and monitoring the plant operation and for archiving and logging functions.

The computer system must be constructed on the basis of standardised hardware and an operating system from a well-known manufacturer. The software must comply with the guidelines specified in the open system architecture international standards such as POSIX, TCP/IP and DIN. The support software programs that perform critical functions, such as communications, database management and user-interface support shall include or be based on no-risk, field proven commercially available products.

A structure which permits TCP/IP connection to other computer systems (e.g., computer system for vibration monitoring) must also be included in the system. The hardware of the system shall be complete in all respects pertaining to interface requirements and communication requirements.

The System shall be able to communicate with other systems by means of standard interfaces and protocols, including LANs, WANs, point-to-point data links, gateways to external networks / SCADA system etc...

Note 1:

The contractor should ensure that the system offered is capable of remote control communication with the Control Centre at Kalamassery through the existing communication network. Communication media between power house & State Load Despatch Centre and power house & Back-up Load Despatch Centre is already operational.

Each control room process computer systems must be provided with two monitors and mouse. Operation without a function keypad should be possible. The monitors should be minimum 20 / 21" TFT high resolution, LED colour monitor, fully graphic with a resolution of 1280 x 960 pixels (or better) and a refresh frequency of at least 66 Hz

The graphical user interface should be based on the windows / better platform. Window should primarily be used for operating dialog. All information shall be visible in one window and all activities belonging to one process element or process can be executed from the same.

The control room process computer system must perform the following functions without any limitation:

- Monitoring
- Alarm and acknowledge
- Process operation
- Archiving and logging, and

- Calculation and logical tasks

Note 2:

The successful bidder should submit a list of probable vendors from whom the SCADA system is intended to be sourced, along with the system configuration details, for approval of the KSEBL / Engineer-in-Charge. The make of each hardware system shall be clearly specified in the list and the systems along with the hardware shall be sourced only from the vendors approved by the KSEBL. (The contractor shall provide the details of the SCADA system used, along with details of all hardware, supported protocols, configuration details and features whether it is in-house manufactured or outsourced).

HMI System

The tasks that the operator must perform and understand, as well as other human factors, should be considered in the HMI design. The HMI shall be designed to assist the operator and all other users of the System in performing their tasks under all the operating conditions. This involves specific displays and alarm handling strategies for the various operating situations. Controls shall be intuitive and images shall be self-explanatory, leading the operator to the corrective actions he has to take to restore the plant to steady state.

The HMI shall be configured with:

Displays which show an overview of the overall operating situation of the plant the operator is monitoring. These displays shall incorporate status, alarms and data. These displays shall provide access to all other operator displays.

Displays that allows the operator to control the plant.

Effective alarm management, which warns and guides the operator when alarms occur.

The HMI should also be configured with:

- Displays, which help the operator achieve a safe and environment-minded, optimum economy operation.
- Display summaries and handover reports to enable the clear handover from one operational shift to another.
- Operational reports on plant performance, maintenance activities and operational planning.

The representation of Power plant overview displays and process flow displays in various degrees of detail must be possible. The Plant / Process displays must be

dynamically provided with all the necessary Plant / Process data, while the representation of Plant / Process data in the form of figures, graphs, charts, trends, colour codes, text and symbols must be possible in every image

In case of a fault, it should be possible to quickly access the plant images, which are necessary for quick corrections and action intended to eliminate the fault.

Power Supply

The control cabinet should be designed to have two separate feeders for incoming power supply. The automation system should be able to operate on 110V DC supply. Power supply to the control room process computer system shall be 230V AC. 24V DC or 48V DC, if required by the sensors etc..., must be generated by the automation system internally with the help of two redundant DC / DC converters suitably isolated on the output side. In the event of failure of any one DC / D C converter, the other should be able to take the entire load. For the 230 V AC power supply, two UPS of required capacity with independent plante / tubular battery systems should also be provided for giving a Backup of minimum 1 or 6 hour as given in 1.3.8.6.2.6 "Auxiliary Electrical Equipment". Each UPS shall be rated such that only 70 percent of its capacity will meet entire load requirements.

Voltage monitoring relays shall be provided on the feeders to monitor the feeder voltage.

Grounding

Each equipment rack in which automation system components are located should be separately connected to the powerhouse ground mat via a large gauge wire as recommended by the manufacturer. During power system fault conditions, communication circuits that connect the different items of equipment should be capable of withstanding the maximum potential rise between the equipment items.

If Shields are used on analog signal cables between the transducers and the automation system, for maximum effectiveness, each shield should be tied to the signal common potential at the transducer end of the cable. If there are terminations or junction boxes between the transducer and the automation system, each shield circuit should be maintained as a separate, continuous circuit through such junction or termination boxes. The shields should then be left un-terminated at the automation system equipment end.

Conditions of Service

The automation system must be designed to the following limiting ambient conditions:

- Temperature - 45°C
- Relative Humidity - 100%
- Pressure - Atmospheric
- Atmosphere - Dusty

1.3.5.6.1.2 Computerized Data Acquisition and Control System (SCADA)

The purpose of the computerized control system is to provide Supervision, Control and Data Acquisition for the generating units, their associated transformers and auxiliaries, switch-yard including feeders and common station auxiliaries from a single control location for automatic operation of the entire power plant. The complete SCADA system shall be provided if included in the Part - 2 Specific Requirements.

1.3.5.6.1.2.1 General Requirements

The system shall be capable of carrying out the following functions automatically with a single keyboard / push button command from control room / local control panel:

- Automatic start / stop of the unit auxiliaries
- Automatic start / stop of the units and checking of the interlocks
- Parameter monitoring and data acquisition on real time basis
- Generating logs at pre-specified intervals, on demand and after a tripping.
- Display of trends
- Sequence of events recording
- Display of mimic on the station computer for effective man machine interaction

In addition to the above, the system must support the following modes of operation:

- Step-by-step mode of operation from control room / local control panel
- Manual operation from the control room and from local panels.

The system should have extensive self-diagnostics capabilities. The local control panel should have control over the respective unit / plant and control room control panel has control of all the station.

1.3.5.6.1.2.2 System Configuration

The system offered should be modular structured and suitable for establishing decentralised and autonomously functioning automation units for the control of individual

turbine generator units and switchyard and common auxiliaries respectively. The individual decentralised automation units must be connected via a redundant station bus system complying to latest international standards. The autonomous automation function units should be located close to the process. A control room process computer system (HMI) will be provided for operator interaction. The process computer system will also be connected on to the redundant station bus system.

A hierarchical structure and further decentralisation with distributed intelligence must be used to create an extremely available system within the individual automation units. All automation tasks must be distributed among the parameterisable and user programmable modules of the automation systems.

The automation system and control room process computer system must be equal bus participants of the station bus. Also smart devices like multifunction meters, numerical protection relays, IEDs etc... should preferably be connected to station bus. The offered system should ensure swift reaction time between command initiation and acknowledgment throughout the process control system. The autonomous function units should have a provision to connect remote Input / Output modules so as to reach very close to the process equipment and reduce the interconnecting wiring.

A GPS synchronised clock must be incorporated in the system for the purpose of time tagging. This system clock must ensure that correct time tag is applied for the real time data as well as on the inputs / outputs of the system and at generation of new signal from the user program. The time synchronization of the input / output modules must be precise to 1 ms. All real time data within the system must be processed with a precision of 10 ms, and 1 ms for some critical signals such as electrical protection. A system wide chronological log must be created.

All sensor wetting voltages and all outputs of the process control system must be short circuit proof and overload proof. Important sensors in the field such as RTDs must operate with modules with sensor monitoring (without interfacing panels). Monitoring must be expanded to cover at least wire breakage and short circuits.

For monitoring the electrical parameters, direct interface with the CTs and PTs will be preferable instead of use of the transducers. Application of transducers should be avoided as far as possible and the connection of all analog sensors in the field to the automation system must be as direct as possible and sufficiently monitored. All necessary auxiliary voltages required for this purpose must be created within the process control system. Use of interposing relays should be avoided as far as possible.

All modules of the automation system must be sufficiently isolated from the field and from each other. Internal function of all modules must be sufficiently monitored. The entire automation system must be able to register, diagnose and limit internal and external errors after they have been recognised. Suitable indication must be available on the front facia of the modules to indicate health of the module.

The functioning of the automation system must be based on the decentralised database. The programming of the automation system must be based on user oriented programming tools.

User oriented automation functions must be performed with function diagram technology according to DIN and IEC. Program examples must be enclosed with the offer.

The entire automation system must be self-explanatory. It must be possible to display and print all programs in functional blocks, parameters and lists any time, if required, without interrupting the operation of the system.

The system shall be capable of taking care of complete control and indication functions of the feeders and all other switchyard devices also.

1.3.5.6.1.2.3 Specification for Station Bus System

A standardised bus system must be provided for communication between the decentralised functional units and with the control room process computer system. The bus system should have the following features:

- Structure of the Bus system must be in accordance with ISO / OSI reference models.
- Deterministic access with calculable reaction times.
- Highest possible availability through redundancy. The station bus must be preferably in ring structure. It must be possible to operate the automation system, in the event of an error without any loss of data or reduction in the level of function.
- In the event of multiple errors at the station bus, the functional areas in the remaining bus islands can continue operation.
- All parts of the automation system connected to the station bus are organised as equal stations at the bus.
- The station bus must be of optical fibre (outdoor type armoured cable).

1.3.5.6.1.2.4 Monitoring

The representation of Power plant overview displays and process flow displays in various degrees of detail must be possible. The Process flow displays must be dynamically provided with all the necessary Process data, while the representation of Process data in the form of figures, graphs, charts, trends, colour codes, text and symbols must be possible in every image.

In case of a fault, it should be possible to quickly access the process images, which are necessary for quick corrections and action intended to eliminate the fault.

An LED display of minimum 65" with sufficient HDMI and USB ports shall be provided in the main control room to view all the important operating parameters at a single glance.

1.3.5.6.1.2.5 Alarms and Acknowledgment, Event Lists

The control room process computer system being offered must perform the following functions:

- Representation according to urgency through the assignment of various priority IDs.
- Differentiation according to source through the assignment of categories.

All types of faults are represented in:

- Overviews (compiled representations in tables or on the screen)
- Lists of faults (summaries of classified single representations)
- Process displays (single malfunction display); and
- Total fault displays (summary of single malfunctions in several trees [e.g., per station]).
- At the same time, faulty and processing states should be differentiated.

It must be possible to mark the faults in the overviews and lists of malfunctions (lists of alarm states), classify the faults according to priority and categories and separate them into waiting and unacknowledged reports. This will direct the control room personnel during analysis of the malfunction.

Acknowledgment will be possible in the alarm states lists, by line and by page or in the process displays (relating to individual process variables).

The analysis of error malfunctions and elimination of errors will be aided by the availability of additional functional modules in the control room process computer system in addition to

alarm management such as:

- Chronological logs and lists. They log the spontaneous events in real-time chronological order with a resolution of 1 ms for protection beginning with acquisition of the signal in the automation system. The system shall be capable of monitoring events from the feeder control and auxiliary control panels and cooling water controls and sufficient provision shall be available for future addition of events.
- Cyclical logs for monitoring changes in values or their constancy.
- Archive evaluations of statistical values; and
- Trend analysis (historical and current values)

1.3.5.6.1.2.6 Process Operation

The following are typical functions in process operations:

- Remote control, including set point adjustment commands
- Correction to a set point of equipment, which is not controlled remotely, and
- Status manipulation, such as processing locks and allocating flags (e.g., due to revision).

It should be possible to operate the system with trackball or mouse alone and the alphanumeric keyboard is used for numerical inputs only.

1.3.5.6.1.2.7 Archives, Logs

Adaptability to new needs is an important quality of the control room process computer system's archives and logs. It must be possible for the user to determine the structure and content of both logs and the forms for processing the process variables from archives. At the same time, these changes must be possible online, without interrupting ongoing operation, and without programming knowledge.

Long-term archives on a hard disk, which make the archived data available for further evaluations, must be created through the compression of data such as the creation of average values, sum values and creation of minimums and maximums. Direct access to the archives must be ensured for all output devices.

The archiving functions must ensure the creation of a correct history of process events, which can be called up at any time. Any missing or faulty data must be marked

automatically and corrected without difficulty.

The archiving functions must include data stream archives with chronological sequencing and cyclical archives for cyclically filed sets at defined points in time and in a defined time-slot pattern. The storage of archives on magnetic tape for long-term archiving must be possible without interrupting ongoing operations (including those of the archive).

The following must be included in the logging functions:

- Event logging
- Update logging
- State logging, and
- Operational data logging
- Automated operator's log - Hourly, daily, and weekly electrical and mechanical data, traditionally logged manually by the operator including printer selection, log output control (such as titles, attributes, forms, etc...) and log calculation.
- The system should be able to give printouts of all the periodical operational logs in KSEBL prescribed format and letterhead on a single click.

It must be possible to store the entire archive or selected parts of it in an SQL database for the purpose of making special analyses.

The data logs must be stored in two redundant historians and disks, one main and one hot standby.

1.3.5.6.1.2.8 Dynamic Behavior, Throughput Capacity

The control room computer system shall be designed to minimize updating time by using technology.

1.3.5.6.1.2.9 Engineering Workstation and Mobile Engineering Workstation

An Engineering workstation and a mobile engineering workstation with loaded software of all automation devices must be provided so that it can monitor online programs, diagnose for errors etc... Also it should be capable of editing and modifying the programs. The Engineering work station shall be similar to operator workstation and mobile engineering workstation shall be a laptop of a reputed manufacturer. It shall be capable of being connected to any network switch in the system for monitoring the PLC's.

1.3.5.6.1.2.10 Specifications of Control Cabinet

The modules of the automation system must be housed in a suitable control cabinet as per the following specifications.

The control cabinets must be of modular design conforming to international standards. The control cubicle should be sufficiently large such that the amount of equipment in the cabinet does not exceed 80% of capacity.

The interior temperature of the control cabinet must be maintained at proper value for optimum performance of the automation system, as far as possible without use of fans. All wires shall be suitable for operation at 90°C. The voltage rating of all insulating wires shall not be less than 600 V to ground impressed on the conductor in normal operation. All wiring shall be clearly marked and so designated on the drawings to permit identification for maintenance. Wires not colour coded shall be identified by a wire number marker on each end.

All connections leading into and out of control cabinets must be directed via terminal blocks. Screw-less spring loaded terminals must be used up to a diameter of 2.5 mm² and screwed terminals thereafter.

Suitable terminal blocks with isolation and shorting facility must be used in current transformer circuits in such a way that all necessary measuring tasks can be performed easily.

1.3.5.6.1.2.11 Power Supply

The control cabinets should be designed to have two separate feeders for incoming power supply. The automation system should be able to operate on 110V DC supply. Power supply to the control room process computers system shall be 230V AC. 24V DC or 48V DC, if required by the sensors etc..., must be generated by the automation system internally with the help of two redundant DC/DC converters suitably isolated on the output side. In the event of failure of any one DC/DC converter, the other should be able to take the entire load. For the 230 V AC power supply, one UPS required for each computer with a minimum of 8 hour backup capacity.

1.3.5.6.1.2.12 Condition of Service

The automation system must be designed to the following limiting ambient conditions:

- Temperature - 45°C
- Relative Humidity - 100%

- Pressure - Atmospheric
- Atmosphere - Dusty

1.3.5.6.1.2.13 Conformance to Standards

- Protection against electrostatic discharge according to IEC 801-2 for power supplies, digital modules and communication interfaces - min. 5 kV
- Noise immunity against electromagnetic irradiation according to IEC 801-3 - min. 3 V/m
- Immunity against current transients according to IEC 801-4 - min. Class III
- Electromagnetic devices' own irradiation within the limits set forth in VDE 0871 - Class A

1.3.5.6.1.2.14 Shop Tests

The automation system shall be factory tested by the supplier to ensure that all equipment, subsystems and modules can perform as per the requirements of this specification. The vendor shall maintain proper records duly signed by authorised quality assurance personnel regarding all stage inspections, tests on individual equipment or subsystem.

1.3.5.6.2 Local Unit Control and Metering Board

The automatic unit start–stop control scheme shall be of microprocessor based programmable logic controllers with provision for manual, step by step and fully automatic operation. The control Board shall be designed for the following functions:

- Automatic / Manual Starting and stopping, automatic shutdown under fault condition, emergency stopping of the machine from UCB and Remote control terminal.
- Generator controls shall also be capable of running the units in synchronous condenser mode for units of rating 50MW and above. Transfer from generator mode to condenser mode and vice versa shall be without interruption and shall be smooth.
- Manual as well as automatic synchronisation from remote terminal.
- Centralised control of unit auxiliaries from UCB.
- Status indication of unit and its auxiliaries.
- Visual and audio alarm annunciation with facilities to accept, reset and test.

- Metering for MW, MVAR, Power factor, Voltage, Current, Speed etc... (MW and MVAR meters shall be of transducer type).
- Energy metering.
- Oil level indication.
- Temperature metering and recording.
- Pressure metering.
- Flow measurement.
- Vibration monitoring.
- Running hours metering.

1.3.5.6.3 Remote Unit Control

Remote unit control shall be suitable for performing following functions in conjunction with local unit control board and control, metering and relay panel for the Switchyard equipment.

- Automatic Starting, stopping and emergency shutdown of the machine.
- Manual and automatic synchronisation.
- Status indication of unit including excitation system, governor system & Bay Control breaker including Mimic Diagram.
- Metering for MW, MVAR, power factor, voltage, current, speed, field current, field voltage etc... of the unit.
- Speed control of the unit.
- Voltage control of the unit.
- Temperature metering and recording.

1.3.5.6.4 Local Unit Auxiliary Control Panels

For automatic as well as manual control of the unit's auxiliaries, local control panels shall be provided for each auxiliary separately. It shall be possible to control the auxiliaries from UCB also in conjunction with local auxiliary panels. Each local auxiliary panel shall be provided with overload relays, voltage and current meters, control switch for start / stop, relays for automatic start / stop, ACB's for incoming supply, indications, Single phasing preventors etc...

1.3.5.6.5 Control, Metering and Relaying Panel for Units

The Control, Metering and Protective relaying function shall mainly include:

- Generators
- Generator transformer bays.
- Unit Auxiliary Transformers.
- Excitation Transformers.
- Synchronising.

Control Function

- Manual opening & closing of circuit breakers and isolators.
- Tripping of circuit breakers under fault condition.
- Automatic shutdown of generators under fault conditions.
- Automatic closing of circuit breakers through command from automatic synchronising equipment.
- The Control switches (for Manual control) shall be placed over the mimic diagram provided in the Control Panel / Desk (if provided).

Metering Function

- Position status of switchgear equipment e.g., CBs and isolators.
- Active and reactive power generated by each generator. (both generated MVAR and transmitted MVAR at Transformer end).
- Active and reactive power flow on each line.
- Power factor of each generator.
- Power factor of each line.
- Generator voltage, line voltage and busbar voltage.
- Generator and bus frequency.
- Current from each generator and through each line.
- Temperature of generator windings and core, rotor temperature, generator bearings, transformer oil and windings etc...
- Recording of bus voltage and bus frequency.
- Transformer cooling water flow meter

- UAT Winding Temperature Monitoring
- Total MW meter and total MVAR meter shall be supplied with provision for all the generators in the Power House.

The above list is not exhaustive. Any other metering and monitoring functions necessary for the smooth operation of the powerhouse shall be provided.

Protection Equipment

The protection offered can be either static or numerical. GMFR relays are also acceptable provided two relays are installed per unit. The following protection shall be provided (as a minimum):

Generator and Unit Transformer

• Stator earth fault protection 95%	59N
• 100% stator earth fault protection	64G
• Negative phase sequence protection	46
• Rotor earth fault protection	64F
• Loss of field protection	40
• Generator over voltage protection IDMT	59
• Impedance backup protection	21G
• Voltage restrained over current	51V
• Low Forward / Reverse power	32
• Generator differential protection	87G
• Overall differential protection	87T
• Under / over frequency protection	81
• Shaft current protection	
• VT fuse failure monitoring protection	
• Transformer oil temp. rise protection	49O
• Transformer winding temp. rise protection	49W
• Transformer oil surge protection	63S
• Alarm for abnormal oil level in transformer conservator	

• Breaker failure protection	50BF
• V/Hz relay	59VHz
• Buchholz relay protection	63
• Transformer time O/C relay on HV side	51/51N
• Transformer REF relay on HV side	87TN

UAT (Unit Auxiliary Transformer)

• Over current protection	50/51
• Sustained earth fault protection (LV side)	64
• Transformer winding temperature alarm & trip protection	

Excitation Transformer

• Over current protection	50/51
• Transformer winding temperature alarm & trip protection	

Synchronising Equipment

The synchronising function shall check the phase, magnitude and slip frequency of the voltages across the open circuit breaker.

Check synchronising shall be provided with a guard function to prevent a continuous close command during a synchronising operation.

Measurement of the following parameters of incoming and running voltages must be provided:

Phase angle difference - Adjustment of the phase angle between incoming and running voltages over which the relay contacts will close shall be provided over the range 20 ° to 45 °. (Note this results in a total angular segment over which circuit breaker closure is permitted of 40 ° minimum to 90 ° maximum).

Voltage difference - A voltage check feature shall be incorporated which shall inhibit operation of the check synchronising relay if either one or both of the synchronising voltages is less than a preset percentage of rated voltage. The voltage check feature shall be adjustable over the range 80 per cent to 90 per cent of the relay rated voltage.

Rate of change of phase (slip) - The maximum slip frequency at which closure is permitted is a function of circuit breaker closure time and adjustment shall be provided for this. The method of measurement of slip in which it is ensured that the true phase angle difference does not exceed the set phase angle difference for more than a given

time, is preferred.

Automatic Synchronising Equipment

The automatic synchronising equipment shall be designed to permit automatic control of turbine speed, voltage and breaker closing for the purpose of connecting the generator to a running system with a minimum of disturbance to the machine or the system.

The automatic synchroniser design shall include the following units:

- Voltage acceptor
- Speed matcher
- Voltage matcher
- Synchronism checking device

A common automatic synchronising equipment with a redundant module shall be provided for all the three machines.

A check synchronising relay also to be provided.

Manual Synchronising Equipment

In case the automatic synchroniser is out of order, the units will be synchronized by the operator using the manual synchronising equipment.

Synchroscope

The synchronising panel shall comprise:

- Incoming and running voltmeter.
- Incoming and running frequency meter.
- Synchroscope with synchronising lamps shall be provided in a location easily visible for the operator while synchronising.
- Synchronising pulse sent indication light (green) separately.
- Check synchronisation relay – numerical with inbuilt guard function.

1.3.5.6.6 Remote Control & Metering Panel for AC auxiliary Supplies

Control Tasks

Remote closing / opening of all 415 V AC circuit breakers. (Necessary hardware scheme shall be included in SCADA specification for remote control and monitoring). LTAC shall be

provided with interconnection of black start DG with necessary interlocks and check synchronising facility.

Indication / Metering Tasks

- Position status of all 415 V AC circuit breakers.
- UAT incomer voltages, Current and Power factor of all the units.
- 415 V station service incomer voltage, Current and Power factor.
- Visual & audio alarm in case of tripping of any circuit breaker and in case of supply changeover etc...

1.3.5.7 Constructional Features

General

The protection relay shall be designed such that if an analogue input module can be removed from its case, the current transformer connections shall be automatically short-circuited before the analogue input module is removed.

All relay cases shall be earthed except where insulated cases are provided for special requirements.

A list of all of the protection and control equipment being offered under the contract shall be provided together with a list of all of the test and ancillary equipment required for commissioning and routine testing of all protection and control equipment.

Equipment Accommodation

Protection and control panels shall be fixed front panels and rear opening for access the relays.

Both the main protections should be in a common protection panel.

Operator Interface

All numerical protection systems shall be provided with an integral local user interface, to enable communication with the relay without the use of external equipment. Any facilities provided for connection to an external computer shall be an additional feature to the local user interface. No exceptions to this requirement shall be permitted. The local user interface is to facilitate setting changes and observation of indications without the use of remote communications.

Relay serial communication facilities should allow all information which is available locally at the relay front panel to be accessed remotely. It should also be possible to carry out bulk

transfer of settings and fault record information using appropriate PC based software. The necessary software for communication with each relay type shall be provided as part of the contract.

Each protection relay shall also comply with the following requirements.

Identification

Each protection relay shall have a unique identifier that is clearly visible. The software and firmware version and / or reference and issue level shall be identified. The marking of all relays shall comply with Clause 9 of IEC 60255-27 (2005).

Settings

Each protection relay shall provide a means by which the user can easily access the protection system to apply the required settings, which shall be password protected and secure from inadvertent operation. A display of the applied settings shall be available on the protection relay.

Indications

Each relay or protection scheme shall be provided with an adequate number of indications to ensure that the appropriate protection function such as differential, stator earth fault, Power function etc. can be easily identified after a fault condition. Each indicator shall be visible and capable of being reset without removing the relay cover. It shall not be possible to operate the relay when resetting the indication.

Numerical relays shall include continuous self-monitoring and supervision of all parts of the relay hardware, DC auxiliary supply, firmware and software and any failure shall be annunciated on the relay and via the remote control facility. An output alarm contact shall close for any detected failure.

The record of relay indications shall be maintained following any DC auxiliary supply interruption and the status of the DC power supplies shall be permanently indicated.

Output Contacts

All protection relays shall be provided with an adequate number of contacts of suitable rating to perform the required tripping functions, alarm indications, fault recorder functions and such supplementary signaling functions as may be necessary for initiation of automatic switching control, inter-tripping etc... In all cases contacts intended for tripping duty shall be designed such that:

- They cannot inadvertently interrupt trip coil current.

- They initiate the circuit breaker trip coil directly without the interposition of auxiliary relays or reinforcing contacts.

Test and Isolation Facilities

Each protection scheme shall be so arranged that operational and calibration checks can be carried out with the associated primary circuit(s) in service.

Adequate test facilities shall be provided within the protection scheme to enable the protection and control equipment to be tested from the front of the protection equipment panel with the primary circuit(s) in service. The test points shall be clearly identified and labeled. The test points should be positioned in right side of the each protection relays .The sufficient number of test plugs and the connecting cables must be provided with the panel supply.

Adequate facilities shall be provided, preferably at the front of each protection equipment panel, to isolate all DC and AC incoming and outgoing circuits so that work may be carried out on the equipment with complete safety for personnel and without loss of security in the operation of the switching station. The isolation points shall be clearly identified and labeled. The labels on the isolation points shall either describe the function or be uniquely numbered.

Service Life and Service Support

The protection systems shall be designed for a service life of 15 years, allowing for only routine testing that is limited to basic functional testing in accordance with manufacturers recommendations.

The service life of the protection system equipment in relation to that of the main HV plant and apparatus shall be stated so that the cost of any replacement during the life of the power plant can be assessed.

The period for which lifetime support will be provided for the protection system equipment shall be stated. Recommendations for the provision of spare parts are required.

Circuit diagrams for each protection system and the associated tripping system(s) (Both in hardware and software) shall be supplied. The diagrams shall provide sufficient information to enable fault finding and maintenance to be carried out and shall not consist solely of information used for equipment manufacture.

1.3.5.7.1 Switches

Control and instrument switches shall be of rotary operated type preferably with silver to

silver contacts of adequate making, carrying and breaking current rating and shall be provided with easily removable protective terminal covers and escutcheon plates clearly marked to show operating position and shall be suitable for flush mounting with only switch front plate and operating handle projecting out. The connections shall be from the back. The contact assembly at the back of the switch shall be enclosed in dust proof removable covers.

The selection of operating handles for the different types of switches shall be as follows:

• Breaker and Isolator control switches	-	Pistol Grip Type (keyed handle, TNC)
• Synchronising switches	-	oval, black, keyed handle
• Selector switches	-	oval or knob, black
• Instrument switches	-	round knurled, black

Circuit breaker and isolator control switches shall be three-position, spring return to neutral type with locking facility and shall be provided with target, which shall indicate the last operation of the switch. The control springs shall be strong and robust enough to prevent inadvertent operation due to light touch. Adequate number of spare contacts shall be provided on breaker control switch for control, interlocking, annunciation and discrepancy indication. Instrument selection switches shall be of maintained contact (stay-put) type.

Synchronising switches shall be of maintained contact (stay put) type with locking keys. These switches shall be arranged to connect the synchronising equipment when turned to the 'ON' position. One contact of each switch shall be connected in closing circuit of the respective breaker so that the breaker cannot be closed until the switch is turned to the 'ON' position. Suitable interlock shall be provided to prevent simultaneous operation of more than one switch.

1.3.5.7.2 Indicating Lamps

LED's (bunched type) shall be of miniature switchboard type suitable for panel mounting with rear terminal connections. If required, Lamps shall be provided with series connected resistors preferably built on the lamp assembly to avoid short-circuiting of control supply in the event of short-circuiting of lamp terminals. The supply for these lamps shall be from DC station battery unless stated otherwise. Lamp covers shall be translucent to diffuse light. Unless otherwise stated, the lamp covers shall be coloured as:

- 'Red' for indicating closed position of breakers and isolators

- 'Green' for indicating open position of breakers and isolators.
- 'Blue' for control supply monitoring
- 'White' and 'Amber' for miscellaneous indications.

1.3.5.7.3 Push Buttons

Push buttons shall be of momentary contact type with rear terminal connection. These shall be suitably shrouded to prevent inadvertent operation. Integral inscription plates engraved with their functions shall be provided. All push buttons shall have two normally closed and two normally open contacts comprising rivets of pure silver. The Emergency Push buttons shall be red coloured and provided with a cover, preferably in Red Colour. The contacts of all switches and push buttons shall be strong and to have a positive wiping action when operated.

1.3.5.7.4 MCBs and Switches

Each control panel shall be provided with necessary arrangements for receiving, distributing, isolating of DC and AC supplies for various control, signalling, lighting and space heater circuits. The incoming and sub circuits shall be separately provided with MCBs. Selection of the main and sub circuits MCB ratings shall be such as to ensure selective clearance of sub circuit faults. MCB Tripped Indication with label "MCB Tripped" shall be provided.

All accessible line connection to MCBs shall be adequately shrouded.

1.3.5.7.5 Earthing

All panels shall be equipped with an earth bus securely fixed along with inside base of panels. All metallic cases of relays, instruments and other panel mounted equipment shall be connected to the earth bus by independent copper wires of sizes not less than 2.5 mm².

1.3.5.7.6 Instruments, Meters and Recorders

All instruments, meters and recorders shall be enclosed in dust proof, moisture resistant, black finished cases and shall be suitable for tropical use. They shall be calibrated to read directly the primary quantities. They shall be accurately adjusted and calibrated at works and shall have means of calibration, check and adjustment at site. The ranges and the ratios of associated instrument transformers are given in the schedule of requirements. The bidder shall confirm that the instruments, meters and recorders offered by them are suitable for connecting to the instrument transformers having the technical particulars given

in the specification. All accessories including the test switches and test plugs, where applicable shall be furnished. Their elements shall be shock resistant and shielded from external magnetic fields.

1.3.5.7.7 Indicating Instruments

Indicating instruments shall be flush mounted and shall comply with the latest standards applicable. Digital Multi-function Meters (DMM) of Class 0.2S capable of displaying various parameters like voltage, current, MW, MVAR, MWh, MVARh, power factor, frequency etc... The Digital Multi-function Meters shall be provided in duplicate. The LED digits shall be of sufficient size so as to have easy readability from the operator work table. The Digital Multi-function Meters shall have communication facility as per latest protocols which shall be finalised during detailed engineering in consultation with KSEBL.

1.3.5.7.8 Relays

This section contains the general requirements applicable to all protection relays.

The protection philosophy applied is that no single failure of a main protection relay or system shall result in a fault clearance time in excess of that specified in the KSEBL Protection Application and Setting Policy. To meet this requirement all plant and equipment shall be provided with two independent high speed main protection systems operating in parallel.

Each main protection shall be capable of detecting all "urgent" faults and issuing tripping commands to the associated circuit breakers within the prescribed time. "urgent" faults shall include 87G, 87GT, 59N, 64G, 87N faults. "Non-urgent" faults are those involving a second order plant failure, for example, 50/51, 51V, 32, 40, 64F, which an extended fault clearance time may be acceptable.

Each main protection shall be electrically separate with respect to current transformer cores, voltage transformer circuits and multicore cables. However, it is acceptable that both the main protections to share a protection panel, have a common dc supply and to operate into a common tripping system.

High-speed discriminative protection systems shall be engineered as complete schemes, with due account being taken of current and/or voltage transformer performance. Attention shall be paid to the total performance including the behavior pattern in the presence of system transients for faults "in zone", faults "out-of-zone", and during the period immediately following a switching operation irrespective of whether that operation is to eliminate a network short-circuit or is to energise or to de-energise any part of the network.

To cater for the possibility of a failed circuit breaker, circuit breaker fail protection shall be provided such that in the event of a circuit breaker failing to operate in response to a protection trip command, all necessary contiguous circuit breakers capable of supplying a fault in feed will be tripped within 200 ms of the main or back-up protection issuing a circuit breaker trip command.

In the event of failure of the main protections, back-up protection shall be provided to clear any primary system fault condition which, if sustained could cause damage.. The target clearance time for back-up protection shall be in accordance with that specified in the KSEBL Protection Application and Setting Policy.

With reference to the above, the protection systems must therefore be designed, manufactured, applied, set and commissioned to offer the highest level of security against incorrect operation for faults beyond the protected circuit or during disturbances or temporary overload conditions from which the power system should recover.

All the equipment described in this Specification is intended for continuous duty at the specified ratings under the climatic conditions.

All equipment supplied under this Specification shall be new and unused.

Wherever there is discrepancy between standard spec and KSEBL protection policy, KSEBL protection policy shall prevail.

All relays shall conform to the requirements of IS 3231 / 8686 or other applicable approved standards. Relays should be static (modular type) or numerical multi-functional and shall be suitable for flush mounting on the front with connections from the rear. Relays shall be rectangular in shape and shall have dust tight dull black enamel painted case transparent cover removable from the front.

All protective relays shall be with proper built in test facilities. Test blocks and switches shall be located on the right side of each relay for testing. The auxiliary relays and timers shall also be modular type supplied in draw out cases and shall be self reset type. The master tripping relays shall be hand reset type.

All AC relays shall be suitable for operation at 50 Hz AC. Voltage operated relays shall be suitable for 110V VT secondaries and current operated relays for 1/5 Amps.

The protective relays shall be suitable for efficient and reliable operation of the protection scheme described in the specification. Necessary auxiliary relays and timers required for interlocking schemes for multiplying of contacts, suiting contact duties of protective relays, and monitoring of control supplies and circuits, lockout relays monitoring circuits etc., and

also required for the complete protection schemes described in the specification shall be provided. All protective relays shall be provided with at least two pairs of potential free isolated output contacts. Auxiliary relays and timers shall have pairs of contacts as required to complete the scheme. Contacts shall be silver faced with spring action. Relay cases shall have adequate number of terminals for making potential free external connections to the relay coils and contacts. Paralleling of contacts, if any, shall be done at the terminals on the casing of the relay.

All protective relays, auxiliary relays and timers except the lockout relays and inter locking relays specified shall be provided with self-reset type contacts. All protective relays, trip relays and timers shall be provided with externally hand reset positive action operation indicators provided with inscription, subject to KSEBL's approval. Timers shall be of the electromagnetic or solid state type.

All relays including all ancillary devices such as interposing transformers, tripping matrix and relays, test facilities, power supply units etc with all circuits shall comply with IEC 60255 recommendation.

All Numerical relays shall be provided with self monitoring so that an alarm shall be displayed locally and the relay blocked for any failure of control DC supply to the relay and /or any failure of internal component that may render the relay inoperative or result in false operation.

The Numerical relays shall have a minimum of following features:

- All numeric relays shall be operating with DSP Principle.
- All numeric / Auxiliary relays shall be suitable for auxiliary supply of 110 V DC +/- 10%.
- All Numeric relays shall be suitable for IEC 61850 Edition 2.0 communication protocol, TFTP, SFTP, HTTP, IEC 60870-5-104, Ethernet global Data (EGD), IEEE C 37.118.
- Have the following: One front USB port, Rear One RJ45 port, 2 optic ports Complying with IEC:61850 with PRP compatible.
- Relay trip O/P contacts shall have sufficient current rating to initiate trip coil of CB.
- Measurements and Recording functions including True RMS values.
- Event recorder with 1000 Last events, less than 1ms time stamped (as a minimum).
- Fault recorder with last 25 faults (as a minimum).

- Disturbance recorder with storage of 32 records for 3 seconds each (as a minimum). Fault recording duration: fault – 3 sec, pre-fault – 2 sec.
- Minimum sampling frequency shall be 1 kHz.

Latest software required for testing and commissioning of the Relays shall be supplied free of cost in a CDROM (including necessary communication interfaces and cables with suitable connectors). Relay test plugs suitable for the test terminal blocks shall be provided.

Redundancy in DC circuit is required. Provision of DC cell for the protective relays as reliable standby power supplies will, however, not be acceptable. Any auxiliary supplies needed shall be drawn from the main station batteries and not from the separate internal batteries in the protection equipment.

Primary protection - main 1 shall initiate mastertrip coil 1 and primary protection- main 2 shall initiate mastertrip coil 2. (Shall be as per trip matrix which shall be finalized during detailed engineering) - Master trip relay shall initiate both the trip coils.

The Contractor shall quote the protection equipment meeting the above requirements. The Contractor may also quote any alternative / additional protections or relays considered necessary by him for providing complete, effective and reliable protection. The acceptance of this alternative / additional equipment shall be with the KSEBL.

a) Trip Circuit Supervision Relays

The trip circuit shall be supervised by means of relays. The schemes shall continuously monitor the complete trip circuit before closing and after closing of the breaker. The scheme shall detect (i) failure of trip supply (ii) open circuit of trip circuit wiring and (iii) failure of mechanism to complete the tripping operation. The relays shall have necessary contacts to be connected to either the alarm bell or to the Annunciator available in the control panel for visual and audible indication of the failure of trip circuit. In addition to a visual alarm, operation of the trip circuit supervision relay shall block the closing of the supervised circuit breaker.

b) DC Supply Supervision and Trip Relay Supervision

Effective DC supply supervision scheme shall be provided. Supervision for Master trip relays (like 86E, 94E of units, 86L of lines, 86 relays of transformers) shall be provided for ensuring healthiness.

c) Relay Panels

Protection relays shall be panel mounted on a per circuit basis, each circuit being allotted its own panels. The protection panels shall be located in a protection and

control room within the main plant building.

Each panel shall be fully wired and equipped with all necessary equipment including alarms, indication, resetting and test facilities, isolating facilities, instruments, MCBs, fuses and cable terminations, etc... necessary to complete the work even if not explicitly specified hereafter. The test and isolation facilities provided within the protection scheme(s) shall enable commissioning and maintenance test procedures to be carried out in a safe and convenient manner.

Height of the control and replay panels shall not exceed 2.2 m. All panels shall be of identical depth and height. The doors shall be hinged to lie back flat to avoid restricting access. Hinges shall be of the lift off type. Doors shall be secured by lockable handles which shall not be more than 1.8 m above floor level.

The relays shall be mounted on 19 inch rack modular designed fixed front panels and rear opening for access the relays.. The panels at the front of the panels shall have a glass window so that the relay panel front is always visible for the alarm LEDs and display units. All relays with LED / LCD displays / operable buttons and operable switches etc. should be mounted below 1.8 m and above 0.5 m.

All equipment as well as the terminals of the cubicles shall be easily accessible.

The Contractor shall be fully responsible for the design and engineering of the protection systems and schematic diagrams However, the Contractor shall ensure the involvement of the relay manufacturer at all stages up to factory testing and site commissioning of the protection panels.

Relay panels shall be supplied with relays fully assembled, wired and tested under close supervision of the relay manufacturer.

Testing of protection functions, including full schemes involving control, communication, supervision, etc..., shall be performed at the factory and should be demonstrated during factory witness test prior to shipment.

All protection relays, control switches, indications etc. shall be clearly labelled as to their purpose and function.

Circuit labels shall be provided on the front and back of each panel and on the outside of the cubicle doors and shall indicate the equipment to be protected or supervised.

All control and relay panels shall have a continuous copper earth bar of sectional area not less than 70 mm², run along the bottom of the panels, each end being

connected to the main earthing system. Metal cases of instruments and metal bases of relays on the panels shall be connected to this bar by copper conductors of cross sectional area not less than 3 mm².

Each panel shall be equipped with a single phase power socket of an approved type, an interior light controlled by a door operated switch located inside the panel and an anti-condensation heater with thermostat.

The closing circuit, signaling circuits and each tripping circuit shall be separately protected by MCBs.

All the CT cables connected to the relays inside the panel must be of 4mm². All the CT and PT connectors in the panel should be of link type (Stud Type with isolating facility).

d) Control, Relay and Metering Panels

The panels shall be provided with close fitting lockable and lift-off rear access doors hinged to open through 180 Degree. The interior shall be finished with a matt white surface and shall include a lamp controlled by a door operated switch. The outside shall be finished semi-matt colour RAL 7032 for the new equipment, and in cases where panels are installed in the same room with the existing equipment, colour of the new panels shall match the existing. Heaters shall be provided in each cubicle.

Panels shall be rigidly constructed from folded sheet steel of adequate thickness to support the equipment mounted thereon, above a channel base frame to provide a toe recess. Alternatively a separate kicking plate shall be provided.

Relay panels shall have lockable, transparent front door.

Overall height, excluding cable boxes, shall not exceed 2.5 m. If the panel is erected in the existing control room, the height should be that of the existing panel . Operating handles and locking devices shall be located within the operating limits of 0.95 m and 1.8 m above floor level. All panels shall be fitted with padlock. The minimum height for indicating instruments and meters shall be 1.5 m unless otherwise specified.

Relay panels shall have minimum size (width) of 800mm.

Panels shall be mounted on an approved form of anti-vibration mountings whenever necessary.

All panels and cubicles shall be vermin proof. All cable entries to equipment shall be sealed against vermin as soon as possible after installation and connecting-up of

the cables to the approval of the Engineer. Ventilation shall be provided for natural air circulation. All control equipment shall be designed to operate without forced ventilation.

All metal surfaces shall be thoroughly cleaned and particular care taken during painting to ensure that both internally and externally a first class cover and finish is achieved.

All nuts, bolts and washers shall be plated.

Door sealing materials suitable for the specified site conditions shall be provided. Doors shall be fitted with handles and locks. Hinges shall be of the lift-off type.

The bottom of all panels shall be sealed by means of removable gasketed steel gland plates and all necessary glands shall be supplied and fitted within the Contract.

Panels shall be suitably designed to permit future extension.

Each panel shall include rear access doors and door-operated interior lamp, and be clearly labeled with the circuit tilted at front and rear, with an additional label inside the panel. Panel sections accommodating equipment at voltage higher than 110 V shall be portioned off and the voltage clearly labeled. Each relay and electronic card within panels shall be identified by labels permanently attached to the panel and adjacent to the equipment concerned. Where instruments are terminated in plug and socket type connection both the plug and the socket shall have permanently attached identifying labels.

Instrument and control devices shall be easily accessible and capable of being removed from the panels for maintenance purposes.

All control circuits shall be provided with suitable means of isolation.

All protective relays shall have input / output connections through Test Terminal Blocks (TTB) for relay testing. Where protection functions are combined, additional Test Blocks as required shall be provided.

1.3.5.7.8.1 Detailed Description of Protection

1.3.5.7.8.1.1 Generator Protection

All relays performing a measuring function shall be of numerical design with continuous self-monitoring.

Auxiliary relays, repeat relays, trip relays and any other simple auxiliary or contact multiplication functions may be based on standard attracted armature or other electro-mechanical techniques.

Multi-function numeric protection relays, also referred to as Intelligent Electronic Devices (IEDs), shall utilise numerical techniques for both measurement and logic functions and in addition to the main protection functions, shall incorporate communication; fault, event and disturbance recording; instrumentation; configurable scheme logic; alternative setting groups and self-supervision facilities.

Each numeric protection relay shall be provided with One front USB port, Rear One RJ45 port, 2 optic ports Complying with IEC:61850 with PRP compatible. The front communications port shall allow direct interfacing to a laptop PC, to facilitate local interrogation, application of relay settings and configuration and extraction of recorded data.

Numerical relays provided shall all be suitable for connection to a local communications network to allow the complete relay scheme to be interfaced to a central computer work station. The communications bus, necessary modems and interface units and all associated software shall be provided as part of the contract. With the resulting system it shall be possible to interrogate all numerical relays to monitor and extract recorded data (including settings, measurement parameters and disturbance records). It shall also be possible to enable remote adjustment of relay settings if required.

All relays should be time synchronised from a central time server either on the IEC 61850 station bus over Simple Network Time Protocol (SNTP) or other means such as an IRIG-B input on the relay.

Depending on the application, each numeric protection relay should accommodate sufficient binary input/binary output contacts to meet minimum requirement as specified in the KSEBL protection application and setting policy and approved trip matrix.

- a) Minimum requirement of BI/BO/LED for some of the major relays will be as below. Main relays like GMR(Generator management Relay) and TMR (Transformer Management Relay) shall have the following:

Minimum 32 binary output contacts including 6 -12 nos. trip duty rated contacts.

Minimum 12- 20 opto - isolated binary inputs.

Minimum 30 nos. configurable LED.

- b) Back up relays shall have:

Minimum 8 nos. binary output contacts.

Minimum 6 opto - isolated binary inputs.

Minimum 6 nos. configurable LED.

Protection relays shall be from approved suppliers and they shall be type-tested according to relevant sections of the current IEC 60255 standards. Copies of type test certificates shall be provided with the supply. Relays shall be CE-marked in accordance with European Union requirements related to Electromagnetic Compatibility and Low Voltage Equipment safety. Equipment complying with other national standards may be accepted at KSEB's discretion and where the vendor provides copies of the relevant standards.

Protection relays shall have a minimum of two year's satisfactory service history in similar applications with at least five (5) utilities. The service history is to be supported by reference lists and end-user endorsements. Priority would be given to KSEBL approved relays.

Relays must be offered on the basis of a minimum service life of 15 years. Statements must be obtained from the relay manufacturer(s) to this effect, with confirmation that a spares and repairs service will be available for the stated minimum service life.

The following features shall be furnished for the generator protection:

a) Power Protection (32)

This system shall protect the unit in the event of low forward power and reverse power.

b) Loss of Field (40)

This protection shall be provided to protect the generator from unintentional opening of field circuit breaker, opening or short-circuiting of field circuit and a fault in the automatic voltage regulator or excitation system.

c) Negative Phase Sequence Protection (46)

This protection shall distinguish between an asymmetrical load and an asymmetrical fault. It must always trip after the fault tripping relays. It shall protect the rotor iron from excessive heating and trip the generator before the permissible I^2t value (rotor thermal capacity). Two set levels shall be available. One fixed time for alarm and one inverse delayed for tripping.

d) Voltage restrained Over-current (51V)

Three-phase over current protection shall be provided for stator to avoid exceeding its current limits.

e) Over-voltage Protection (59)

This protection shall protect the generator against over voltages produced within the generator, for example by a failure of the voltage regulator. The relay shall operate independent of the frequency within the range of at least 0.8 - 1.2 times rated frequency. The relays shall be provided with two independent stages for delayed and instantaneous trip.

f) Under-voltage Protection (27)

This protection shall be used as a back-up protection against loss of excitation. It shall have a time-delayed stage. It shall operate independent of the frequency within the range of 0.5 - 1.2 times rated frequency.

g) Under / Over Frequency Protection (81)

In the case of variations in frequency, this protection is used. The scheme shall have a working range of 45 - 55Hz and an adjustable time delay of 0.5 to about 5 sec.

h) Generator Voltage Transformer Fuse Failure (VT fuse fail) monitoring Protection

This shall be provided for the machine since it is required for blocking of protection scheme, which may mal-operate in the event of PT fuse blowing in primary side or secondary side. It shall be of voltage balance or equivalent type. It shall have sufficient contacts to block tripping of those relays, which are voltage dependent and give alarm.

i) Generator Differential Protection (87G)

The generator differential protection shall be three phase, current adaptive changed and high stability through fault. This shall be highly sensitive for internal faults and operating time shall necessarily be very short period to minimize the possible damage.

This protection shall not operate in the presence of magnetizing inrush current and be capable of rapid tripping in the event of energizing onto a fault.

It shall detect and trip all phase and earth faults within the protection zone and shall remain stable for all faults outside the area limited by the relevant current transformers.

The pick-up ratio shall be adjustable. The bias and sensitivity shall be adjustable in steps.

j) Rotor Earth Fault Protection (64F)

Rotor earth fault protection shall be provided to detect the earth fault in rotor and to trip the machine with a short time delay. External voltage injection principle shall be employed. Provisions may be provided to isolate the voltage injection circuit from the rotor field winding.

k) Rotor Excitation circuit Over-current Protection

A definite-time three phase over current protection shall be installed on the excitation transformer feeding side to protect the alternating current section against short circuits. The operating range has to be such that the actual circuit current will be within this range.

The relay shall be equipped for time delayed and instantaneous tripping.

l) Shaft Current Protection

For detection of current in the generator main shaft, which could damage the bearings, a shaft current monitoring and protection scheme is required.

m) Stator 95% Earth Fault Protection (59N)

For this protection over voltage measured across the NGT is utilised.

n) 100 % Stator earth fault Protection (64G)

In this protection the third harmonic reduction techniques has to utilize.

o) Impedance back up protection (21G)

The measurement of the impedance of the total supplied load or the voltage restrained techniques has to be utilized.

p) Breaker failure protection (50BF)

In the event of a circuit breaker failing to operate, the CB fail protection shall be arranged to trip all circuit breakers capable of feeding fault current to the faulted circuit. Inter tripping to remote circuit ends shall also be initiated where appropriate.

In the event of a circuit breaker failing to open within a preselected time the breaker failure protection shall initiate re tripping of the failed CB after an initial 100ms time delay. If the re-trip attempt is unsuccessful, all adjacent circuit breakers capable of supplying a fault in-feed shall be issued a trip command 200ms after the initial trip command from the main or backup protection.

1.3.5.7.8.1.2 Generator Transformer Protection

The following features shall be furnished for the generator transformer protection:

a) Generator transformer overall differential protection (87T)

The generator differential protection shall be three phase, current adaptive changed and high stability through fault. This shall be highly sensitive for internal faults and operating time shall necessarily be very short period to minimize the possible damage.

This protection shall not operate in the presence of magnetizing inrush current and be capable of rapid tripping in the event of energizing onto a fault.

It shall detect and trip all phase and earth faults within the protection zone and shall remain stable for all faults outside the area limited by the relevant current transformers.

The pick-up ratio shall be adjustable.

The bias and sensitivity shall be adjustable in steps.

Calculations to determine current transformer requirements to achieve stability on through faults for differential protection shall be submitted to the Purchaser for approval.

The relay shall:

- be high speed percentage biased differential type.
- have an operating time not greater than 30 milliseconds.
- be rated for 5 Amps at 11kV side and 1 A at 110kV side.
- have protection against magnetizing inrush currents.
- be stable under normal over-fluxing conditions.
- have a minimum operating current setting of 10%.
- have 5th harmonic blocking protection.

b) Restricted Earth Fault Protection (64)

Where specified, transformer windings and connections shall be protected by restricted earth fault (REF) protection. It shall be of high impedance circulating current type with protection against over voltages. If necessary, it shall provide sensitive and instantaneous earth fault protection for the transformer windings. It shall have maximum sensitivity and minimum operating time consistent with stability for faults outside the protected zone and on magnetizing inrush surges. Each relay shall have an instantaneous trip attachment.

Separate current transformers (i.e., not sharing transformer biased differential

protection) are preferred for this protection.

The relay shall:

- be of voltage operated high impedance type with suitable setting range to take care of extreme external fault conditions; or
- be a biased relay having a minimum current setting of 10% of 1 Amps.

c) Volt per hertz Protection for Generator-Transformer over fluxing

This system shall protect the generator transformer from over fluxing.

The relay shall:

- operate on the principle of voltage to frequency ratio.
- have a continuously adjustable setting range (V/f) of 100-130% of the rated value have start and trip alarm facilities.

d) Buchholz Protection (63)

All oil type transformers shall be fitted with Buchholz devices of the two-element type giving operation under gassing and under surge conditions. All necessary indication, tripping and alarm associated with this protection shall be provided, mounted and connected under this Contract. The Buchholz relay shall be equipped with gas sampling and testing devices to be operated from the ground level at convenient height.

e) Oil and Winding Temperature

Transformers will be provided with oil and winding temperature protection. These will be of the two stage type with adjustable settings giving alarm and trip facilities. All necessary indication, tripping and alarm associated with this protection shall be supplied and connected under this Contract. Transformer protection shall also include Low / High oil level alarm.

f) Transformer Mechanical Protection Repeat Relays

The Buchholz, temperature and other trip devices at the power transformer will, normally, have only one contact each. For maximum security it is preferred that these contacts shall operate the appropriate trip relays directly. For local and remote alarms a current operated repeat relay shall be connected in series with each transformer protection trip device and the trip relay. These repeat relays shall have hand reset flag indicators and sufficient contacts for all remote alarm and indication functions.

Similarly Buchholz, temperature and other alarm devices at the power transformer will have only one contact. To provide flag indication and sufficient contacts for all remote alarms and indication functions, voltage operated repeat relays shall be

provided.

The number of repeat relays required will depend upon the number of transformer protection devices, details of which will be supplied to the Contractor when the design of the transformers has been finalized.

g) Time delay phase over current and earth fault protection

This protection covers phase over current and earth fault in transformer HV side.

1.3.5.7.8.1.3 Station Auxiliary Transformer Protection

50/51N - Transformer Over current & Earth Fault protection to be implemented.

1.3.5.8 Inspection and Tests

During the course of manufacture, KSEBL's representative shall have the right to inspect the materials, workmanship, labour and the progress of manufacture of the equipment under order and may reject any item which is found defective or unsuitable for the purpose intended or which is not in accordance with the intent of this specification. The Contractor upon demand by the KSEBL or its representative shall rectify the defects or replace such defective or unsuitable materials. The Contractor shall provide all reasonable inspection facilities to the KSEBL's inspecting personnel.

Equipment shall be capable of performing satisfactorily up to Contractor's maximum guaranteed values. All tests required by specification, including repeat tests and inspections that may be necessary owing to failure to meet any tests specified shall be made at Contractor's expenses. If equipment fails to pass the specified tests, KSEBL shall have option to reject the unit. Additional tests shall be made to locate the failure and after reconstruction, testing shall be repeated to prove that the rebuilt equipment meets the specification in all respects.

1.3.5.9 Cabling System

The control, protection, metering and instrumentation cables shall be manufactured based on IEC publications for cables or any other equivalent international standards. All cables shall be 650 / 1100 V stranded tinned copper conductors, fire resistant, armoured low smoke, PVC sheath with different number of conductors to comply with the functional requirement.

Wherever required, screened cables shall be used, e.g., for RTD wiring, signal pickup etc... RTDs shall have 3-wire connection for lead compensation. All multi-core cables shall be distinctively identical using separate colour for each core or by printing core numbers.

For 1 Amp CTs, 4 mm² copper cables shall be used. For essential small motors such as isolator operating motor, circuit breaker spring charging motor etc..., 6 mm² copper cables shall be used.

For support of the power and control cables, cable ladder system shall be used. There must be separate cable trays for Power cables, control cables and instrumentation cables. The system shall comprise of cable ladders, cable trays, mounting rails, supports, clamps etc... The ladders / trays shall be of different types and sizes adaptable to its special field of use.

1.3.5.10 Alarm and Annunciation

Window annunciation shall be provided on the control panels in the control room as well as those near the generating units and the same shall be complete with audio alarm system. The system shall be designed to have low DC power consumption.

1.3.5.11 Metering

- i. All panel meters shall be digital with at least 2 cm digit size, at least three-and a-half digit LED display and accuracy class of 0.2S
- ii. Energy metering shall be provided on the 11 kV and generators with microprocessor based trivector meters of an accuracy class of 0.2S or better.
- iii. Electronic energy meters of accuracy class of 0.2S or better will be provided for metering at 250 kVA station transformer.

1.3.5.12 Temperature Scanners

Temperature scanners shall be installed for stator windings, bearing temperatures and transformers including cables from temperature sensors. The scanners shall have two alarm settings for high temperature for each point adjustable over the entire range. There shall be one scanner for each generating unit along with generator transformer. The scanners shall be provided with communication ports with open protocols.

1.3.5.13 Data Acquisition

The PLCs shall acquire on continuous basis the parameters of Turbine, like Guidevane / Nozzle opening, deflector limiter setting, Speed Setting, RPM, Parameters of Generator like all 3 phase current, voltage, PF, MVAR, MW, Frequency, Bearing Temperatures, generator stator winding, core & teeth temperatures, Excitation Voltage / Current, 11 kV switchgear, auxiliaries, transducers / sensors, similar parameters of Generator Step-up and auxiliary

Transformer etc... as necessary for their optimal operation.

Wherever signals are weak or there is strong noise due to EMI or RI etc..., shielded cables shall be used to carry signals / data.

1.3.5.14 Tools and Instruments

One no. Three phase Test kit (preferably Omicron / Programma / Megger / equivalent make approved by the KSEBL) for testing all the relays supplied shall be provided along with a Laptop pre-loaded with the required configuration / setting / testing software for the same. All necessary interfaces including connecting cables, protocol converters, connectors etc... required for communicating with the relays and connecting to the Laptop and Test Kit shall be supplied.

Necessary manuals giving complete information on installing, configuring, trouble shooting etc... of the software including methodology for data retrieval / display of the data stored in the relays, changing relay settings etc... shall also be provided. Software required for the configuration, setting change, maintenance, trouble shooting, retrieval and display of stored data etc... of the relays and the testing software etc... shall be provided in CD / DVD also.

1.3.5.15 Spares

Spares required for 5 years of maintenance shall be supplied.

PLCs	- 1 No. each
Power Supply module	- 1 No.
Communication Module	- 1 Set
Input / Output Cards	- 1 Set of each type
DC / DC Converter	- 1 No. of each type
Laser Printer	- 2 No.
LCD Monitor	- 1 No. of each type
Keyboard / Mouse	- 1 No. each
Other peripherals	- As required

All SCADA software including System software, Database, design / configuration files, engineering / configuration tools etc shall be supplied in CD / DVD media with complete loading, engineering and configuration instructions and guidelines.

Any other spares recommended by the manufacturer as essential for the satisfactory and

trouble free operation of the equipment as per Clause 1.1.32 under Part-1 of this specification.

1.3.6 Protection

1.3.6.1 Introduction

This section of the specifications covers the KSEBL's requirements for the design, manufacture, test at works, supply, delivery at site, supervision of erection, testing at site and commissioning of protection, metering, indication, control equipment & other devices as required by the specific design offered to complete the system in all respects, including spares for 5 years operation of the plant, special tools and testing devices as described and detailed in the specifications and in the annexed schedule of requirements. The scope of supply shall include all parts, accessories, spares etc..., which are essential for construction, operation and maintenance of the complete system even though these are not individually or specifically stated or enumerated. Corresponding components of the supplied equipment and the spares shall be of the same material, dimensions and finish and shall be interchangeable.

The Contract Works to be supplied shall include all work incidental thereto whether specified in detail or not, or not specifically mentioned in the specification so as to complete the intended works in total.

1.3.6.2 Reference Standards and Codes

- IEC 60050 - International Electro technical Vocabulary.
- IEC 60059 - IEC Standard Current Ratings.
- IEC 60068-2-1 - Environmental testing - Part 2-1: Tests - Test A: Cold.
- IEC 60068-2-2 - Environmental testing - Part 2-2: Tests - Test B: Dry Heat.
- IEC 60068-2-78 - Environmental Testing - Part 2-78: Tests - Test C: Damp Heat, Steady State.
- IEC 60255 - Electrical Relays.
- IEC 60255-1 - Measuring Relays and Protection Equipment - Part 1: Common Requirements.
- IEC 60255-5 - Electrical Relays - Part 5: Insulation coordination for Measuring Relays and Protection Equipment -

Requirements and Tests.

- IEC 60255-12 - Electrical relays - Part 12: Directional Relays and Power Relays with Two Input Energizing Quantities.
- IEC 60255-13 - Electrical relays - Part 13: Biased (percentage) Differential Relays.
- IEC 60255-16 - Electrical Relays - Part 16: Impedance Measuring Relays.
- IEC 60255-21-1 - Electrical relays - Part 21: Vibration, Shock, Bump and Seismic Tests on Measuring Relays and Protection Equipment - Section One: Vibration tests (sinusoidal).
- IEC 60255-21-2 - Electrical relays - Part 21: Vibration, Shock, Bump and Seismic Tests on Measuring Relays and Protection Equipment - Section Two: Shock and Bump Tests.
- IEC 60255-21-3 - Electrical relays - Part 21: Vibration, Shock, Bump and Seismic Tests on Measuring Relays and Protection Equipment - Section 3: Seismic Tests.
- IEC 60255-26 - Measuring Relays and Protection Equipment - Part 26: Electromagnetic Compatibility Requirements.
- IEC 60255-27 - Measuring Relays and Protection Equipment - Part 27: Product Safety Requirements.
- IEC 60255-127 - Measuring Relays and Protection Equipment - Part 127: Functional Requirements for Over/Under Voltage Protection.
- IEC 60255-149 - Measuring Relays and Protection Equipment - Part 149: Functional Requirements for Thermal Electrical Relays.
- IEC 60255-151 - Measuring Relays and Protection Equipment - Part 151: Functional Requirements for Over/Under Current Protection.
- IEC 60076-7 - Loading Guide for Oil-Immersed power transformers.
- IEC 60529 - Degree of Protection provided by Enclosures (IP Code).

- IEC 61869-1 - General Requirements for Instrument Transformers.
- IEC 61869-2 - Additional Requirements for Current Transformers.
- IEC 61869-3 - Additional Requirements for Inductive Voltage Transformers.
- IEC 61869-5 - Additional Requirements for Capacitor Voltage Transformers.
- IEEE C37.2-2008 - IEEE Standard Electrical Power System Device Function Numbers, Acronyms, and Contact Designations.

1.3.6.3 Reference Sections

- Section 1.1 General Technical Requirements
- Section 1.3.3 Generators
- Section 1.3.4 Excitation Systems
- Section 1.3.5 Control and Monitory System
- Section 1.3.14 Power Plant Field Testing & Tests on Completion
- Section 1.4.2 Power Transformers
- Section 1.4.3 Switch-yard Equipment
- Section 1.4.4 Switch-yard Control, Protection & Instrumentation
- Part - 2 Specific Requirements for the Project

1.3.6.4 Submittals and Approvals

All necessary drawings, design specifications, design details, operation and maintenance manuals and other information shall be provided.

The equipment supplied under this Specification shall be documented to the extent necessary as to allow KSEBL , including their operators, to fully understand the product and/or system, its theory of operation, its application, performance, and maintenance.

In addition it must enable KSEBL to efficiently communicate with the manufacturer about all aspects of operating, maintaining and servicing the substation control, protection, metering and monitoring systems.

All data provided for this equipment shall show the equipment as specified and ordered. Typical drawings are not acceptable unless they are revised to show only the equipment being furnished. The format, standards, quality and quantities of drawings shall be manufacturer's standard, but shall be subject to KSEBL approval as per the requirement of these Specifications.

The Contractor shall seek the prior approval of the KSEBL or the KSEBL's Representative at the following points of work execution using timely submittals.

- Complete protection scheme coordination.
- Calculations supporting CT sizing / selection
- Alarm List and Annunciator Facia / Window Inscription Details
- List of suppliers / manufacturers supported with Brochures / Catalogue of equipment for Vendor approval.
- Relay setting calculations and data.

1.3.6.5 Deliverable Documents

The contractor shall deliver at least the following information and documents:

- Completed Technical Data Sheets.
- Protection single line diagrams of the Power house.
- General arrangement drawings of the protection and indication panels with labelling showing all the components.
- Manufacturing specification of the protection and indication equipment.
- Catalogues, literature and reference lists of proposed equipment.

A comprehensive set of documentation shall be provided for all protection relays covering, as a minimum, the following topics:

- Detailed description of protection relay including coverage of self-monitoring facilities, if applicable.
- Range of features provided as standard.
- Range of optional features.
- Range of settings provided for all features, both standard and optional.
- Details of all of the operating time characteristics for the protection relay.

- Statement of performance under reference conditions.
- Variation of performance with departure from reference conditions.
- Effects of interruptions to dc auxiliary power supply.
- Current transformer requirements.
- Voltage transformer requirements.
- Type test certificates from an independent testing authority or independently witnessed.
- A type test certificate shall be provided for each relay type, which should confirm compliance of the protection relay with the requirements of the relevant sections of IEC 60255. Any areas of non-compliance shall specifically be identified. It shall be stated whether the protection relay has been approved by any independent approval bodies or users.
- Quality Management System Manual and ISO Certificate of the equipment manufacturer.
- All documents required for KSEBL's approval shall be submitted by the Contractor in accordance with the agreement.

1.3.6.6 KSEBL's other Requirement

Instrument Transformers

CT and VT ratios are indicated on the protection single line drawings in the KSEBL Protection Application and Setting Policy. The Contractor shall ensure that the CT and VT characteristics (VA burden, accuracy limit factor, etc... or V_k , etc...) are calculated to meet at least the minimum protection and instrumentation manufacturers requirements.

Current Transformers

The current transformers shall comply with IEC 61869 -1 & 2.

The current transformers shall have the following accuracies:

Instruments	Class 0.2s
Over-current and earth fault protection	5P10/20
Differential / REF Protection	Class PS

For Generator / Transformer Differential protection and REF protection schemes, the Contractor must state clearly the accuracy necessary for the correct functioning of the protection system offered and show that the secondary output of the current transformer is

satisfactory for this purpose.

The rated continuous thermal current of current transformers shall be at least equivalent to the rated primary current of the circuit in which they are to be installed.

Transformer circuits may be subjected to overload duties in accordance with IEC 60076-7; current transformers in transformer circuits shall have a rated continuous thermal current equivalent to at least the transformer long-time emergency cyclic loading capability.

Each current transformer secondary winding circuit shall be earthed at only one point.

Where adequate earth screens are fitted between the primary and secondary windings, earthing of the secondary winding shall be via a link mounted in the related protection or instrument cubicle. Where such earth screens are not fitted a separate earth system may be necessary.

Wherever possible the connection to earth shall be on the side of the S2 terminals.

Neutral current transformers shall be of the outdoor Ring type as per CT specifications with all the necessary environmental protection as per relevant IEC standards.

Voltage Transformers

Voltage transformers may be either the capacitor type or electromagnetic wound type.

Wound type voltage transformers may be of the single or cascade winding type, they shall comply with the requirements of IEC 61869-1 and 3.

The design of capacitor voltage transformers shall be such that the accuracy shall not be affected by the presence of pollution on the external surface of the insulation, they shall comply with the requirements of IEC 61869-1 and 5.

Voltage transformers shall have the following accuracies:

Metering and instruments	Class 0.5
Protection	Class 3P

Secondary fuses shall be provided on or adjacent to each voltage transformer, located such that they are accessible while the primary winding is alive. MCBs shall be identified by labels indicating their function and phase colours. The voltage transformer secondary circuits shall be complete in themselves and shall be earthed at one point only. A separate earth link shall be provided for each secondary winding and shall be situated at the voltage transformer.

All 11kV PTs used for Generator protections must have PT fuses in each phase.

Where voltage transformers are supplied which are, or may be, connected to different sections of the busbar, it shall not be possible for the voltage transformer secondary circuits to be connected in parallel.

An auxiliary switch or relay shall be provided in each phase of the secondary circuit of the

synchronising and metering voltage supply connections to break the circuits automatically as soon as the circuit breaker is opened.

To prevent ferroresonance, suitable damping devices shall be provided for connection to the transformer secondaries.

Environmental Requirements

a) Atmospheric Environment

Temperature:

The standard nominal range of ambient temperature shall be +5 °C to +50 °C.

The protection system shall operate satisfactorily when tested to the following requirements:

IEC Publication 60068-2-1 with severity class -10 °C, 96 hours.

IEC Publication 60068-2-2 with severity class +55 °C, 96 hours.

The protection system shall be able to withstand the temperature requirements for storage and transportation and shall be tested to the following requirements:

IEC Publication 60068-2-1 with severity class -25 °C, 96 hours.

IEC Publication 60068-2-2 with severity class +70 °C, 96 hours.

Relative humidity:

The protection system shall operate correctly with a relative humidity of 100 % and shall be tested to IEC Publication 60068-2-3 with severity class 56 days at 93 % relative humidity and +40 °C.

Enclosure:

The protection relay shall meet the requirements of the tests detailed in IEC Publication 60529 with classification IP50 (dust protected). If the individual enclosure of the relay is to a class less than IP50 then the Contractor shall provide a cubicle to classification IP50 to accommodate the relay.

b) Mechanical Environment

Vibration:

The protection system shall meet the requirements of the tests detailed in IEC Publication 60255-21-1 with severity class 1.

Shock and bump:

The protection system shall meet the requirements of the tests detailed in IEC Publication 60255-21-2 with severity class 1.

Seismic:

The protection system shall meet the requirements of the tests detailed in IEC Publication 60255-21-3 with severity class 1.

c) Electrical Environment**DC auxiliary energising quantity:**

The protection systems shall be capable of being energised from a DC auxiliary energising voltage of 110 V (nominal).

The protection system or its associated power supply for use in a 110 V (nominal) DC supply system shall operate correctly over a voltage range of 48 V to 150 V.

Numerical protection systems shall meet the requirements of IEC Publication 60255-11 with interruptions to the DC auxiliary energising quantity of 20 ms.

Frequency:

The rated frequency shall be 50 Hz. The nominal range of operating frequency shall be -5 % to +5 % of nominal.

Thermal rating:

Relay equipment intended to perform a current measurement function shall be capable of continuous operation at a current of not less than 2.4 times the nominal rating or 2 times the setting value, whichever is the more onerous.

Relay equipment intended for use in a normally quiescent mode and having a short time rating - for example, high impedance differential protection - shall be rated in accordance with the intended function and taking account of such inherent protective devices as may be incorporated in the design.

The short time rating for all protection relaying schemes shall be 100 times the nominal relay rating for duration of 1 s.

Voltage sensitive equipment intended for use on effectively earthed networks shall have a continuous withstand of not less than 1.2 times nominal voltage and a short duration withstand of not less than 1.5 times nominal phase-to-ground voltage for 30s.

Insulation**a) Rated Insulation Voltage**

The rated insulation voltage of circuits connected to current transformers of high impedance relays shall be 1000 V. All other circuits shall have an insulation voltage of 250 V.

All open contacts of the protection system shall withstand a voltage of 1000 V.

b) Dielectric Tests

The protection system shall comply with the dielectric test requirements of IEC Publication 60255-5 EN 60255-27. The test voltage shall be selected according to the rated insulation voltage of the circuits being tested from Series C of Table 1 of

IEC Publication 60255-5 EN 60255-27.

c) Impulse Voltage

The protection system shall comply with the impulse test requirements of IEC Publication 60255-5 EN 60255-27 with test voltage of 5 kV.

Electromagnetic Compatibility

The requirements of this section of the specification are applicable to electronic protection systems whether these are based on analogue digital or numerical design techniques. The requirements may also be applied to electro-mechanical relays that may radiate electromagnetic interference during their operation.

a) 1 MHz Burst Disturbance

The protection system shall comply with the requirements of IEC Publication 60255-26 with severity Class III.

b) Electrostatic Discharge

The protection system shall comply with the requirements of IEC Publication 60255-26 with severity Class III.

c) Radiated Electromagnetic Field Disturbance

The protection system shall comply with the requirements of IEC Publication 60255-26 with severity Class III. The test shall be carried out by using Test Method A and by sweeping through the entire frequency range 27 MHz to 500 MHz.

d) Electromagnetic Emissions

The protection system shall comply with the requirements of IEC Publication 60255-26.

e) Fast Transient Disturbance

The protection system shall comply with the requirements of IEC Publication 60255-26 with severity level IV.

Packaging, shipping, transport and storage

Packing, shipping and transport and storage of the relay protection panels and accessories are the sole responsibility of the contractor and the quoted price includes this also.

1.3.6.6.1 Detailed Scope of Supply

The protection required for:

- Three 27.5 MW with 10% COL turbine-generator unit along with Main Inlet Valve.
- Three 35 MVA, 11 / 110 kV generator-transformer, Unit Auxiliary Transformers, One - Station Auxiliary Transformer (SAT) and One - Station Service Transformer
- 11 kV Switchgear.

- AC and DC supplies for power house.
- All special devices, tools, maintenance equipment etc... required for installation, testing, commissioning & maintenance of protection system.
- Spares.

The protection requirements mentioned, are indicative only and are a minimum for giving a base line. The Bidder should ensure that the ratings / protection requirements etc... of the various equipment are sufficient to take care of the design requirements of the equipment offered for the project. Any increase in rating / upward change in protection requirements during detailed engineering stage will not entitle the Successful Bidder / Contractor for any extra charges.

The equipment covered under this contract shall be capable of performing all intended duties and it is the responsibility of the Contractor to supply the equipment as per guaranteed technical particulars.

1.3.6.6.1.1 Special Design Requirements

This section of the equipment specifies the special design and layout condition requirements of the electrical protection systems to be provided for the individual plant components, comprising at least of the following equipment. Protection shall be provided through relays, which shall be Numeric type protection relays with redundancy in main protections.

The protection scheme shall be coordinated with control & protection of turbine, governing system, inlet valves and generator transformers etc... The list of protection given in Clause 1.3.6.7 is indicative only.

All protection, though not specified but which are recommended for this capacity of the machine as per relevant IEC / other Standards shall be provided.

The relays / protection system shall be of state of the art of technology and only latest proven versions of the relay series shall be offered. If the protection system mentioned in the awarded Contract become obsolete at the time of supply, the Supplier shall offer the latest model with the approval of purchaser, without any extra cost.

Protection shall be designed to ensure reliability, sensitivity and stability under through fault conditions of the Generators. Means shall, be provided to prevent operation of protective equipment due to, magnetizing current inrush during switching-in of the transformer from the high voltage side. Precaution shall also be taken so that the unavoidable inductive and capacitive couplings from the power circuit do not cause disturbances.

Protection relay shall have features but not limited to the following:

- a) Man machine communication interface with alarm and trip value setting, displaying of service values, alarm / trip set values, alarmed / tripped values, fault current and disturbance values etc...
- b) Self-supervision and indication of any failure.
- c) Continuous monitoring of external and internal auxiliary voltages.
- d) Easiness of replacing a module in case of failure.
- e) Communication interfaces or ports.
- f) Indication of alarm and trip condition.
- g) Test facilities.

1.3.6.7 Other Protections

1.3.6.7.1 Station Service Transformer Protection (11/0.440 kV)

- 50/51N Transformer Over current & Earth Fault
- 50 BF Breaker fail protection
- 49TW Station Auxiliary transformer winding temperature alarm and trip
- 26OT Station Auxiliary transformer oil temperature alarm and trip
- 63T Transformer Buchholz type gas protection

1.3.6.7.2 415 Volt Incoming Feeders

415-Volt incoming feeders from all transformers shall be protected for instantaneous and time delay over current, earth fault & under voltage protection (50/51, 27 and 64 relays). The relays will be installed on 415V switch-gear.

1.3.6.7.3 110 Volt DC System

All required protection system shall be supplied by the Contractor. The 110 V DC battery and charging systems should be used to provide the required DC supply for the protection relays, tripping and control circuits.

Basic requirement:

- Redundant DC supply system
- One number battery charger suitable for plante type battery.

- One DC distribution board for distributing power to the various loads.
- Voltage Controlled Units (VCUs) for regulating the DC output voltage at the 110VDC distribution board when the rectifier or chargers are in float or boost charge mode.
- Two fuse boxes with supervised fused switch dis-connectors.

Battery systems shall be referred to as A battery and B battery and the protective equipment divided between the two battery banks, so as to maximise the reliability of the protective systems in the event of failure of one of the battery banks or related equipment.

In DC system, earth fault detecting relay , which will centre tap the system via a high resistance ,shall be incorporated .This detecting relay shall each have two alarm contacts ,one for local visual annunciation and one for station alarm indication.

1.3.6.8 Basic Dimensions and Ratings

1.3.6.8.1 General Arrangement

The system shall provide a high degree of selectivity and discrimination between faulty and healthy circuits. A microprocessor based modular system associated with a Human machine communication interface shall be preferred.

All devices shall remain inoperative during internal faults and transient phenomena. They shall be insensitive to mechanical shocks, vibration and external magnetic fields.

All relays shall have self-monitoring facilities and LED status indication. Service voltage failure and any fault in relays and tripping circuitry shall be indicated.

Tripping circuits shall be operable at 70 % nominal voltage.

CTs shall be shorted automatically, when relevant modules are withdrawn.

Main and back up protection system shall be separated and shall have individual power supply from different source.

The relays shall be provided with the following information, suitably located:

- Function of relay
- Phase identification
- Main characteristics

The protection system shall be divided into protection groups and subgroups, each installed in a separate cubicle or cubicles. Each protection group shall consist of solid state

numerical protection, auxiliary relays, tripping unit and all accessories as required and further specified in the following sections.

The protection groups are defined as follows:

- Mechanical protection for the generating unit
- Electrical protection for the generating unit
- Transformer protection, for the main transformer and for the auxiliary transformer.
- 415 volt switch gear protection
- 110 volt DC switchgear protection.

Each protection group shall be divided into two subgroups. The division shall be maintained throughout to the tripping coils and shut down solenoids. Each breaker and shut down device will be equipped with two tripping coils or solenoids.

The protective equipment for the generating unit shall be installed in the Powerhouse along with UCB.

1.3.6.9 Design and Construction

The protection systems shall be the standard product of a competent manufacturer, with organized type test certificates and adequate record of satisfactorily working plants.

The relay used in protection system shall be of the numerical, and plug in type arranged in protection cubicles. All relays including all ancillary devices, such as interposing transformers, tripping matrix and relays, test facilities, power supply units, etc... with all circuits shall comply with IEC 60255 recommendation.

1.3.6.9.1 Mechanical / Electrical Protection

1.3.6.9.1.1 General

The mechanical protection for the generating unit shall be connected to the relevant protective devices or sensors as described in the respective sections of these Contract Documents and upon mechanical failures shall trip the turbine-generator unit and annunciate alarms.

The mechanical protection shall consist of the necessary relays, as applicable, connected to one or a group of protection devices or sensors, and a tripping unit as described in Design requirements.

The protection sensors and devices are described in the relevant sections of these Contract Documents and are wired to terminal blocks in different wiring cubicles.

1.3.6.9.1.2 Tripping Functions

At least the following protection sensors and devices shall be used to shut down the generating unit:

- Very high temperature in upper guide bearing, thrust bearing and lower guide bearing-RTDs.
- Over-speed mechanical device.
- Electrical governor fault.
- Very low governor oil pressure, pressure switch.
- Very low oil level in governor pressure tank, level switch.
- Very low inlet valve oil pressure, pressure switch.
- Very low oil level in inlet valve pressure tank, level switch.
- Very high temperature in Generator bearings, bulb thermometers.
- Very high temperature in Generator winding & core, temperature supervision system.
- Excitation system failure.
- Emergency stop push buttons.
- Starting or stopping time too long.
- Total cooling water flow too low.
- Generator protection trip.
- Gen. Transformer protection trip.
- SAT protection trip.

Any other protection devices considered necessary by the Contractor for the equipment supplied under this contract shall also be connected to the mechanical protection.

1.3.6.9.1.3 Alarm Functions

All tripping functions described above shall in addition to the tripping, give alarm indication

to the alarm annunciation system:

- High temperature in Turbine guide bearing, bulb thermometers or RTDs.
- Low governor oil pressure, pressure switch.
- Low oil level in governor pressure tank, level switch.
- Low inlet valve oil pressure, pressure switch.
- Low oil level in inlet valve pressure tank, level switch.
- High temperature in Generator bearings, bulb thermometers.
- High temperature in Generator winding & core, temperature supervision system.
- Excitation system in trouble.
- Low oil level in governor sump tank, level switch.
- High oil level in governor sump tank, level switch.
- Low oil level in inlet valve sump tank, level switch.
- High oil level in inlet valve sump tank, level switch.
- High temperature in winding of SAT.
- High temperature in generator transformer winding and oil.
- GSU transformer Buchholz relay operated.
- Generator transformer differential pressure alarm.

1.3.6.9.1.4 Over-speed

To prevent over speeding of the unit when tripped upon mechanical faults, tripping of excitation breaker and generator circuit breaker shall only be effected after the load-rejection. Adequately located position switches or other equally suitable system separately wired to the protection cubicle shall be furnished. The manufacture shall ensure field breaker tripping after GCB is tripped.

1.3.6.9.1.5 Starting of Unit

The unit shall not be ready unless confirming at least the following status:

- Mechanical brake released.
- Bearings oil level normal.

- Cooling water system healthy.
- Governor oil pressure normal.
- Governor AC / DC supply healthy.
- All protection supply healthy.
- No protection is operated.

1.3.6.9.2 Generator Protection

1.3.6.9.2.1 General

Generator protection shall be provided through an integrated numeric type relay. The relay shall have all the inherent characteristics like - Simplicity, Flexibility, Reliability, Selectivity, Stability, Accuracy, Sensitivity, and Redundancy. The relay shall be microprocessor based and shall be controlled by programs. The protection device shall have provision for human machine communications interface. The programs should be externally user-friendly for operation by the operator. It should prompt the user with messages and confirmations in order to guide the user and avoid errors or incorrect situations. Provision for transfer of sets of parameter settings etc... from and to floppy disk / CD shall be there.

The device should have self-diagnosis and supervisions functions to ensure maximum availability of the protection device as well as the power system it is protecting. Any failure of hardware or software shall be signaled out immediately by alarm contacts. The external and internal auxiliary supplies should be continuously supervised. Special algorithms should be incorporated to check the processor's memories regularly, to check the execution of the programs etc...

The operator program shall be suitable for configuration and setting of the protection, listing parameters, reading events, and listing the various internal diagnostic data. Provision shall be there for the user to create logical combinations of signals and pick-up and reset delays. Provision for detection of system asymmetric e.g., in the secondary circuits of CTs and VTs shall be made.

1.3.6.9.3 Protection and Tripping Relays

Two numbers Generator management relays and two numbers transformer management relays shall be supplied per unit for ensuring redundancy. Trip relays shall also be duplicated (two trip relays for same class) for redundancy. Trip relay shall be supervised for ensuring coil healthiness.

Relays shall be of approved types with IEC 60255 or IS, as appropriate, fully tropicalized and shall have approved characteristics. The protection relays shall be located in conventional panels and shall be flush mounted in dust and moisture proof cases with protection class IP54 and of the draw out type with rear connections. The protection class of the cover for all relays or protection systems, in which the modules are mounted, shall not be inferior to IP53.

Relays, where appropriate, shall be provided with LED or indications, phase coloured where applicable. LED or indicators shall be of the hand reset pattern / remote reset and shall be capable of being reset without opening the case. Where two or more phase elements are included in one case, separate indicators shall be provided for each element.

Relays, which rely for their operation on an external DC supply, shall utilize for this purpose the same DC supply battery as the trip supply of the associated circuit breaker trip coils. The supply shall be monitored and an alarm provided in the event of failure.

All DC breakers and relays for DC main switch-gear protection shall be based on AC trip and close coils and protection relays.

Any auxiliary supplies needed shall be drawn from the main station batteries and not from the separate internal batteries in the protection equipment.

Relays, whether mounted in panels or not, shall be provided with clearly inscribed labels describing their functions and designation in addition to the general-purpose labels.

Withdrawal pattern relay shall be so designed so that when in the withdrawn position associated CTs shall be automatically short-circuited and tripping circuits disconnected.

All relays shall be adequately protected against damages from incoming surge and shall meet relevant IEC, IS and ANSI SWC test standards.

The selectivity with the other protection modules shall be proved by a protection setting study covering the entire system. This study shall be based on a short circuit calculation for maximum and minimum short circuit capacity and shall prove the selectivity of the relay settings from the high voltage to the low voltage system, taking into consideration the different modes of operation of the system.

The input circuit must be galvanically isolated from the electronic circuits. Potential free output contacts must be suitable for the direct control of breaker trip coil.

The trip circuit supervision scheme shall provide continuous supervision of the trip coils and trip circuits with the circuit breaker in either the open or the closed position and scheme

shall have sufficient contacts for visual / available alarm and indication.

Protection scheme shall be designed to prevent false alarms during faults on DC wiring on adjacent circuits or due to operation of a trip relay contact.

Provision shall be made in trip circuit supervision circuits to prevent any type of mal-tripping of a circuit breaker.

Relay alarm should be equipped with well resetting indicators. The numerical protection relays shall have an operating time of less than 20 ms and single function protection relays shall have the operating time less than 15 ms. The total time taken by the protection system including auxiliary and tripping relays to send trip command to circuit breaker from the occurrence of the fault shall not exceed 70 ms.

Each relay or relay assembly shall have a test device, which facilitate checking the correct functioning of the equipment during operation or stand still.

1.3.6.9.4 Auxiliary Relays

Auxiliary relays for inputs from the protection sensors and devices such as thermal relays, pressure switches etc... shall be provided as specified in the following sections, and as necessary for the installation.

The relays shall be equipped with a manually reset indicator when applicable.

Each relay shall have self-resetting potential free contacts of suitable rating as needed for connection in the tripping circuits and at least two self-resetting potential free contacts for local and remote alarm and supervision, both wired to terminals.

All relays shall be clearly marked with the corresponding relay function.

Trip Relays (86)

All trip relays shall be of the high burden type (Class EB2 in accordance with ENA TS 48-4) to ensure immunity to operation due to capacitive discharge currents resulting from an earth fault on the dc wiring. They shall be fast operating manual and electrical reset with an operator indicator.

Trip relays shall be of the heavy-duty type suitable for panel mounting and shall have operating coils, which are rated sufficiently to operate in conjunction with series flag relays.

If necessary, normally closed contacts in series with the relay operating coil, shall be delayed for a period which will allow series flag relays to operate satisfactorily. All other tripping contacts should be instantaneous i.e, no intentional time delay.

The operating range of the relay shall be from 60 % to 130 % of rated voltage.

Electrical reset facilities shall be available for operation, from remote and supervisory controls.

High speed tripping relays shall prevent closing of the associated circuit breakers until reset.

Wherever the tripping relay contacts need to break the DC current sufficiently rated magnetic blow-out contacts or other approved means shall be used.

Trip-repeat relays shall have fast operating times (not to be greater than 10 ms at rated voltage) to achieve an overall trip time of the scheme within the specified limits.

The Trip relay must have sufficient number of NO / NC contact to cover all essential functions.

1.3.6.9.5 Control and Tripping Circuitry

The tripping circuits shall be accomplished via a tripping MATRIX. The MATRIX shall include all electrical and mechanical signals as per alarm / tripping schedule and sequence diagram.

Trip circuit supervision systems shall be provided. They shall preferably supervise the circuits continuously irrespective of circuit breaker position whether it is closed or open. Supervisory systems combined with automatic test facilities will also be considered.

Any fault in a tripping circuit shall be announced individually.

If applicable, the relevant alarm and tripping circuits shall be blocked in case of electrical braking of the unit to avoid mal-function / information.

Buzzer and bell shall be provided for alarm and trip functions separately.

Each relay or relay assembly shall have a test device, which facilitates checking the correct functioning of the equipment during operation or stand still.

The trip circuits shall not be interrupted during test procedure. Correct working shall be indicated by LEDs.

For relay testing and setting by means of a portable, precision test set all required circuits shall be terminated to test plugs / switches, arranged at easily accessible locations.

Power Supply Requirements

110V DC shall be provided for the power supply to the control and protection of AC switch-gear equipment, while AC shall be provided for the power supply to the control and protection of DC switch-gear. Both systems shall be used to supply auxiliary voltage and tripping voltages to the protection system.

All components of the protection system shall function properly at DC voltages from 70% - 115% of nominal voltage.

If short-circuit protection is needed inside each protection group, miniature circuit breakers shall be used, having auxiliary contacts for initiating alarm for open position.

Converters and suppression filters shall be provided for each protection part.

The converters shall have high insulation level, and shall be equipped with internal fault detection, initiating alarm upon failure in the converter.

The protection systems shall be fed by the 110 V battery banks installed in the Battery Room. Relay shall be suitable for operation on 110 V DC systems without the use of voltage dropping resistors. Each DC supply shall be designed to protect it from high voltage and surge and provide electrically isolated contacts for annunciation. Relays shall utilize a DC-DC converter type regulated power supply to provide transient surge isolation between the station battery and protection equipment. The supply units shall be equipped with input filters to protect against external voltage peaks. Protection shall be provided in the primary and secondary circuits of the DC transducers. The supply voltage and all secondary voltages produced by the DC-DC transducers shall be monitored.

The protection systems shall have double in feed with main switch, DC-DC transducers, stabilizers and voltage monitors. Redundancy shall be obtained by de-coupling the two DC-DC transducers by diodes so that, on failure of one circuit, the power supply can fully be maintained. In case of supply voltage drop the auxiliary voltage shall be maintained for 50 ms

1.3.6.9.6 Shop Tests

Protection Testing – General

Tests shall be performed at independent institutes or at the Contractors premises if approved by KSEBL, and at site (if applicable), in the presence of KSEBL Engineers.

The Contractor shall provide all the equipment necessary for the tests and shall furnish such equipment for the tests free of charge.

KSEBL is entitled to specify in detail which part of the total scope of supply shall be taken for testing.

The Contractor shall forward copies of all original test laboratory results to KSEBL if so required.

All necessary preparations for factory and site testing shall be carried out by the Contractor under supervision of the respective manufacturer's specialist.

KSEBL Engineers has the right to attend any or all tests to be performed on the equipment. Acceptance of test results by KSEBL shall not relieve the Tenderer / Contractor from his responsibilities to supply, install, commission and guarantee these equipment as per relevant specification and Standards.

KSEBL reserves the right to require the Contractor to repeat any one or all of the tests stated in this Specification, if such tests are not successful as per specification and latest IEC Standards or other applicable Standards. Such tests would be witnessed by KSEBL at the cost of the Contractor.

1.3.6.9.6.1 Type Tests

A type test certificate shall be provided for each relay type, which should confirm compliance of the protection relay with the requirements of the relevant sections of IEC 60255 as detailed in this specification. Any areas of non-compliance shall specifically be identified. It shall be stated whether the protection relay has been approved by any independent approval bodies.

Should the certificates be invalid or unacceptable to KSEBL, the type tests shall be performed by a recognised and KSEB approved independent laboratory at no extra cost to KSEBL.

1.3.6.9.6.2 Routine Tests

Contractor shall submit to KSEBL / Engineer for approval test protocols, list of tests, etc... at least three (3) months before the tests are undertaken at the premises of the equipment supplier. The routine testing shall comprise, as a minimum, of the following tests:

- Functional tests.

Dielectric Test (a.c. power frequency high voltage test) with 2 kV, 50 Hz for 1 min as per IEC-60255-5. EN 60255-27;2005.

Electrical disturbance test (for numeric relays only) to IEC 60255-26. EN 60255-22-1:2008.

- Calibration accuracy

Protection panels including protection relays, all components and wiring shall be inspected and tested at the factory. The tests shall include but not be limited to the following: Secondary injection scheme checks.

- Relay logic checks

- Functional Trip Tests
- Testing of Communication interfaces
- Testing of event and disturbance recording facilities
- Insulation resistance tests

The tests shall be conducted in the presence of KSEBL Engineers. The Contractor shall submit a report detailing the routine tests and the test results to KSEBL for review and approval prior to shipping.

Inspection and taking over in the factory do not relieve the Contractor from his obligations as per the contract documents and guarantee of performance.

1.3.6.9.7 Field Tests

The Contractor shall perform the following site tests on the protective systems:

- Relay auxiliary D.C. wiring and supply checks
- CTs and associated secondary wiring tests
- VTs and associated secondary wiring tests
- Application of relay settings as determined in the Protection Setting Report.
- Primary injection tests where appropriate
- Secondary injection testing to prove applied relay settings and operation within manufacturers stated parameters.
- Checks of all alarm circuits
- Functional testing of all relays. This includes testing protection relays, aided by secondary injection as necessary and scheme operation of relevant CBs.

The Contractor shall submit for approval a Commissioning Programme, three (3) months prior to the tests being performed. The Commissioning Programme shall be in accordance with the KSEBL Commissioning Policy and include, as a minimum, the following:

- List of the site tests for all protection systems/relays and associated HV equipment (CTs / VTs etc...).
- Procedures and methods for each commissioning test including those to be performed on-load.

- Calibration certificates for the testing equipment and instruments necessary for performing of each test.
- Format of site test reports for each test.
- Installation, operation and maintenance manuals.

Each site test shall be witnessed and signed off by KSEBL Engineer Three (3) months before the site tests and commissioning start the Contractor shall submit to KSEBL , the approved Protection Setting Report.

Contractor shall provide sufficient number of experienced test personnel during inspection, factory testing and site testing (preferably from manufacturer). For the site testing, the Contractor's testing and commissioning engineer/s shall be approved by the Protection Authority of KSEBL.

Contractor shall not withdraw or change the test engineer(s) before completion of all testing activities, unless at the instruction of KSEBL in the event that the test engineer(s) lacks adequate testing skills, knowledge base and technical expertise in the concerned protection systems / equipment.

Where Permits to Work or other Safety Documentation at existing grid stations are required, the Contractor shall give sufficient notice (at least two weeks prior to the testing activity) to KSEBL to plan and prepare for the necessary outages (if any) to be arranged.

Contractor shall carry out any additional site tests, other than those mentioned in the approved site test programme, if deemed necessary by KSEBL / Engineer, due to some unforeseen technical requirements arising out of operational contingencies or loading conditions in the network.

Commissioning will be deemed complete when all relevant equipment is energised and carrying load and all necessary on-load tests, measurements and checks are complete and signed for by KSEBL.

1.3.6.9.7.1 Primary Injection

Primary injection tests shall be performed to ascertain:

- Ratio and polarity of CTs & Pts.
- Correctness of interconnections between CTs & PTs as well as associated relays.
- Relay settings.

1.3.6.9.7.2 Secondary Injection

Secondary injection shall be carried out on all A.C. relays using voltage and current of sine wave form and rated power frequency.

D.C. Tests

D.C. tests shall be carried out to prove the correctness of all D.C. polarities, the operating levels of D.C. relays and the correct functioning of D.C. relay schemes, selector and control switches, indications and alarms.

1.3.6.9.8 Spares

Spares required for 5 years of maintenance shall be supplied. **For all protective relays, one relay of each type used shall be supplied as spare.** Any other spares recommended by the manufacturer as essential for the satisfactory and trouble free operation of the equipment as per Clause 1.1.32 of this specification.

The contractor has to supply 20 % of relays(Minimum 1 number, whichever is higher) of each type of relays and 100 % electronic cards used in C& R Panels as spare. The quoted price should include the spares cost also. A separate spare list has to be attached. Any other spares if required recommended by the relay manufactures also has to include in this list.

The contractor must supply a latest version of three phase relay testing kit of Omicron / Megger / Prograamme or equivalent with all necessary accessories including lap top, software, interconnecting cables, communication cables and other accessories as the part of this contract.

1.3.6.9.9 Tools and Instruments

Necessary manuals giving complete information on installing, configuring, trouble shooting etc... of the software including methodology for data retrieval / display of the data stored in the relays, changing relay settings etc... shall be also provided. Software required for the configuration, setting change, maintenance, trouble shooting, retrieval and display of stored data etc... of the relays and the testing software etc... shall be provided in CD / DVD also.

Terminal blocks and wiring shall be marked as per final revision of drawings. At least 20 % of spare terminal blocks shall be installed.

1.3.7 Segregated Phase Ducts, LAVT & NGT

1.3.7.1 Introduction

This section covers the KSEBL's requirements for the Segregated Phase Bus ducts (SPB) for the evacuation of power from the generators in the powerhouse, LAVT and NGT cubicles. The SPBs shall extent from the generator to the Generator transformer, Unit Auxiliary Transformer, LAVT cubicle and excitation transformer of each unit.

The details of Generator Transformer 11kV termination shall be collected from the KSEBL and proper flexible interlinking connections shall be provided according to transformer LV bushing design.

1.3.7.2 Reference Standards and Codes

The Equipment shall be designed, manufactured, tested, installed and commissioned in accordance with the latest revision of applicable IS / IEC or equivalent standards.

The Contractor shall adhere to sound design and construction practices with regard to codes and material specifications in order to warrant operational safety and ease of maintenance of plants as well as simplicity of control and stability in plant operation.

• IS 8084	- Interconnecting bus bars.
• IS 5082	- Aluminium / Aluminium alloy bars for electrical purposes.
• IEEE 60298	- AC Metal-enclosed switchgear and control gear for rated voltages above 1kV up to and including 52kV.
• IS 2062	- Steel for General Purpose Specification.
• IS 1367	- Technical Supply Conditions for Threaded Steel Fasteners - Part 13 : Hot-Dip Galvanized Coatings on Threaded Fasteners..
• IS 2099	- Bushings for alternating voltage above 1000V.
• IS 13947 Part 1	- Low voltage switchgear and Control gear.
• IS 2544	- Porcelain post insulator for voltages above 1000V.
• IS 2633	- Methods of testing uniformity of coating on zinc coated articles.
• IS 2705	- Current transformers.

- IS 3070 Part III - Lightning Arresters.
- IS 3151 - Earthing Transformers.
- IS 3156 - Voltage Transformers.
- IS 4759 - Hot dip zinc coating on structural steel and allied products.
- IS 5082 - Wrought aluminium and aluminium alloy for electrical purposes.
- IS 8084 - Interconnecting bus-bars for AC voltages above 1 kV up to and including 36 kV.
- IS 9431 - Specification for indoor post insulators of organic material for systems with nominal voltages greater than 1000 volts up to and including 300 kV.
- IEEE 32 - Neutral Grounding Devices.
- IEC 60726 - Dry type power transformers.
- ANSI C 37.20 (IEEE-27) - Switchgear assemblies including metal enclosed bus.
- ANSI,C 37.23 (IEEE-298) - Calculating losses in isolated Phase Bus.
- ANSI,C 37.24 - Effect of Solar Radiation on Outdoor Metal enclosed switchgear.
- BS 3816 - Cast epoxy resin insulating material for electrical application at power frequency.

1.3.7.3 Reference Sections

- Section 1.1 - General Technical Requirements
- Section 1.3.3 - Generators
- Section 1.3.4 - Excitation
- Section 1.3.5 - Control and Monitoring
- Section 1.3.6 - Protection
- Section 1.3.8 - Auxiliary Electrical Equipment
- Section 1.4.2 - Power Transformers
- Part - 2 - Specific Requirements for the Project.

1.3.7.4 Submittals and Approvals

The Contractor shall seek the prior approval of the KSEBL for the following through timely

submittals.

- The design and General Arrangement drawings of the segregated phase bus ducts, LAVT & NGT cubicles shall be submitted for approval by the KSEBL.
- The Contractor shall purchase equipment from reputed vendors only and the name of vendors shall be submitted for KSEBL's approval.
- Calculations for sizing of Bus Duct, LAVT, Neutral Grounding Transformer, NGR etc...
- Schematic drawings and circuit diagrams at agreed stages.
- Material certificates and test reports
- Inspection, Erection, Testing and Commissioning methodologies.
- For the alignment of embedded parts before grouting.

Before delivery of equipment to site, the contractor shall submit all work test certificates / reports for approval and obtain despatch clearance from the KSEBL's representative.

1.3.7.5 Deliverable Documents

- Layout drawings of the powerhouse showing the location of Bus ducts, LAVT and NGT, clearly indicating dimensions and all important elevations.
- Schematic drawings, circuit diagrams and specifications
- Design calculations
- A complete list giving details of equipment and auxiliaries.
- Operation and maintenance manual covering full details of operation and maintenance procedure.

1.3.7.6 KSEBL's other Requirements

Other technical requirements shall be as given in Part-2 (Specific Requirements of the Project) of this specification.

The layouts of the powerhouse are given in drawings appended to the specifications.

The segregated phase duct (for each unit) shall comprise of

- Bus ducts forming the main current carrying leads from the generator barrels to the

terminals of the three phase generator transformer.

- Bus ducts of suitable rating forming the current carrying leads for tap-off to the Unit Auxiliary Transformers.
- Bus ducts of suitable rating forming tap-off and connection to the voltage transformer and surge protection cubicle (LAVT cubicle).
- Bus ducts of suitable rating forming tap-off and connection to the rectifier transformer.
- The Bus duct shall be perfectly sealed in order to avoid entry of moisture. Sufficient space heaters shall be provided.
- 11kV bus bar in the duct shall be supported by porcelain insulators suitable for 11kV system.
- Set of flexible isolating links for isolation of all tap-off ducts and generator terminals.
- Set of supporting structures, columns, frames, wall plates, hangers, mounting plates, hardware etc...
- Sets of items not specified above but are necessary for the satisfactory operation of bus ducts.
- Set of voltage transformers and current transformers.
- All special devices, tools, testing equipment etc... required for installation, testing, commissioning and maintenance of the bus ducts.
- One set of spares required for 5 years of normal operation for each unit.

The minimum supply of spares shall be:

- Bus bar shorting link having the capacity of 11kV bus - 1 Set
- Supporting Insulator - 20%
- Flexible link - 1 No of each type

All equipment shall be neatly arranged and shall be readily and easily accessible for operation and maintenance. Necessary walkways, handrails, ladders, chequered plates, platforms etc... required should be provided by the contractor.

1.3.7.6.1 Scope of Work

Detailed scope of work is specified in Part-2 “**Specific Requirements for the Project**” of

this specification.

Any ratings, if mentioned, are indicative only and are a minimum for giving a base line. The Bidder should ensure that the ratings of the various equipment are sufficient to take care of the design requirements of the equipment offered for the concerned project. Any increase in rating during detailed engineering stage will not entitle the Successful Bidder / Contractor for any extra charges. The Contractor should submit for approval the calculations for arriving at the ratings of the various equipment.

Any item of work not specifically mentioned in the specifications but which are usual and / or necessary for the satisfactory operation of the equipment supplied shall be deemed to be provided by the Contractor and included in the quoted Price. All work shall be complete in all details whether such details are mentioned in the specifications or not.

1.3.7.6.2 Description of the Equipment

1.3.7.6.2.1 Segregated Phase Bus Ducts

1.3.7.6.2.1.1 General

The generator bus-duct shall comply with the requirements of the latest versions of relevant IS / IEC standards. The bus duct shall be of standard size as per IS-8084 and continuous (bonded enclosure), natural air cooled and positive pressure type. The SPBD will serve as an interconnection between generator, and its associated generator transformer banks and unit auxiliary transformers. The layout of the bus duct and number of flexible, bolted and welded joints shall be provided as per requirement.

The segregated phase bus duct shall extend from the generator to the main transformers, to the unit-auxiliary transformers, to the potential transformer cubicle, to the lightning arrestor tube housing and to the excitation transformers etc... The bus shall be of segregated phase type in which each conductor is supported on porcelain insulators at each supporting point and enclosed by an electrically continuous aluminium housing. Generator Bus-duct rated more than 3150 A shall be continuous isolated phase type. Space heaters shall be provided to prevent moisture deposition in bus ducts.

The bus duct will be installed partially indoor and partially outdoor and shall be suitable for hot, humid and tropical atmosphere. However, cubicles for neutral grounding, voltage transformers and surge protection equipment will be installed indoors.

The portion of the bus duct at the generator end will be subject to vibrations. Bus duct enclosure shall not be bolted with generator. A slit of 10–20 mm shall be kept between

enclosure and generator flange. Suitable covering shall be provided on the slit to allow escape of hydrogen and avoid dust entry inside the common chamber.

Flexible conductors shall be provided for connection to the generator terminals, main transformer terminals, auxiliary transformer terminals, excitation transformer terminals and the potential transformer bus terminals and lightning arrestor units. Necessary facilities shall be furnished for connecting the bus enclosures and connectors to the transformers. Manholes shall be provided at suitable locations for inspection / maintenance with proper sealing.

The bus-duct shall be designed to carry maximum continuous current under normal site conditions without exceeding temperature rise limits. Based on these requirements standard size of bus-duct as per relevant IS / IEC standards shall be used. The bus assembly shall be designed to mechanically withstand a rated continuous current as well as the specified short-circuit current without damage or permanent deformation of any part of the bus structure.

The following calculations for main run delta and tap-off run bus duct shall be furnished:

- a) Temperature rise at rated current considering effect of solar radiation.
- b) Conductor size.
- c) Guaranteed kW losses in conductor and enclosure.
- d) Supporting span.
- e) Dynamic and static forces transferred to TG foundation.

Generator transformers and sometimes unit auxiliary transformers may be placed on the rail track. The bus duct and supporting structure shall be designed in such a way so as to permit transformers removal, after opening the terminations, but without dismantling bus duct run or supporting structure.

The maximum temperature rise of the bus conductor and enclosure shall be as defined below when operating at maximum ambient temperature and carrying rated current continuously. For outdoor portions the effect of solar radiation shall also be considered. The bidder shall furnish calculation for temperature rise taking effect of solar radiation into consideration.

Permissible temperature rise for:

- Bus conductor 55 °C
- Bus enclosure 30 °C

1.3.7.6.2.1.2 General Technical Parameters

a) Rated maximum Voltage (r.m.s)	- To suit generator voltage
b) No. of phases	- 3
c) Frequency	- 50 Hz
d) Neutral grounding	- Non-effectively grounding
e) Insulation level	- As per standard to suit generated voltage
f) Creepage distance	- As per standard to suit generated voltage

1.3.7.6.2.1.3 Enclosure

The phases shall be enclosed in a weather proof, dust tight, non-magnetic metal (aluminum alloy) enclosure. The enclosure shall be designed for welded connection.

Filtered drain tapping with dual stop cocks shall be provided for drainage of condensate at the lowest point and at such other locations where accumulation of condensate can be expected. In particular a drain valve shall be provided at the lowest point of transformer end termination. The contractor shall be required to add drainage points if required during installation.

1.3.7.6.2.1.4 Bus Conductor

The Bus Conductor shall be of high conductivity, painted aluminum alloy as per IS: 5082 supported on insulators.

The bus conductor shall be designed for welded connections except at equipment terminations, bolted disconnect links, and bolted flexible.

Flexible connections shall be provided between bus sections to allow for expansion and contraction of the conductor. Flexible connections shall also be provided at all equipment terminations.

All contact surfaces shall be silver plated. All connection hardware shall be nonmagnetic and shall have high corrosion resistance.

1.3.7.6.2.1.5 Insulators

Bus support insulators shall be interchangeable, high strength and fine glazed porcelain manufactured by wet process.

Insulator shall be mounted in such a way so as to permit its easy removal or replacement without disassembly of the bus.

The conductor shall be fastened on the insulator through fixed and sliding joints so as to allow conductor expansion or contraction without straining the insulator. Positive contact shall be made between end caps of the supporting insulators and the conductors.

Additional support insulators shall be provided at bend and at tap offs for withstanding all possible forces.

1.3.7.6.2.1.6 Connections and Terminations

All matching flanges, seal off bushings, gaskets, fittings, hardware and supports required for termination of the bus duct at Generator, Transformers and other equipment shall be furnished under the scope of this specification. Flexible connections both for conductor and enclosure shall be furnished:

- a) At all equipment termination to take care for misalignment up to 25mm in all directions.
- b) Between bus duct supported from building steel and that supported by turbine foundation to prevent transmission vibrations.

The equipment terminal connections shall be readily accessible and shall provide sufficient air gap for safe isolation during electrical testing.

If the material of bus conductor and that of the equipment terminal is different, then suitable bi-metallic connectors shall be provided by the contractor.

Seal off bushings shall be provided at the generator end of the bus duct, tap off to PT cubicles and neutral grounding (NG) cubicle.

1.3.7.6.2.1.7 Grounding

The electrically continuous bus enclosure shall be used as the grounding bus. All parts of the bus enclosure, supporting structure and equipment frames shall be grounded to earthing mat.

Duplicate bolted type ground pads shall be provided to accommodate 50x10 mm galvanized steel flats, wherever isolated phase bus duct terminates.

1.3.7.6.2.1.8 Supporting Structure

All supporting structure required for hanging and / or supporting the complete bus duct shall be furnished. These shall include all members, indoor / outdoor posts, bolts, shims, base plates, hangers, brackets, bracings and hardware.

All bus ducts shall be adequately supported and braced to successfully withstand normal operation, vibrations, thermal expansion, short circuit forces and all specified design loads. Supports shall be designed to provide tolerance of 12mm in the horizontal and vertical directions.

All steel members shall be hot dipped galvanised after fabrication. All hardware shall be of high strength steel with weather resistant finish.

Arrangement of support steel work shall be such as to prevent heating of structures caused

by circulating currents.

Hinges of all inspection covers shall be strapped across with flexible earth connections.

1.3.7.6.2.1.9 Moisture Retention

Suitable arrangement for prevention of moisture retention shall be provided.

1.3.7.6.2.1.10 Current Transformers

The current transformers shall be epoxy cast-resin, single core ring type conforming to IS2705. It shall be mounted within the bus duct enclosure and suitable for operation at an ambient temperature existing within the bus duct enclosure which may be in range of 90°C to 100°C. Mounting arrangement of CT shall be so designed so as to avoid equalising connections between live conductor and CT inner surface.

CT secondary leads shall be brought out through non-magnetic metallic conduits to a marshalling box (MB) with degree of protection IP-55 (IS:13947 Part-1). The MB shall be provided with removable aluminium gland plate. The facility for shorting and grounding shall be provided at the terminal blocks.

1.3.7.6.2.2 LAVT Cubicle

One number LAVT panel having necessary surge capacitors and lightning arrestors shall be provided for generator protection. The cubicles shall be of sheet steel, suitably, compartmentalized with doors and shall be furnished complete with base mounting arrangement, foundation bolts, etc... The internal illumination for cubicles shall be provided with guarded lamps having on / off switch. Aluminum / Copper conductors of appropriate size shall be used for bus bars and connections in the cubicles. The bus bar and main & connecting conductors shall be suitably insulated to make them compatible with generator temperature rise and insulation. The support insulators for the bus connection shall be provided as necessary. GI earth bus of adequate cross-section will be provided in the cubicle. The cubicles shall have rigid frames of rolled steel sections supported on a steel channel base. Welded parts shall be carefully cleaned and phosphated after assembly. Panels shall be removable single piece steel plates, with a minimum thickness of 11 gauge (3 mm), bolted to the frame. No part shall be subject to excessive heat rise and natural ventilation shall be supplied. Suitable tapping connection shall be provided for metering & protection PT and AVR power & sensing PTs. Current transformers shall also be accommodated in LAVT. The cables from stator shall be terminated in LAVT.

The surge arrester and voltage transformer (LAVT) cubicle shall meet the requirements of relevant IS / IEC standards. The LAVT cubicle shall consist of a terminal cubicle for each

machine housing surge capacitor, potential transformers, lightning arresters, cable boxes, etc... The cubicle shall be complete with necessary tapings for excitation system, etc... The rating of the CTs for AVR shall be decided by the supplier taking into account the requirements of AVR.

The VT cubicles and LA cubicles shall be provided separately for each phase and shall be metal-clad, dust and vermin proof, free standing, dead front assemblies housing VTs, surge capacitor, lightning arrester, fuses on LV side of VT etc...

Each VT and SP cubicle shall have seal off busing at the terminations of tap-off bus duct to cubicle.

Lightning arrester shall be of modern metallic gapless (ZnO) type , hermetically sealed, connected between line and ground, specifically suitable for generator.

Mineral oil filled / Askarel filled surge capacitor shall not be acceptable.

The voltage transformer shall be epoxy cast-resin type conforming to IS:3156.

The voltage transformer along with secondary fuses shall be mounted on draw out type carriage. Suitable guide slots and stops shall be provided to ensure easy withdrawal and positioning. The fixed and draw out contacts of voltage transformer primary shall be tinned or silver plated.

Marshalling box shall have sufficient number of terminals with 20% spare, to accommodate all VT leads.

The cubicles shall be fabricated from cold rolled sheet steel of 3 mm thick suitably reinforced to ensure structural rigidity and compartmentalized with doors and shall be furnished complete with base mounting arrangement, foundation bolts, etc... The degree of protection for all indoor cubicles shall be IP52.

Sufficient protective Electrical interlock shall be provided to prevent the opening of the LAVT cubicle while the machine in service.

Each cubicle shall be equipped with space heater with thermostat, internal illumination lamp, 240 V AC, 5A receptacle. Ground bus suitable for receiving two (2) numbers of 50x6 mm galvanized steel flats shall be provided on each cubicle.

Three capacitors and three station type lightning arrestors for surge protection shall also be provided in each LAVT cubicle.

Instrument Transformers

- The current transformers shall preferably be window type fitted around the bus conductors for meeting the protection and measuring requirements.

- The voltage transformers shall be located in separate cubicle for each of the three phases and mounted in withdrawable cabinets.
- The surge diverters and / or the surge capacitors shall be provided in the same cubicle as that of the voltage transformers with suitable barriers.

Two sets of draw-out epoxy cast type voltage transformers with two cores each for metering, protection and control with necessary protection, isolating facility and grounding devices shall be provided in the LAVT cubicle.

The secondary of the voltage transformer shall be protected by MCBs provided with sufficient spare contacts for "PT failure" annunciation and a fast acting auxiliary contact for "blocking the trip" of the backup under impedance relay provided for generator protection.

Potential Transformers

The potential transformers will be single phase, epoxy, cast, dry type units. Potential Transformer will be protected on primary and secondary side by current limiting fuses. The PT shall conform to IS: 3156. The primary neutral terminal shall be terminated on separate terminal which in turn shall be connected to ground.

Lightning Arrestors

The lightning arrestors shall be heavy duty, indoor station class and of modern metallic (ZnO) non-linear resistor gapless types suitable for repeated operation to limit voltage surges on alternating current power circuits and to interrupt power follow current. The arrestors shall conform to IEC 99-4. The nominal discharge current of lightning arrestor shall not be less than 10 kA.

Surge Capacitors

The surge capacitors shall conform to the latest edition of IS:2834 and shall be rated 0.25 Micro Farad. The capacitors shall be connected in parallel with lightning arrestors and shall be provided with a built in discharge resistor. The capacitor shall be suitable for indoor mounting.

Current Transformer

The current transformers will be epoxy cast, dry type units conforming to IS:2705. Provision shall be made for connecting the generator terminals to the bus ducts, on both line and neutral side through seal-off bushings and flexible leads. The neutral formation shall be made and connected to the grounding cubicle.

All CT's shall have 5A secondary rating. The current transformers shall be designed to

withstand the thermal and magnetic stresses from the maximum short circuit current. The accuracy class shall be 0.2S for metering and Class 5 P 20 or Class PS (as applicable) for protection. All protection class CTs shall have a minimum knee point voltage of 600 V. The CT locations, rating, accuracy class shall be suitable for adequate metering and protection.

1.3.7.6.2.3 NGT Cubicle

All large hydro-electric machines having a wye-connected stator winding with the neutral brought out of the machine housing shall be grounded via a high-resistance circuit consisting of a single-phase grounding transformer connected between the generator neutral and ground having a standard, high voltage rating approximately equal to 1.5 times the maximum machine phase-to-ground terminal voltage rating. A resistor shall be connected across the secondary terminals of the grounding transformer.

The transformer and resistor shall be located in separate cubicles / compartment adjacent to each other. The cubicles shall have hinged access doors capable of being pad locked.

The neutral grounding transformer shall be cast epoxy resin dry type natural air cooled single phase connected between generator neutral and ground.

The loading resistor shall be formed of non-aging, corrosion resistant punched stainless steel grid element provided with necessary insulation and designed for indoor service for a temperature rise not exceeding 300⁰C.

All alarm, protection and indication leads shall be wired up to terminal blocks that shall be mounted in an IP52 enclosure suitable for flush mounting and having a fully hinged cover with lock.

Neutral grounding equipment shall be designed taking into account the maximum permissible operating voltage of the generator, voltage rise on load throw off (subsequent to detection of earth fault) field suppression time, ferro-resonance etc... System earthing shall be such that it shall be possible to provide earth fault protection with proper discrimination.

The neutral grounding cubicle, fabricated from sheet steel, shall be suitable for floor mounting. The grounding transformers, isolator switch, resistor, etc... shall be housed in the neutral grounding cubicle. The position of the isolator switch shall be externally visible.

The cubicles shall be fabricated from cold rolled sheet steel of minimum 2mm thick suitably reinforced to ensure structural rigidity and compartmentalized with doors and shall be furnished complete with base mounting arrangement, foundation bolts etc... The degree of protection for all indoor cubicles shall be IP52 except for neutral grounding resistor enclosure which shall be minimum IP23.

Each cubicle shall be equipped with space heater with thermostat, internal illumination lamp, 240 V AC, 5A receptacle. Ground bus suitable for receiving two (2) numbers of 50x6 mm galvanized steel flats shall be provided on each cubicle. The internal illumination for cubicles shall be provided with guarded lamps with on / off switch. Copper / Aluminium conductors of appropriate size shall be used for bus bars and connections in the cubicles. The bus bar and main connecting conductors shall be suitably insulated to make them compatible with generator temperature rise and insulation. The support insulators for the bus connection will be provided in the cubicle.

A metal enclosed generator neutral grounding system shall be provided. It shall include dry type neutral grounding transformer and neutral grounding resistor of suitable rating. The neutral grounding cubicle shall be suitable for indoor mounting and shall be equipped with terminal box, ground pad and suitable connectors for connection to station ground.

1.3.7.7 Finish

Except for supporting steel structures which shall be galvanised, all equipment including bus duct enclosure shall be finished with an under coats of high quality primer followed by two coats of synthetic enamel paint which shall have a thickness not less than 80 microns. The interior surface finish of bus duct enclosure shall be as per manufacturer's standard. The shade of exterior surface shall be shade 697 (Light Admiralty Grey) as per IS 5 or as specified in Part-2 of this specification for bus duct and equipment. The shade of interior surface of cubicles shall be glossy white. The identification tag shall be Signal Red shade IS 5 shade 537 or RAL 3001.

1.3.7.8 Testing

The Contractor shall conduct shop tests on dates agreed with the KSEBL and make arrangements for the KSEBL's representative to witness the tests.

All testing envisaged in IS / IEC standards shall be carried out. The Contractor shall make all arrangements, equipment, material and consumables for the tests and prove compliance of the equipment with the standards at shop and at site.

The test reports shall be got approved by the KSEBL before requesting despatch clearance for any item.

1.3.7.9 Spares

Spares for 5 years satisfactory and trouble free operation and maintenance of the equipment shall be supplied as per Clause 1.1.32 of this specification.

Following spares (minimum) shall be supplied for the three units:

- 11kV CT (of each type) - 2 Nos
- 11kV PT(of each type) - 2 Nos
- 11kV LA - 3 Nos
- Surge Capacitor - 3 Nos
- HT Fuse for 11kV PT - 3 Nos

• IS 10118 (Part 1 to 5) • IS 13118 • IS 13947 (Part 1 to 5) • IEC 60298 • IEC 60947 • IEC 62271 • IEC 60044 • IEC 60076 • IEC 60905 • IEC 62060 • IEEE 484-1996 • IEEE 450-2002 • IEEE 485-1997 • IEEE 1184-1994 • IEEE 1375-1998 • IEEE 1491-2005 • CBIP Publication No.317	- Code of practice for selection, installation and maintenance of switchgear & control gear. - Circuit breakers. - Specification for low voltage switchgear and control gear. - AC Metal-enclosed switchgear and control gear for rated voltage above 1 kV up to and including 52 kV - Low Voltage Switchgear & Control-gear - High Voltage AC Circuit breakers - Instrument Transformers - Dry Type Transformers - Loading guide for dry type transformers - Secondary cells and batteries – Monitoring of lead acid stationary batteries – User guide - Recommended Practice for Installation Design and Installation of Vented Lead-Acid Batteries for Stationary Applications. - Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications. - Recommended Practice for Sizing Lead Acid Batteries - Guide for the Selection and Sizing of Batteries for Un-Interruptible Power systems - Guide for Protection of Stationary Battery Systems - Guide for Selection and Use of Battery Monitoring Equipment in Stationary applications. - Manual on Transformers.

1.3.8.3 Reference Sections

Section 1.1	-	General Technical Requirements

Section 1.3.5	-	Control & Monitoring
Section 1.3.6	-	Protection
Section 1.3.10	-	Lighting & Grounding
Section 1.4.3	-	Switch-yard Equipment
Part - 2	-	Specific Requirements for the Project

1.3.8.4 Submittals and Approvals

The Contractor shall seek the prior approval of the KSEBL for the following through timely submittals.

- The design and sizing calculations for Transformers, Cables, Battery, Charger and UPS and drawings of the auxiliary electrical.
- The Contractor shall purchase equipment from reputed vendors only and the name of vendors shall be submitted for KSEBL's approval.
- Schematic drawings and circuit diagrams, operating philosophies, inter-locking logics and schemes etc... at agreed stages.
- Material certificates and test reports
- Erection, Testing and Commissioning methodology

Before delivery of equipment to site, the contractor shall submit all work test certificates / reports for approval and obtain despatch clearance from the KSEBL's representative.

1.3.8.5 Deliverable Documents

- Layout drawings of the power house showing the location of Auxiliary Equipment including LT / DC Boards, Battery & Charger, Transformers etc..., clearly indicating dimensions and all important elevations.
- Schematic drawings, circuit diagrams and specifications
- Design / Sizing calculations, Quality Assurance Plan
- A complete list giving details of equipment and auxiliaries.
- Operation and maintenance manual covering full details of repair procedure.

1.3.8.6 KSEBL's other Requirements

Other technical requirements shall be as given in Part-2 (**Specific Requirements of the Project**) of this specification. Any item of work not specifically mentioned in the specifications but which are usual and / or necessary for the satisfactory operation of the equipment / system shall be deemed to be provided by the Contractor and included in the quoted Price. All work shall be complete in all details whether such details are mentioned in the specifications or not.

The layouts of the powerhouse are given in drawings appended to the specifications.

The auxiliary electrical equipment shall consist of:

- 415V LT AC power supply system
- 110V DC power supply system
- Uninterrupted power supply system
- All special devices, tools, testing equipment etc... required for installation, testing, commissioning and maintenance of the supplied equipment.
- One set of spares required for 5 years of normal operation for each equipment.

All equipment shall be neatly arranged and shall be readily and easily accessible for operation and maintenance. Necessary walkways, handrails, ladders, chequered plates, platforms, etc... required should be provided by the contractor.

1.3.8.6.1 Scope of Work

Any item of work not specifically mentioned in the specifications but which are usual and / or necessary for the satisfactory operation of the equipment supplied shall be deemed to be provided by the Contractor and included in the quoted Price. All work shall be complete in all details whether such details are mentioned in the specifications or not.

Any ratings, if mentioned, are indicative only and are a minimum for giving a base line. The Bidder should ensure that the ratings of the various equipment are sufficient to take care of the design requirements of the equipment offered for the concerned project. Any increase in rating during detailed engineering stage will not entitle the Successful Bidder / Contractor for any extra charges. The Contractor should submit for approval the calculations for arriving at the ratings of the various equipment.

1.3.8.6.2 Description of Equipment

1.3.8.6.2.1 415V LT AC Power Supply System

The LTAC system shall, in general, comprise of the following:

- 11kV/415V or 6.6kV/415V or 3.3kV/415V, 3-phase, indoor, dry type, air cooled, two winding Unit Auxiliary transformers (UAT).
- 11kV/415V or 6.6kV/415V or 3.3kV/415V, 3-phase, outdoor type, oil filled, air cooled, two winding Station Service transformer (SST).
- 11/6.6/3.3kV, outdoor type, Vacuum / SF6 circuit breaker for the SST (if required) along with necessary control and protection as required and / or
- 11/6.6/3.3kV Indoor type VCB / SF6 Switchboard.
- 415V Main station service board (MSSB) for the powerhouse with Incomers and sufficient outlets, with interlocks provided for incomers along with auto changeover so that the system will be energised if any one incomer is live.
- 415V Unit Auxiliary Boards (UAB) for machines
- DG sets if specifically mentioned in Part-2
- Set of tools, handling devices, testing instruments for erection, testing and maintenance of the complete system
- One (1) set of spare parts sufficient for 5 years of operation
- Any other item not specified above but necessary for satisfactory operation of the system.

The LT AC system shall also include provisions for catering to the LT requirements of the future addition of units, if any.

The station auxiliary A.C. supply system shall be designed to provide a high degree of reliability, continuity of service and primarily to supply uninterrupted AC supply to station auxiliaries during normal operation and unit auxiliaries during starting and stopping of the unit.

The station supply loads for various equipment shall be determined and normal maximum demand shall be calculated at a diversity factor of 0.75. The availability of input supply shall be ensured from the sources independent of station generation. In addition, adequate provision for meeting load of auxiliaries for one unit during starting and / or during the stopping of the unit shall also be kept and for this purpose the unit auxiliary boards shall be

connected to station auxiliary boards through tie breakers.

If specifically mentioned in Part-2, Two nos. of Station Service Transformers of equal capacity; one main and other as standby shall be provided for supplying power to the station service board feeding power to the station auxiliaries. In the event of A.C. supply failure, the station load shall be supplied by diesel generating set(s) of suitable capacity connected to the station service board (SSB). The station service transformers, DG sets and station service boards shall be located at higher level.

The various auxiliary systems shall incorporate appropriate auto transfer scheme and / or manual changeover to bring in the reserve supply source as required to prevent the loss of unit(s) and to ensure the equipment safety.

Each switchgear, motor control centres (MCCs), distribution boards (DBs) shall be fed by 2x100% transformers / feeders and these shall be rated to carry the maximum load expected to be imposed.

Power supplies, buses, switch-gears, interlocks and standby supply systems for station and unit auxiliaries shall be designed in such a way that the main equipment and auxiliaries are not endangered under any operating conditions. Transformer voltage ratios, type of tap changers and tap ranges, impedances and tolerances thereon shall be so optimised that the auxiliary system voltages under various grid and loading conditions are always within permissible limits and equipment are not subjected to unacceptable voltages during operation and starting of motors. The vector groups of the generator transformers, unit auxiliary transformers and station transformers shall be so selected that the paralleling at 11/6.6/3.3kV buses shall be possible. Further, the vector group of other auxiliary transformers shall have identical vector groups.

1.3.8.6.2.1.1 Auxiliary Transformers

- Primary voltage - 11/6.6/3.3kV
- Secondary voltage - 415V
- Rated capacity - As per Part-2 - Specific requirement of the project
- Insulation level
 - high tension - 95/38 kV for 11 kV, 40/10 kV for 3.3kV
 - low tension (BIL) - 3 kV
- Winding material - Copper

- Taps (off-load) - $\pm 5\%$ in steps of 2.5%
- Vector group - Dyn
- System earthing - Solidly earthed

With each transformer, suitable current transformers shall be provided for over-current and earth fault protection. Unit auxiliary transformer shall be protected by differential protection and from sustained earth fault on LV side also, for which additional CT shall be provided. All required Current Transformers for metering including energy meter shall be also provided.

A) Dry Type Transformers

The Cast Resin (Dry type) Transformer with class F insulation shall be suitable for continuous indoor operation in a tropical climate on a 3 phase distribution system with solidly earthed neutral. It shall be of a short circuit, impulse and moisture proof design.

The cast resin transformer shall be designed, manufactured and tested in compliance with the IEC, IS codes & standards. They shall also be satisfactory in operation under the atmospheric and climatic conditions, prevailing at the site and under such variations of current, voltage and frequency as may be met under fault and surge conditions on the system in the area.

The transformer shall be designed to deliver continuously its rated current under steady loading conditions without exceeding the temperature rise, at rated voltage and frequency. Overloading as per IEC 60905 shall be possible for these transformers. The cast resin transformers shall be compact and suitable for easy installation on site, and shall be suitable to operate in an enclosure of the protection class IP 23 without de-rating.

The HV and the LV winding shall be of insulation class F in respect of mechanical and electrical strength (Partial Discharge Test). The insulation system of the windings shall consist of approved materials for assigned temperature class. The maximum continuous operation temperature shall be within the limit of the maximum system temperature according to IEC 726, i.e. 155°C . The maximum temperature rise shall be limited to 100 K at 40°C ambient.

The Transformer shall be possible to withstand condensation or pollution or combination of both. It shall be suitable for installing in indoor and operation at site maximum and minimum ambient conditions.

The core laminations shall be made of cold rolled grain oriented high quality silicon steel with non-hygroscopic insulation material covering both sides. The laminations shall be step lap overlapped to minimize core losses & noise. The assembled core shall be braced in suitable steel frames that make up the base frame & lifting facilities for complete transformer. The core assembly shall enable the removal of the coils in the field, if this should become necessary. The entire core assembly shall be covered with a resin based lacquer for corrosion protection before the coils are mounted. The flux density shall be selected in the way that the core material used is efficiently operating.

The clamping structure of the core and coil arrangement shall be of robust construction to withstand the system short circuit stress to which it may be subjected during operation. The clamping frame shall respect the requirements of high voltage equipment. Tie rods shall be located next to the lamination. The clamping structure shall not allow any bolt piercing the core lamination.

Lifting lugs capable to carry the weight of the transformer shall be provided at the core frame. An adequate painting shall cover the complete core and the clamping structure and shall protect it against corrosion.

The conductor material used at the HV windings shall be of high conductivity copper. Enamel wire and fibreglass insulated wire shall be allowed. HV windings shall be vacuum cast with copper as conductor material & 155 deg C insulation systems. Winding design shall be adequate to allow for full encapsulation with filled resin under vacuum. The resin system shall be two components epoxy filled with a mixture of inorganic fillers improving its thermal, mechanical & fire behaviour properties. The single resin component & filler will be carefully stirred & degassed under vacuum in order to eliminate all air bubbles & then mixed together throughout a static mixer just before to pour them, under vacuum, into the mould that contains the coil.

The material used for insulation and reinforcement shall be of fibreglass and of pure epoxy resin. Filler shall not be allowed.

The HV winding shall be wound in a multi layer winding technique and shall be in such a way that a linear potential distribution during impulse stresses is achieved. The winding process must position accurately each winding in order to minimize and control the electric stress on the insulation material.

HV winding shall be arranged to minimize the temperature gradient in the coil.

The HV coil shall be moulded and cast under vacuum with epoxy resin to ensure complete void-free resin impregnation throughout the entire insulation system. The flexibility of the resin shall be such that the formation of cracks shall be avoided during short circuit stresses and temperature shocks. Penetration of moisture shall be avoided by the vacuum cast process.

HV terminals shall be suitable for connecting 11 kV Bus Duct or XLPE Insulated Copper cable of size as specified in Part-2 of this specification.

The HV winding shall be equipped with off load tapings as specified in the Part-2 scope of work. The tapping range shall be -5% to +5% at 2.5% steps. The tap changer shall be located in an easily accessible location.

The conductor material used at the LV windings shall be of high-grade copper formed as a foil. The width of the foil shall form the height of the winding (foil winding).

With resin pre-impregnated multi layer type insulation material of Class F shall be used for insulation. After thermal treatment, the winding shall form a solid structure, which shall be capable to withstand the stress occurring during a short circuit.

The LV winding shall not be wound on the core to create a cooling duct between core and LV winding. LV winding shall be arranged to minimize the temperature gradient in the coil. Rectangular section terminals shall be rigidly fastened to the upper clamping structure.

The neutrals of wye (star) connected secondary windings shall be rated for full capacity and fully insulated. The neutral connection shall be made inside the transformer enclosure. The termination pad provided for the neutral connection shall be drilled as required by area standards.

The transformers shall be capable of withstanding, on any tapping, for two seconds (as per IEC), without damage, under service conditions, the thermal and mechanical effects of a short circuit at the terminals of any winding.

Noise level shall be limited to 65 dB(A). The transformer shall be made for air natural cooling.

Earthing terminal shall be provided to connect external earthing at bottom at two points and the terminal shall have adequate size to receive the external earthing conductor / strip. All metal parts of the transformer with the exception of the individual core laminations, core bolts and associated individual clamping plates

shall be maintained at same fixed potential. The bottom main core clamping structure shall be connected to the enclosure by copper cable.

Pre set PTC sensors shall be provided and attached to each of the LV winding as close as possible to the hottest spot to detect and measure the temperature of each phase with a control unit. The temperature sensors provided shall have two numbers of potential free contacts for trip / alarm.

PTC sensors shall be selected in order to protect both, HV and LV windings.

The transformer shall be installed in a rectangular enclosure for additional protection with a protection degree IP23, as specified in the scope of work. Passivity processed saline mist resistant sheet steel of minimum thickness 2.5mm, completely rust free, shall be used for the enclosure. Standard colour for the enclosure shall match with the other plant equipment specified elsewhere in this specification and average thickness of painting shall be 70 micrometre, no point less than 50 micrometre.

The transformer shall be provided with the following accessories:

- Under carriage with rollers for bi-directional movement.
- Lifting eyes.
- Hauling lugs.
- Grounding terminal.
- Rating plate (shall cover all details as per IEC).
- Connection diagram plate.
- HV and LV terminals (suitable for connecting bus duct or cable as per Part-2).

B) Oil Filled Transformers

The transformer shall be 3-phase, oil immersed with core type of construction, tank mounted radiators, and suitable for outdoor service as step-down transformer. Adequate Ceramic ball / spacers shall be provided in the core / winding for circulation of oil so as to ensure proper cooling. All apparatus shall be designed to ensure satisfactory operation under such sudden variations of load, frequency and voltage as may be met-with under system working conditions including those due to short circuits. To minimize the eddy current losses in the windings, CTC shall be used wherever required.

Similarly, for minimizing the stray losses, magnetic shield in yoke, magnetic shunt in tank walls, bushing turrets, clamps, flitch plates etc... shall be provided, wherever required.

Design of all outdoor apparatus, including bushing insulators with their mountings shall ensure that no pockets be formed wherein collection of water can take place. Corresponding parts, which are liable for replacement, shall be interchangeable.

Each transformer shall be capable of operating continuously on any tap at normal rating under service conditions without exceeding following temperature rises, over maximum ambient temperature of 40° C:

- a) 55° C in winding (by resistance)
- b) 50° C in oil (by thermometer)
- c) The temp. of hot spot in the winding not to exceed 90 °C when calculated over max. annual weighted average temp. of 40 °C & 105 °C at worst ambient of 45 °C.

Transformer shall be capable of delivering rated current at an applied voltage up to + 10% of rated voltage without exceeding the temperature limit.

The transformers shall be operable without exceeding temperature rises, winding gradients and hot spot at any particular tapping at the rated MVA for ±10% of the voltage corresponding to that tapping.

Each transformer shall be provided with an off-circuit tap changing switch suitable for varying its effective ratio of transformation whilst the transformer is de-energized and without producing phase displacement. The off-circuit switch handle will be provided with a locking arrangement along with tap position indicator, thus enabling the switch to be locked in position. A warning plate, indicating that switch shall be operated only when the transformer is de-energized, shall be fitted.

Off-circuit tap changer having local manual control and with following features shall be provided:

- i. Designed for sustained over current of not less than 150% of rated current of the winding.
- ii. It shall not occupy any intermediate position between clearly marked tap positions.
- iii. It shall be capable of repeated operation and withstanding S.C. forces.

- iv. It shall have integral handle with pad-locking facility at every tap position.
- v. The tap charger shall have tap position indicator.

Working flux density under rated voltage shall not exceed 1.55 Tesla at normal voltage, frequency and voltage ratio. Over fluxing capability shall be as per relevant standards.

The core shall be built up with thin laminations of high grade, non-ageing, low loss, high permeability, cold rolled super grain oriented silicon steel, known as HIBIMOH or low loss CRGO silicon steel of maximum 0.27 mm or low lamination thickness specially suitable for transformer cores.

The laminations shall be annealed in a non-oxidizing atmosphere to relieve stresses and restore original magnetic properties of material after cutting and punching operation.

The laminations shall be treated after cutting etc... to remove all burrs and checked during stage inspection. These shall be coated with baked enamel insulation coating. The insulation shall be inert to the action of hot transformer oil and be perfectly adhesive. Paper and varnish insulation will not be accepted.

The core shall be rigidly clamped and / or bolted to ensure adequate mechanical strength and to prevent vibrations during operation. The bolts used in the assembly of the core shall be suitably insulated and the clamping structure be so constructed that the eddy currents will be minimum.

The design of magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthing clamping structure and the production of flux components at right angles to the plane of the lamination which may cause local heating.

Number of steps in the limb and yoke shall be matching and dimensionally identical to minimize the effect of cross-fluxing and for better mechanical strength.

The core shall be provided with lugs suitable for lifting complete core and coil assembly of transformer and be fixed in the tank so that its shifting will not occur when the transformer is moved or when a short circuit occurs.

Every care shall be exercised in selection treatment and handling of core steel to ensure that the laminations are flat and that finally assembled core is free from distortions.

Supporting frame of the core shall be so designed as to avoid presence of pockets

which would prevent complete emptying of the tank through the drain valve or cause trapping of air during filling.

Oil ducts, wherever necessary, should be formed across the plane of the lamination and be given a suitable slope to assist oil circulation. The overall design of core and winding should ensure free flow of oil without obstruction.

Frame work and clamping arrangement shall be earthed by connecting to the tank body through a copper strip. Yoke bolt area should be compensated if bolts are used for fastening of the core. Also, flitch plate area will not be counted in core area.

The insulation of core to bolts and core to clamp plates shall be able to withstand a voltage of 2 kV (RMS) for one (1) minute.

Core and winding shall be capable of withstanding shocks during transport, installation, service etc... and adequate provision shall be made to prevent movement of core and winding relative to tank during these conditions.

All steel sections used for supporting the core shall be thoroughly sand blasted after cutting, drilling and welding.

CRGO used shall be procured from reputed vendor.

KSEBL's representative may inspect the built-up core for verification of flux density for which all facilities shall be provided. Core may also be inspected during horizontal assembly, built up assembly.

The conductor used for the winding shall consist of solid drawn high conductivity electrolytic grade copper free from scale and burrs.

In case of copper strip, the corners shall be rounded-off to eliminate risk of injury to internal insulation during winding & other operations. No strip Conductor wound on edge should have width, exceeding six times its thickness.

All permanent current carrying joints in the windings and leads shall be welded or brazed. Preference shall be given to a winding with a continuous conductor. The windings shall be pre-shrunk during manufacture so as to avoid any chances of any further shrinkage taking place during service.

Provision shall be made so that it will be possible to take up this shrinkage by means of adjustable clamping screws and end rings in case of occurrence of shrinkage.

The voltage between adjacent coils shall be kept as low as consistent with the given design.

The windings shall be so designed that all coil assemblies of identical voltage ratings shall be interchangeable and field repairs to the windings can be made readily without special equipment.

The coils shall be supported between adjacent sections by insulation used in the assembly of the windings.

The windings shall be arranged so as to ensure free circulation of oil and to reduce hot spots in the windings.

All threaded connections shall be provided with locking facilities. All leads from the windings to the terminal board and bushings shall be rigidly supported to prevent injury from vibration. Guide tubes shall be used wherever practicable.

The winding shall be designed to reduce the out of balance forces in the transformer to a minimum at all voltage ratios.

The windings shall be clamped securely in place so that they will not be displaced or deformed during short circuits. The assembled core and winding shall be dried and suitably impregnated before removal from the treating tanks.

The insulation of the coils shall be treated suitably to develop full electrical strength of the windings and for this, hot oil vacuum impregnation process shall be used for improving the electrical and thermal properties of insulating paper.

All materials used in the insulation and assembly of the windings shall be insoluble, non-catalytic and chemically inactive in the hot transformer oil and shall not soften or otherwise be adversely affected under the operating conditions.

Windings shall preferably be made in dust proof condition.

Tappings shall be so arranged as to preserve the magnetic balance of transformer at all voltage ratios. Tapping winding shall be provided separately from the main HV winding.

Coil assembly and insulating spacers shall be so arranged as to ensure free circulation of oil and to reduce the hot spot of the winding.

Inter-coil and inter-turn insulation shall be designed to ensure that dielectric stress is uniformly distributed throughout the windings under all operating conditions.

The insulation of transformer windings and connections shall be free from insulating compound which are liable to soften, ooze out, shrink or collapse and be non-catalytic and chemically inert in transformer oil during service.

The windings shall be braced to withstand shocks due to rough handling and forces due to short circuits, switching or other transients.

At each end of HV winding an electrostatic shield and / or cap & ring shall be provided so as to increase the ratio of the electrostatic capacity between turns as compared with the electrostatic capacity of the high voltage winding to earth and to the low voltage winding. HV winding shall preferably be interleaved.

The design of the transformers shall ensure that the current density of the HV windings at the lowest tap does not exceed 250 A/cm^2 , and that of the LV windings 200 A/cm^2 .

The insulating material to be used, shall be of class "A" as specified in the latest relevant standards.

The dielectric strength of winding insulation and of the bushings shall conform to values given in IS: 2026 - 1981 part-III amended up to date except for the changes made in this specification.

The impulse test and power frequency test voltage shall be as per the relevant IS / Standards followed.

Transformers shall have ON type of cooling.

Radiators shall be of pressed steel, tank mounted, bolted type. Bolted, gasketed and flanged connections shall be used for connecting the radiators to the tank.

Radiators shall be designed to withstand the pressure conditions specified for the tank and shall be designed so as to be accessible for cleaning and painting to prevent accumulation of water on the outer surfaces.

Radiator shall be provided with:

- i. Top and bottom shut-off valves and blanking plates.
- ii. Bottom drain plug, top filling plug and air release plug.
- iii. Lifting lugs.

Valves and connections shall have following features:

- i. Sluice type valves with hand wheels.
- ii. Clear indication of open and closed positions.
- iii. Provided with blanking plates and screwed plugs.

The transformer tank and cover shall be oil tight and fabricated from good

commercial grade low carbon steel of adequate thickness. The weld procedure and performance shall be in line with ASME-BPV-9 / IS: 2062. The tank and the cover shall be of welded construction. All seams shall be welded and where practicable they shall be double welded. The tank shall be designed and constructed for vacuum filling of oil and be capable of withstanding without leakage or distortion continuous internal gas pressure of 0.7 atmospheres with oil at operating level. The tank cover shall be bolted with the lower position of the tank and the transformer design shall make it possible to move the complete transformer unit by skidding in any direction without injury when using plates or rails.

Where the design of the tank is such that the bottom plate will be in direct contact with the surface of the foundations, the bottom plate thickness shall not be less than 20mm.

All bolted connections to the tank and connections between sections of the tank shall be provided with suitable flanges, with properly spaced bolts and suitable oil tight gasket which shall give satisfactory service under operating conditions.

The thickness of M.S plate for bottom, sides and top of the tank shall be adequate as per CBIP recommendations.

The main body including tap changing compartments, radiators and coolers shall be capable of withstanding full vacuum of 760mm of mercury when empty of oil.

The design of tank, its shape, proportions, weight of material and construction shall be such as to best facilitate oil circulation and to ensure against transmission or magnification of noise or vibration, which might be injurious or objectionable.

The transformer tank along with radiators and other accessories shall be tested for vacuum and pressure test as per CBIP recommendations.

Suitable guides shall be provided for positioning the various parts during assembly or dismantlement. Adequate space shall be provided between the cores and windings and the bottom of the tank for collection of any sediment.

Lifting eyes or lugs shall be provided on all parts of the transformer requiring independent handling during assembly or dismantlement. In addition, the transformer tank shall be provided with lifting lugs and bosses properly secured to the sides of the tank for lifting the transformer by using hydraulic or screw jacks.

As far as possible, the transformer tank and its accessories shall be designed without pockets so that gasses may not collect. Where pockets cannot be avoided,

pipes shall be provided to vent the gas into the main explosion pipe. The vent pipes shall have a minimum inside diameter of 15mm except for short branch pipes which may have 6mm minimum inside diameter.

The tank cover shall be provided with pockets one for mercury in glass thermometers and two pockets for the bulbs of oil and winding temperature indicators. Minimum depth of the thermometer pockets shall be 10" from top oil level. Protection shall be provided where necessary, for each capillary tube. The thermometer pockets shall be fitted with a captive screwed top to prevent ingress of water. The pockets shall be located in the position of maximum oil temperature at CMR and it shall be possible to remove the instrument bulbs without lowering the oil in the transformer tank.

Each transformer tank shall be fitted with the following valves / plugs with standard screw connections for external piping:

- i. One filter-cum-oil drain valve with plug or blanking flange (size 80mm / 100mm dia) and so placed as to completely drain the oil of the transformer.
- ii. One no. top filter valve of size 50mm near the top of the tank diagonally opposite to filter-cum-drain valve.
- iii. At least two nos. 15 mm / dia air release plugs suitably located on top of cover.
- iv. One pressure relief valve / device to operate at a pressure below the test pressure for the tank.
- v. Suitable no. of jacking bolts shall be provided on tank cover and inspection covers.

The design of the tank, the lifting lugs and bosses shall be such that the complete transformer assembly filled with oil can be lifted with the use of these lugs without any damage or distortion.

All bolts and nuts used in connection with tank and fittings shall be galvanized / Zinc plated & passivated.

The tank shall be provided with suitable lugs for the purpose of grounding with mild steel flat.

An oil conservator tank preferably air cell type complete with sump, filling hole and drain valve shall be mounted above the radiators and located so as not to obstruct taking of bare connections from the transformer terminals.

The capacity of the conservator tank shall be adequate to meet the requirements of expansion of the total cold oil volume in the transformer and cooling equipment from minimum ambient temperature of minus 5 °C. to 115 °C.

The minimum indicated oil level shall be, with the feed pipe from main tank cover, under not less than 15mm depth of oil and the indicated range of oil level shall be from minimum to maximum.

One magnetic type oil level gauge with alarm contacts shall be mounted at a convenient height to be read from ground level. Prismatic oil level gauge shall also be provided.

Oil level at 30 °C. shall be marked on the gauge.

The conservator tank shall have one oil filling hole with cap at the top and drain valve of appropriate size at the bottom. A shut off valve shall be provided at the conservator to cut off supply to the transformer.

The conservator tank will be designed to withstand strong wind pressure. Adequate stiffeners may be added, if necessary.

Each conservator shall be fitted with a double compartment breather with oil seal in which silica gel is the dehydration agent and designed so that:

- a) The passage of air is through the silica gel.
- b) The external atmosphere is not continuously in contact with the silica gel.
- c) The moisture absorption is indicated by change in colour of the tinted crystals and can be observed from distance.
- d) All breathers shall be mounted at approximately 1400 mm above ground level.
- e) The breather should be made of superior quality see-through material and should consist of two compartments placed in parallel.
- f) The conservator shall be of air cell type, if possible, having provision for rubberised air cell so that air does not come in contact with oil in the conservator.

Two earthing pads suitable for connecting 50x 8mm mild steel flat shall be provided at positions close to the two diagonally opposite bottom corner of tank. These grounding terminals shall be suitable for bolted connection. Two earthing terminals shall also be provided on marshalling box and any other equipment mounted

separately.

The transformer shall be supported on a strong structural steel base equipped with forged steel or cast steel, single flanged, bi-directional wheels suitable for moving the transformer completely filled with oil. Jacking pads shall be provided to make it possible to change the direction of wheel through 90 degree when the transformer is lifted on jacks and permit movement of the transformer both in the longitudinal and transverse direction. Track gauge in both longitudinal and transverse direction shall match with the existing track at power house switch-yard site. Means shall be provided for locking the swivel movement in position parallel to and at right angles to longitudinal axis of the tank.

Pulling eyes and skids shall be provided to facilitate moving of the transformer. These shall be suitably braced in the vertical direction to avoid bending when the pull has a vertical component.

Bushing shall be suitable for 25 times rated current for 5 seconds.

The electrical characteristics of bushings shall be in accordance with IS: 3347 and IS: 2029.

All bushings shall be equipped with suitable terminals of approved type and size and all external current carrying surfaces shall be adequately silver plated.

All ends as well as all tapplings on the windings shall be brought to terminals.

Bushings which pass through the cover shall be removable without disturbing the transformer cover.

The bushings shall have high factor of safety against leakage to ground and shall be so located as to provide adequate electrical clearances between bushings of various voltages and between bushings and grounded parts.

Bushings of identical voltage shall be interchangeable. All Clamps and fittings shall be galvanised.

Each bushing shall be so co-ordinated with the transformer insulation that all flash covers will occur outside the tank. All bushings shall have puncture strength greater than dry flash over value. Any stress shield shall be considered as integral part of bushing assembly. Only condenser type bushing shall be accepted.

Neutral bushings shall be provided as required for earthing of neutral point.

All gasket used for making oil tight joints shall be of proven material such as granulated cork bonded with synthetic rubber. The material used should not

deteriorate under the action of hot oil.

All valves up to and including 100 mm shall be of gun metal or of cast steel. Larger valves may be of gun metal or may have cast iron bodies with gun metal fittings. They shall be of full way type with internal screw and shall open when turned counter clockwise when facing the hand wheel. Means shall be provided for padlocking the valves in the open and closed position. Every valve shall be provided with flanges having machined faces. The drilling of valves flanges shall comply with the requirement of IS: 2026 / IS: 3639.

All corrodible parts and surfaces shall be of such material and shall be provided with such protective finish that no part of the installed equipment is injuriously affected by atmospheric conditions.

The whole of the exposed portion except bright parts shall be thoroughly cleaned by sand blasting and painted with two primary coats of approved rust resisting paint in a colour shade matching with the rest of the plant equipment. Inside surface shall be clean, smooth and free from voids and of best construction. The nature of coatings, provided inside, shall be specified and it shall be ensured that it does not react with transformer oil or deteriorates its electrical / chemical properties. Some paint suitable for primary and secondary coats shall also be supplied to cover the damage to paint work which may be experienced during transportation.

Note:

The rating / capacity of the transformers specified in Part-2 (Specific requirement of the project) is a minimum for giving a base line. The essential load consists of mainly cooling water pump motors, excitation and AVR cooling fans, space heaters and OPU, etc... The capacity of a UAT shall be selected based on the consideration that it is able to continuously cater to the requirement of all auxiliaries of the respective unit. During the starting and stopping of the units, these unit auxiliaries shall be supplied power from the station auxiliary A.C. supply system. The Bidder should ensure that the Capacity of the offered transformers are sufficient to take care of the load requirements of the equipment offered for the concerned project. Any increase in Capacity during detailed engineering stage will not entitle the Successful Bidder / Contractor for any extra charges. The Contractor should submit for approval the calculations for the sizing of the Transformers.

Tests

Tests shall be carried out to evaluate the performance of the material and appliance

generally as per the provisions of IS 2026 or its equivalent in the presence of KSEBL's personnel. Contractor shall raise the inspection call at least four weeks in advance along with intimation of the test date and venue. Further prior to issue of the call, the Contractor shall submit to the KSEBL a detailed Inspection Test Plan / procedure for approval.

Following test sequence shall be followed while taking up testing of transformers:

- Ratio, Polarity and Phase displacement.
- Resistance measurement.
- No-Load test.
- Sound Level test (if specified).
- Load Loss and Impedance measurement.
- Zero Sequence impedance test (for three phase transformers).
- Dielectric tests:
 - Switching Impulse test.
 - Lightning Impulse test (line terminals).
 - Lightning Impulse test (Neutral terminal).
 - Separate source AC withstand test (Applied voltage test).
 - Short-duration induced AC withstand voltage test including partial discharge measurement.
 - Long-duration induced AC withstand voltage test including partial discharge measurement.

The completely assembled transformer should be subjected to the following tests as per the above sequence and in accordance with IS 2026 or its equivalent standard.

Type tests:

- Full wave lightning impulse test
- Temperature rise test

Routine tests

- Measurement of winding resistance.
- Measurement of turns ratio & vector group.

- Measurement of impedance voltage & load loss.
- Measurement of no load loss no load current.
- Measurement of insulation resistance.
- Dielectric tests.
- Separate-source power frequency voltage withstand test.
- Induced over-voltage withstand test.
- Measurement of partial discharge (value shall be less than 10 pC).
- Measurement of tan delta.
- Oil leakage test for tanks.
- Vacuum test for tanks.
- Pressure test for tanks.
- Efficiency tests.

Special tests:

- Measurement of zero sequence impedance..
- Measurement of acoustic noise level.
- Measurement of power taken by oil pumps / cooling fans.
- Measurement of harmonics at no-load current.
- Short circuit test.
- Capacitance test to determine the capacitance between windings to earth.
- Sweep Frequency Response Analysis (SFRA) test shall be carried out on 220 kV transformers at factory. The values / data shall be furnished to the KSEBL for future reference.

The transformer manufacturer shall provide all documents for proving the ability of the intended transformer to withstand the effects of dynamic short circuit as per procedure elaborated in IS 2026 (part 5). However, if the said documents are inconclusive or are not sufficient to prove the short circuit capability, KSEBL may opt for physical conduct of short circuit at an accredited lab. The cost of conducting the test shall be reimbursed by KSEBL as per the rate quoted by the bidder in the BOQ.

Tests at Site

The following pre-commissioning tests shall be carried out (including as per Section 1.4.5 -Switch-yard Installation and Tests on Completion of this specification).

1. Checking ratio and polarity. The ratio shall be checked on all taps and between all the windings and the results should tally with the Contractor's tests.
2. Resistance measurement of windings. Kelvin Bridge meter should be used for the measurement of resistance. Tapped winding resistance shall be measured at all tap positions.
3. Insulation resistance measurement. IR value between windings and between windings to earth shall be checked using a 5000 Volts meggar.
4. Measurement of PI value.
5. Magnetising current and iron loss test.
6. Test on tap changer. Operation of the tap changer shall be checked.
7. Sweep Frequency Response Analysis (SFRA) Test shall be carried out on 220kV transformers during pre-commissioning at site. The values / data shall be furnished to the KSEBL for future reference.

1.3.8.6.2.1.2 MV Outdoor Switchgear

The MV outdoor switchgear for the station service transformer shall contain an outdoor cubicle with SF₆/ Vacuum circuit breaker or an outdoor structure mounted circuit breaker (SF₆ / Vacuum) rated for 11 or 6.6 or 3.3kV, 11/6.6/3.3kV AB switch, supporting structures etc... The outdoor cubicle shall contain the 11/6.6/3.3kV SF₆ / Vacuum circuit breaker with current transformers for overload protection. The type and ratings will be as specified in Part-2. This cubicle shall be suitable for XLPE cable termination. If outdoor structure mounted circuit breaker is specified then suitable Cubicle shall be provided for incorporating necessary metering, indication / annunciation and protection equipment. Instrument transformers of suitable rating for metering and protection shall be also provided to meet the above requirement.

1.3.8.6.2.1.3 MV Indoor Switchgear

The switchgear shall consist of switchboard with vacuum circuit breaker, instrument transformers and necessary metering, indication / annunciation and protection equipment. These circuit breakers shall be horizontal draw-out type of latest generation vacuum break, electrically trip free, with anti-pumping device and operated by means of motor charged, stored energy type spring mechanism.

The breaker shall be tripped electrically by means of protective relays. However control of all breakers will normally be accomplished automatically via the under voltage relays and auto transfer scheme i.e. through the auto manual control switch in the control room and remote / local selector switches on each bus section of the MV switchgear or through SCADA.

In addition to automatic transfer, manual control of these breakers will be provided locally at each breaker and remotely from main control room. Operation of any automatic transfer system or fault occurrence on any board will be annunciated in the main control room and in SCADA.

Rubber mats shall be provided in front of the 11 kV Switchboard, with one separate mat for each panel.

The switchgear shall be fully compartmentalised metal clad construction, comprising of floor mounted panel. The switchgear assembly shall be rodent and vermin proof.

The circuit breaker shall be mounted on with drawable trucks, having distinct 'Service', 'Isolated' and 'Withdrawn' positions. Testing of breaker shall be possible in isolated position by keeping control plug connected.

In panel design where breaker compartment does not have a door i.e. breaker truck front serves as a door, suitable blanking cover for each switchboard shall be supplied. Use of inflammable material such as Hylam as an Inter-pole / Inter-panel barrier will not be accepted.

The height of panels shall not exceed 2600 mm. Bushing or other sealing arrangement between breaker and bus bar / cable compartments shall be provided so that there is no air communication around isolating contacts in the safety shutter area with truck in service position. The horizontal bus bars, vertical droppers and connections to the fixed end of the isolating contacts shall be of high conductivity copper. Pressure relief device shall be provided in each high voltage compartment.

The over-voltage generated by switching of breaker / contactor under any duty condition shall not exceed 2.5 pu of nominal line to neutral voltage. Evaluation criteria shall be as per IEEE envelope. Suitable surge suppression device, if required, may be provided.

Bus bar insulators shall be of track-resistant, high strength, non-hygroscopic, non-combustible type and suitable to withstand stresses due to over-voltages and short circuit current. The temperature rise of bus bars shall not exceed 55 °C for silver plated joints and 40 °C for other joints under any condition over an ambient of 50 °C.

The internal earth bus shall be provided to withstand short circuit currents for one second. All enclosures shall be connected to this earth bus. Earthing arrangement for breaker / VT

trucks shall be provided either through integral earth switch or through separate ear thing truck. In case of latter arrangement, one set of different types of ear thing trucks per switchboard shall be supplied. Suitable mechanical interlock shall be provided to prevent inadvertent ear thing of any live part. Ear thing switch shall have short time (1 second) current withstand capability equal to the breaker.

All components shall be correctly rated. Use of two breakers in parallel shall not be acceptable.

Panels should be suitable for top/bottom cable entry.

Each breaker panel shall have breaker control switch of spring return type and a local / remote selector switch of stay-put type. The panel shall also have 'ON', 'OFF', 'Spring charged', 'Trip Circuit Healthy', 'Auto-Trip' and 'Control supply healthy' indicating lamps. The lamps shall be LED (bunched) type and with built-in resistors to prevent inadvertent short circuiting.

The switchboard / panel shall have suitable arrangement to receive and distribute AC and DC supplies. Control DC supply shall be duplicated for each board. Each switchgear panel shall have thermostatically controlled space heater with switch, illumination and power plug point. All panels on front and back as well as inside shall have engraved nameplate giving circuit description and component identification.

1.3.8.6.2.1.4 415V Station Service Board

This board shall be indoor type, metal clad, factory assembled and fully tested. Each board shall have sufficient number of air circuit breakers for incoming supplies. For supply to various loads including feeders to unit auxiliary boards, moulded case circuit breakers and motor starter equipment shall be provided. All necessary control, metering and indication shall be provided.

The interconnection between the unit auxiliary transformer, station service transformer and the station service board shall be made by means of LT power cables of sufficient rating. Similarly, connection between station service board and unit auxiliary boards shall be made by LT power cables of required rating.

Provision shall be made in the station service board for feeding to the unit auxiliary board of the future units (if any) also. The station service board assembly shall be made up of sheet steel vertical cells of standard dimensions bolted together and mounted on a common channel base to form a free-standing, self-supporting structure and completely metal enclosed. It shall be vermin and dust proof.

The vertical cell containing the incoming circuit breakers shall be divided in three separate sections from front to back. The front section includes the circuit breakers, the control and

the potential transformer compartments; control cables shall terminate in this section. The middle section forms the bus-bar compartment and the back section is for power cable terminations. The breaker compartments shall be equipped with shutters that close automatically when a breaker is disconnected.

The switchgear assembly shall have common main and ground buses and shall be equipped to accept additional future cells of motor control centre. Each frontal compartment shall be equipped with an individual hinged door. All control and power cables shall enter through the top or bottom of the incoming cell and of the feeder/motor control cells. Power cable supports shall be provided to prevent any excessive stress on power cable connection lugs. All cell openings both at top and bottom shall be equipped with removable plates for incoming cables. All cut outs shall have synthetic rubber gaskets. All non-current carrying metal works of boards / panels shall be effectively bonded to earth bus of galvanised steel extending throughout the switchboard / MCC / DB. Positive earthing shall be maintained for all positions of chassis and breaker frame.

The bus bars shall be of high-strength, high conductivity copper and braced to withstand the maximum short circuit current of the system. Bus joints and taps shall be silver-plated and shall utilize anti-corrosion hardware. Buses and joints shall be designed so that the maximum temperature rise of any part does not exceed 65°C over an ambient temperature of 40°C. Bus-bar barriers shall be provided between switchgear equipment to prevent the spreading of ionised gases in the event of a fault. Main and auxiliary bus-bars shall be covered with insulating sleeves to safely prevent internal bus bar faults and spreading of arcs. The covering material shall be non-deteriorating at the rated short - time maximum temperature of the bus-bars and shall have such thickness as is required to withstand rated line to line voltage between bus-bar and a conducting object on the exterior of the covering material for a period of not less than 60 seconds.

All bus-bar connections and joints shall be silver-plated. Access to bus bars and the connections directly connected thereto shall be gained only by the removal of covers secured by bolts or screws. Such covers shall be clearly and indelibly marked "BUS-BARS".

Bus bars shall be extensible at both ends; such extension shall entail the minimum disturbance to bus bar compartments.

A continuous ground bus (50 mm x 10 mm [min]) of high strength, high conductivity copper shall be provided the length of the assembly and solidly bolted to the steel framework. It shall be capable of carrying the rated short circuit current of any breaker in the assembly for a period of three seconds. A compression type connector for up to 70mm² for grounding

copper conductor shall be provided at each end of the ground bus.

Insulating mats as per IS shall be provided in front of the Switchboard.

Adequate number of spare outlets shall also be provided.

415 V Incomer Circuit Breakers:

These circuit breakers shall conform to the following technical parameters:

- Type - Air insulated, draw-out type, motor operated (closing)
- Type of operating mechanism - Spring charged stored energy type
- No. of poles - 4
- Rated voltage - 415 V
- Rated current - As per Part-2 of this specification

The circuit breakers shall have three positions: 'Connected', 'Test', 'Disconnected' and 'Draw-out'. The breakers shall have protection for over-current and earth faults by relays connected with CT's in addition to thermal overload protection. The circuit breakers shall have the following devices and mechanisms:

- a set of main draw-out contacts;
- a set of secondary draw-out contacts;
- a safety device preventing drawing-out of circuit breakers in connected position, when closed;
- a safety device preventing connection of circuit breakers when closed;
- a safety device preventing closing of circuit breakers before the main draw-out contacts are completely connected or separated by a safe distance;
- a safety device ensuring discharging of springs when the circuit breaker is drawn out from its compartment;
- an anti-pumping device and a 110 V DC motor for automatic charging of the closing springs and an emergency handle for manual charging of the closing springs. The charging of the closing springs shall ensure a complete O-C-O cycle;
- a device to indicate that the springs are charged;
- a position indicator (closed / open);
- Pilot lights (with Bunched LED type) for Close, Open, Fault Trip, Spring charged

indication etc...

- push buttons for local and manual control (closing and tripping);
- a set of four auxiliary contacts wired to a terminal block as spare.
- Provision for Remote Operations (Close / Open) from SCADA / Control room shall be provided
- Provision for providing Close / Open, Trip Indication to SCADA / Control room.

Control, Protection and Metering

The incoming circuit breakers of the switchgear shall be suitable for remote electrical control at 110V DC from the control room. A local / remote selector switch to transfer control without interrupting the protection circuits and two sets of auxiliary contacts for remote position indication shall be provided.

The incoming circuit breakers of the switchgear shall be controlled by a switching system operating as described below. With the automatic switching system, it shall be possible to keep the preferential feeder breaker closed while the other breakers are open. A three-position selector switch, mounted on the compartment door, shall permit the choice of modes of operation 'Auto', 'Manual' or 'Off'.

Suitable mechanical and electrical interlocks shall be provided in auto-changeover circuits.

All incomer and bus coupler ACBs shall be of 4 poles. There shall be outgoing ACBs to each Unit Auxiliary Boards and common Auxiliary board. The common Auxiliary LT board shall be fed from both bus bars. All incomer, outgoing and tie feeders shall be equipped with ACBs at both ends. The incomers and bus coupler ACBs shall be properly interlocked. One outgoing ACB shall be provided as spare on both bus sections.

The Auto-Changeover operation due to mains failure shall be annunciated as a persistent alarm in the Control room / SCADA. The same shall be reset only on attaining the normal operating status of the system.

When the selector switch is in the 'Manual' position, either Incomer circuit breaker may be operated or the transfer made manually. When the selector switch is in 'Off' position, electrical control shall not be possible. Control power transformer with pull-out type primary and secondary fuses shall be mounted inside the switch-gear's instrument compartment.

Control and timing relays shall be of the plug-in type. Timing relays shall preferably be solid state. Relay coils shall be at 230 V AC, relay contacts shall be rated at 10 A minimum, 230 V AC. Other control devices such as push buttons, switches etc... shall be oil-tight, heavy

duty and equipped with identification nameplates.

Indicating instruments shall be digital red LED meters, flush mounted, with totally sealed case front. The size of display shall be minimum height of mm. The indicating instruments shall conform to IEC 51 and shall have a measuring precision of $\pm 0.2\%$ of full-scale value at rated voltage. These instruments shall be powered by 110 V DC supply. One energy meter should be provided in each breaker cubicle for incoming feeders.

Ammeters shall be of digital meters with 4 digits for each phase. Energy meters shall be static and shall conform to IS 722 and have an accuracy class of at least 0.2S or better. Voltmeter shall be of digital type with 4 digits.

1.3.8.6.2.1.5 415V Unit Auxiliary Boards

These boards incorporate the auxiliary supply feeders to individual units and are fed from the station service board. The panel shall be equipped with tinned copper bus bars and a ground bus. For supply to various loads, MCCBs and motor starter equipment shall be provided. The number of circuits, branch circuit breakers and the circuit breaker ratings shall be designed according to the requirement of various unit auxiliary loads. 20% fully equipped spare outlets shall also be provided.

415V Moulded Case Circuit Breakers and Motor Starters

All outgoing feeders emanating from the unit auxiliary boards, station service boards and distribution panels shall be controlled by means of three-pole and two pole MCCB's. These circuit breakers shall have magnetic tripping on short circuit and delayed thermal tripping on overloads.

All the live parts shall be enclosed in a moulded, insulated housing of simple, compact and robust mechanism suitable for quick break and make operation. Each MCCB shall be equipped with trip-free mechanism, On / Off / Trip indication and auxiliary contact block. Mechanical tripping shall be through red 'Trip' push buttons outside the panel for breakers, and through switches for other circuits.

The motor starters shall be three-pole and of combination circuit breaker magnetic air break type. Each starter shall be mounted in a separate compartment with a hinged door. Each door shall have a handle to operate the circuit breaker with a mechanical interlock to ensure that the circuit breaker is open before access into the compartment is allowed. It shall be possible to padlock the handle in the 'Open' position. All cut outs shall have synthetic rubber gaskets. All non-current carrying metal works of boards / panels shall be effectively bonded to earth bus of Copper / Aluminium extending throughout the

switchboard / MCC / DB.

The starter modules shall be of the plug-in type so that the assembly can be removed without de-energizing the MCC. Alternately the Draw Out MCCB Modules can be provided instead of plug in type. Large capacity Starter shall be connected directly to the bus without use of cables. All plug-in starters shall have tin-plated copper contact material. The circuit breakers shall have a minimum symmetrical interrupting capacity of 22kA RMS.

Motor starter contactors shall be of air break, electromagnetic type as per IS: 13947 Part-4, section-1 suitable for DOL starting of motors, and shall be of utilisation AC-3 for ordinary and AC-4 for reversing starters. DC contactors shall be of DC-3 utilisation category.

Isolating switches and MCCBs shall have door interlocks and padlocking facility.

Fuses, if provided, shall be HRC type with operating indicator. Isolating switches shall be of AC 23A category when used in motor circuit, and AC 22A category for other applications.

The temperature rise of the horizontal and vertical busbars and main bus link including all power draw-out contacts when carrying 90% of the rated current along the full run shall in no case exceed 55 °C with silver plated joints and 40 °C with all other types of joints over an ambient of 50 °C.

All switchgear, MCCBs, DBs, panels, modules, local starters and push buttons shall have prominent engraved identification plates.

Each starter shall include the following features and components as a minimum:

- Circuit breakers shall be moulded case, three-pole, rated at 415 V with magnetic trip only. The magnetic trip shall be adjustable;
- A non-reversing, single speed, full voltage, three-pole contactor with 230 V AC coil. The contactor shall operate at 80% of rated voltage;
- One three-phase overload relay with contracts for annunciation and a reset push button mounted on the door;
- One single phase control transformer, 415-230V, 240VA with a secondary fuse according to the starter size;
- Pilot lights (with Bunched LED type) shall be provided on the door for status indication;
- Set of auxiliary contacts with 20% as Spare.
- Provision for Remote Operations (Close / Open) from SCADA / Control room shall

be provided

- Provision for providing Close / Open Indication to SCADA / Control room.

Protection

All types of relays and timers shall be subject to KSEBL's approval. They shall be flush mounted with connections from inside, and shall have transparent & dust tight cover, removable from front, draw-out type construction for easy replacement and testing facility. The auxiliary relays and timers may be provided in fixed cases. All relays and timers shall operate on available DC supply and not have any inbuilt batteries. They shall be provided with hand-reset operation indicators (flags) or LEDs with push buttons for resetting.

All equipment shall have necessary protections. However, following minimum protections shall be provided.

Motor feeders (motors rated up to 160 kW):

- Instantaneous short circuit protection on all phases
- Thermal overload protection
- Single phasing protection for motors protected by fuses.

All meters / instruments shall be flush mounted on front panel, at least 96 sq.mm size with 90 degree line scales and accuracy class of minimum 2.0. All motors of 10 kW and above shall have an Ammeter. Bus-sections have bus VT, voltmeter with selector switch, and other relays and timers required for protection. Adequate control and selector switches, push buttons and indicating lamps shall be provided. Thermostatic controlled space heaters with switches shall be provided to prevent condensation.

Current Transformers of required ratios shall be provided in the panels as per details in the protection scheme submitted for approval. CT cores rating and type shall be subject to approval by the KSEBL.

1.3.8.6.2.2 Bus-Bars and Insulators

All busbar and jumper connections shall be of high conductivity aluminium alloy / copper. They shall be adequately supported on insulators to withstand electrical and mechanical stresses due to specified short circuit currents. Busbar cross-section shall be uniform throughout the length of switchgear. Busbars and other high voltage connection shall be sufficiently corona free at maximum working voltage. Contact surfaces at all joints shall be silver plated or properly cleaned and non-oxide grease applied to ensure an efficient and trouble free connection. All bolted joints shall have necessary plain and spring washers. All

connection hardware shall have high corrosion resistance. Bimetallic connectors or any other technically proven method shall be used for aluminum to copper connections.

Busbar insulators shall be of arc and track resistant, high strength, non-hygroscopic, non-combustible type and shall be suitable to withstand stresses due to over-voltages, and short circuit current. Busbar shall be supported on the insulators such that the conductor expansion and contraction are allowed without straining the insulators.

1.3.8.6.2.3 Instrument Transformers

All current and voltage transformers shall be completely encapsulated cast resin insulated type, suitable for continuous operation at the ambient temperature prevailing inside the switchgear enclosure, when the switchboard is operating at its rated load and the outside ambient temperature is 50 deg. C. The class of insulation shall be E or better.

All instrument transformers shall have clear indelible polarity markings. All secondary terminals shall be wired to separate terminals on an accessible terminal block.

Current transformers may be multi or single core and shall be located in the cable termination compartment. All voltage transformers shall be single phase type. The bus VTs shall be housed in a separate panel on a truck so as to be fully withdrawable.

1.3.8.6.2.4 Power Cable Termination

Cable termination compartment shall have provision for termination of power cables of sizes as indicated during detailed engineering with removable undrilled gland plates. For all single core cables gland plates shall be of nonmagnetic material. Cable entry shall be from bottom.

A minimum clearance of about 600 mm shall be kept between the cable lug bottom ends and gland plates for stress cone formation for XLPE cables. Inter-phase clearance in the cable termination compartment shall be adequate to meet electrical and mechanical requirement besides facilitating easy connections and disconnection of cables. Dimensional drawing of cable connection compartment showing the location of lug, glands, CTs, gland plates etc... and the electrical clearances available shall be submitted for KSEBL's approval during detail engineering.

1.3.8.6.2.5 110V DC Supply System

The 110V DC system shall, in general, comprise of the following:

- 110V Flooded type Lead Acid battery (Plante type) of adequate capacity, complete

with inter-cell connectors, terminal lugs, Battery Stand and all necessary auxiliary equipment and electrolyte for first filling.

- The Contractor shall size the Battery during engineering phase. The battery capacity shall be decided with 10% design margin and ageing factor as applicable. Generally, DC system shall comprise of two DC battery sets (both battery sets of full capacity) each with one float-cum-boost charger with initial charging. The battery shall have sufficient capacity to provide 8 hours requirement of uninterrupted emergency illumination independently.
- Battery charger, 415V, 3-phase, 50 Hz input, 110V DC output voltage, having sufficient capacity to supply the total constant DC load and FC and FCBC operating modes for the above battery complete with all auxiliary equipment including alarms for AC Input fail, Charger fail, Under / Over Voltage, Earth Fault, DC Output Fail, Overload, Battery Under voltage etc..., Status Indications, Metering and associated controls. (One set of FCBC charger with facility for float charging, boost charging and automatic float or boost selection shall be provided for one set of existing battery). Sufficient numbers of Potential free contacts shall be provided for remote alarming of AC input fail and DC Output Fail conditions to Control room, SCADA / PLC and Control Centers.
- The Battery Charger shall have the following facilities:
 - The float cum boost battery charger as well as its automatic regulator shall be of static type.
 - Manual selection facilities for battery charging mode i.e. whether trickle or boost. It shall have a facility of both auto as well as manual control in both the float and boost modes.
 - Automatic and manual control of output voltage and current. Selector switch shall be provided for auto / manual selection. Auto to manual changeover shall not result in any harmful surges.
 - Effective current limiting feature and filters on both input and output to minimize harmonics, RFT, EMT etc...
 - When on automatic control mode during trickle charging, the charger voltage shall remain within 1% of set value for maximum permissible voltage, frequency and combined voltage and frequency variation on feeding system and DC load variation from zero to full load.

- Degree of protection shall be IP: 42. For chargers located in air conditioned areas, same may be IP: 31.
- The rectifier shall utilise diode / thyristors and heat sinks rated to carry 200% of the load current continuously. Temperature of heat sink shall not be permitted to exceed 85⁰C duly considering the maximum charger panel inside temperature.
- Rectifier fuse and RC surge suppressor.
- Ripple content to be limited to 1% peak to peak.
- All inter cell connectors and terminals shall be fully insulated / shrouded.
- Batteries and chargers shall be connected to separate DC distribution boards (DCDBs) through single core cables for each pole. The main HRC fuses on battery and charger output shall have alarm contacts. The battery fuse shall be located close to battery in the battery room.
- The DC systems shall be unearthed, and relays shall be provided for a sensitive earth fault detection and annunciation. The low / high voltage alarms, instruments for indication of charger current and voltage, DC voltage, battery current, etc... shall also be provided.
- Batteries having complete cell weight of 50 kg or more shall be arranged in single tier.
- The main DC DB should be equipped with Two numbers incomer and coupler arrangement. Main DC distribution panel having a main bus with isolation facility and sufficient number of manually operated outgoing feeder breakers, complete with instrumentation, protective relaying and all necessary auxiliary equipment for switch-yard battery. 20% fully equipped spare outlets shall be provided in the Main DC distribution panel. The main DC panel shall also have provision for feeding to the DC distribution board of the future units and for catering to the load of future feeder bays, if the same is indicated in Part-2, Specific requirement of the Project. DC distribution boards shall be designed to supply the various station loads like normal continuous load, emergency lighting load, excitation current for field flashing of generators and indicating lamp loads.
- Emergency distribution boards each equipped with one main incoming and adequate number of feeder distribution moulded case circuit breakers with all necessary auxiliary equipment. 20% fully equipped spare outlets shall be provided in the Emergency distribution board.

- Set of tools, handling devices, testing instruments for erection, testing and maintenance of the complete system. One complete set of all accessories and devices required for maintenance and testing of batteries shall be provided for each battery bank. Each set should include at least the following:
 - a) Hydrometer - 2 no.
 - b) Set of hydrometer syringes suitable for the vent holes in different cells - 2 no.
 - c) Digital Thermometer for measuring electrolyte temperature - 5 no.
 - d) Specific gravity corrections chart – 2 nos.
 - e) Wall mounting type holder made of teak wood for hydrometer thermometer – 2 no.
 - f) Cell testing voltmeter (3-0-3V) - 2 no.
 - g) Electrolyte handling jars - 2 no.
 - h) Rubber apron - 2 no.
 - i) Pair of rubber gloves - 2 no.
 - j) Set of spanners - 2 no.
 - k) No smoking notice - 2 no.
 - l) Goggles (industrial) - 2 no.
 - m) Min and max temperature indicator for each battery room - 1 no
 - n) SCR and associated control cards for the charger - 20% minimum
- One (1) set of spare parts sufficient for 5 years of operation.
- Any other item not specified above but recommended by the manufacturer as essential for the satisfactory and trouble free operation of the equipment as per Clause 1.1.32 of this specification.

Note:-

1. The capacity for the Battery shall be sufficient for all equipment in this tender. Provisions shall also be made for future extension. The rating / capacity of the Batteries specified in Part-2 (**Specific requirement of the project**) are a minimum for giving a base line. The Bidder should ensure that the Capacity of the offered Battery and Charger is sufficient to take care of the load requirements of the equipment offered for the concerned project. **Any increase in Capacity during detailed engineering stage will not entitle the Successful Bidder / Contractor**

for any extra charges. Detailed calculations for the determination of the capacity of the Battery shall be submitted by the contractor for approval by KSEBL.

2. MCB's shall be used for protection in the chargers. An alarm will be provided for MCB tripped condition. In case protection fuses are used internally inside the chargers, these fuses have to be provided with auxiliary alarm contacts for local and Remote Alarm.
3. Only DC MCBs shall be used for DC circuits.
4. The Battery, Chargers and DC distribution boards shall be located at a floor higher than that of machine hall.

1.3.8.6.2.6 Uninterrupted Power Supply

The Uninterrupted power supply system (if indicated in Part-2 "Specific Requirements for the Project") shall, in general, comprise of the following:

- Uninterrupted power supply panel with associated equipment for 240V AC single phase, 50 Hz. The system shall be complete with Alarm annunciators, Indications, Metering etc... with minimum 6 hours backup with requisite redundancy shall be provided for computerised control system equipment located in control room and DC power supply system with minimum of 1 hour battery backup for controllers, input / output cards, control network etc... shall be provided. Minimum Rating shall be as per Part-2 or shall be sufficient for all equipment to be served by the UPS as stated in this tender.
- Set of tools, handling devices, testing instruments, software, if any, complete with interfacing cables, communication interfaces, protocol converters, connectors etc... for erection, testing and maintenance of the complete system.
- SCR and associated control cards for the charger - 20% minimum as spare
- One (1) set of spare parts sufficient for 5 years of operation
- Any other item not specified above but necessary for satisfactory operation of the system.

1.3.8.7 Diesel Generator (DG) Sets

If specifically mentioned in Part-2, an Automatic mains failure (AMF) diesel generators (DG) shall be installed for feeding emergency loads in the event of failure of Station supply. The provision of the diesel generators shall be made to meet the requirement of emergency power supply for essential station services and black starting of the units considering the

starting up of one generating unit at a time during black start condition. In the event of normal station service power disruption and for standby supply during grid black-out condition, it shall be ensured that the essential auxiliaries of all the units are fed from diesel generator and non-essential loads are automatically tripped.

One DG set shall be provided for each unit of 200 MW and above. In addition, there shall be one common standby DG set of same rating to serve a block of two units. For unit sizes less than 200 MW, one DG set may be provided for every two units. However, a Station with a single unit of 200 MW or higher rating shall be provided with two DG sets.

1.3.8.8 Testing

The Contractor shall conduct shop tests on dates agreed with the KSEBL and make arrangements for the KSEBL's representative to witness the tests.

All testing envisaged in IS / IEC Standards shall be carried out. The Contractor shall make all arrangements, equipment, material and consumables to the tests and prove compliance of the equipment with the standards at shop and at site.

During commissioning process, Battery charging & discharging is a continuous process and is required to be done without interruption. Skilled manpower shall be deployed by the Contractor round the clock till completion of activity.

Before requesting despatch clearance for any item, the approval of the test reports shall be got from the KSEBL.

1.3.8.9 Spares

The following spares for 5 years operation and maintenance of the Equipment shall be supplied:

Contactors	-	1 set of each type
Control switches	-	1 set of each type
Fuses	-	1 set of each type
Relays	-	1 set of each type

Any other spares recommended by the manufacturer as essential for the satisfactory and trouble free operation of the equipment as per Clause 1.1.32 of this specification. The same shall be listed out in detail in the offer.

1.3.9 Power and Control Cables

1.3.9.1 Introduction

This section covers the KSEBL's basic requirements for the design, manufacture, testing at manufacturer works, standard and quality of workmanship, general finish of plant, compliance to the latest published edition (prior to the date of closing of tender) of the international standards and recommendations specified throughout the specifications, supply, insurance, delivery and storing at site, erection, site testing, commissioning, performance and reliability confirmation, warranty confirmation of the power and control cables complete with cable terminals and all accessories for making the systems complete in the Powerhouse and Switch-yard.

1.3.9.2 Reference Standards and Codes

The equipment shall be designed, manufactured, tested, installed and commissioned in accordance with the latest revision of applicable IS / IEC or equivalent standards.

The Contractor shall adhere to sound design and construction practices with regard to codes and material specifications in order to warrant operational safety and ease of maintenance of plants as well as simplicity of control and stability in plant operation.

- IS 7098 (Part-1) Cross linked polyethylene insulated PVC sheathed cables for working voltage up to and including 1.1kV.
- IS 7098 (Part-2) Cross linked polyethylene insulated PVC sheathed cables for working voltage from 3.3kV up to and including 33kV.
- IS 10418 Drums for cables.
- IS 8130 Conductors for insulated electric cables and flexible cords.
- IS 10877 Moulds for cast resin based straight through joints for cable for working voltage 3.3kV and above up to and including 11kV.
- IS 8308 Compression type tubular inline connectors for aluminium conductors.
- IS 8309 Compression type tubular terminals for aluminium conductors.
- IS 8438 Moulds of cast resin based straight joints of cable up to including 1.1kV.

- IS 11967 Specifications for co-axial cables.
- IS : 2062 Specification of Structural Steel for fabrication.
- IS : 513 Cold rolled low carbon steel sheets & strips.
- IS : 277 Galvanized sheet steel.
- IS : 808 Rolled Steel Beam, Channels and Angle section.
- IS : 2629 Recommended practice for hot dip galvanizing of iron and steel.
- IS : 2633 Method of testing uniformity of coating on zinc coated articles.
- IS : 800 Specification for use of structural steel in general building construction.
- IS 732 Code of practice for Electrical wiring installation.
- IS 694 PVC insulated cable for working voltages up to and including 1100 volts.
- IS 9537 Specification for conduits for Electrical Installations.
- IS 1554 PVC insulated cables upto and including 1100 volts.

Cables and other accessories complying with other internationally accepted standards such as IEC, IEEE, BS etc... will also be accepted if they ensure performance and constructional features equivalent or superior to standards listed above.

1.3.9.3 Reference Sections

Section 1.1	General Technical Requirements.
Section 1.3.5	Control and Monitoring System.
Section 1.3.6	Protection.
Section 1.4.3	Switch-yard Equipment.

1.3.9.4 Submittal and Approvals

The Contractor shall seek the prior approval of the KSEBL for the following through timely submittal.

- The Calculation for fault level and short circuit calculation for selecting the cable

size, Cable schedule.

- The Contractor shall purchase equipment from reputed vendors only and the name of vendors shall be submitted for KSEBL's approval.
- Material certificates and test reports.
- Erection, Testing and Commissioning methodology.

Before delivery of equipment to site, the contractor shall submit all work test certificates / reports for approval and obtain despatch clearance from the KSEBL's representative.

1.3.9.5 Deliverable Documents

- Layout drawings of the power house showing the detailed arrangement of cable trenches, cable racks etc...
- Design calculations for selection of cables.
- Erection, Testing and Commissioning methodology.
- Test Report / Data.

1.3.9.6 KSEBL's other Requirements

The tentative layouts of the powerhouse and switch-yard are given in drawings appended to the specifications.

The power, control, instrumentation and communication cables are required for interconnection between various equipment panels, control, protection, monitoring, interlocking, tripping, alarm, indication, annunciation, data communication of various system conditions of the power house equipment.

All cables shall be Fire Retardant Low Smoke (FRLS) type.

The cables shall be sized based on the following considerations:

- Rated current of the equipment
- The voltage drop in the cable, during motor starting condition, shall be limited to 10% and during full load running condition, shall be limited to 3% of the rated voltage.
- Short circuit withstand capability.

De-rating factor for various conditions of installations including the following shall be

considered while selecting the cable size.

- Variation in ambient temperature for cables laid in air.
- Grouping of cable.
- Variation in ground temperature and soil resistivity for buried cables.

All cables shall be designed to cope with the short circuit conditions and voltage drop. Maximum short circuit current for 11 kV & 415 V systems may be taken as 40 kA and 25 kA respectively. Size of aluminium power cable shall in no case be less than 16 mm² and copper power cable shall not be less than 6 mm². Where there is requirement of cables less than 16 mm², copper cable of appropriate size but not less than 6 mm² may be used. Minimum size of the control cable for CT & PT circuit shall be 4 mm². Screened control cable for C&I purpose shall be minimum of 0.5 mm² subject to verification by sizing calculation.

The cables shall be capable of satisfactory operation under a power supply system voltage variation of $\pm 10\%$ and frequency variation of $\pm 5\%$. The cables shall have heat and moisture resistant properties. These shall be of type and design with proven record of power station installations.

Sufficient cores in control cables shall be kept as spare cores in cable scheduling for future use. Before charging of cables all wiring / cable shall be checked as per cable schedule Programme.

Cable lengths shall be considered in such a way that straight through cable joint is avoided.

Contractor shall be responsible for complete design of the cable network comprising of following:

- a) Preparation of co-ordinated drawings for termination of cables for all equipment in power house including turbine, generator, transformer, HV & LV switchgear, D.C. cables etc...
- b) Cable routing drawings and the estimation of cable quantities of different sizes.
- c) Preparation of cable schedules.
- d) All cable termination kits including cable termination kits for high voltage cable and cable glands for low voltage power cables and control cables.
- e) Cable conduits / pipes, cable glands etc...

- f) Cable identification tags for cables and wires, lugs etc...

Any other item necessary for completeness of the cable, cable laying termination system shall be supplied.

1.3.9.7 Scope of Work

The intent of scope is to provide all cabling, cable routing & termination in power house and all adjoining functional areas.

The scope of work shall be a comprehensive functional system complete in every respect including but not limited to following.

Power control cable shall comprise of:

- 1 lot – 11kV XLPE power cable (High voltage cable).
- 1 lot – 600 / 1000 volt grade power cable (Low voltage cable).
- 1 lot - Control, instrumentation and communication cables.
- 1 lot - Cable trays, supporting steel structures, cable terminals, termination kit, cable lugs, cable glands, PVC conduits, button tape (strap & stud), and cable junction boxes, hydraulic operated crimping tools and control cable crimping tools and all other accessories.
- All special devices, tools, maintenance equipment etc... required for installation, testing, commissioning and maintenance of power and control cable.
- Set of spares.

The contractor shall assess the quantity of various sizes of the power, control, instrumentation and communication cables & its accessories along with cable racks & trays including the mandatory spares required for the project. The number of cores and sizes of the cables required for various circuits shall be worked out during detailed engineering.

Any item of work not specifically mentioned in the specifications but which are usual and / or necessary for the satisfactory operation of the equipment supplied shall be deemed to be provided by the Contractor and included in the quoted Price. All work shall be complete in all details whether such details are mentioned in the specifications or not.

1.3.9.8 Power Cables

1.3.9.8.1 General

The continuous withstand temperature shall be 90°C and 70°C for XLPE and PVC cables respectively. The short circuit withstand temperature shall be 250°C and 160°C for XLPE and PVC cables respectively.

To facilitate easy identification of phases, colour scheme of red, yellow, blue for phases and black for neutral shall be adopted for power cables.

Straight through joints in the run of cables, wherever unavoidable will be made through joint boxes.. The design of the jointing boxes must ensure that the actual insulation strength between phases and to earth is greater than that of the associated cable and eliminate any possibility of moisture entering the joint or the compound surrounding the joint.

Provision shall exist for binding the sheaths of the two cables being joined solidly by approved means to ensure the electrical continuity of the sheath from one end of the cable run to other.

Full details of the Jointing Boxes and of the Joints including dimensions shall be given.

The Jointing Boxes shall comply in all aspects with the provision of the latest issue of relevant standards.

Heat shrinkable cable terminations wherever required shall be supplied. The termination kits shall be of reputed make only.

The Contractor shall supply all hardware, filling compounds, plumbing metal, tapes and other materials required for the making of these joints and terminal connections of the various size of cables given in the schedule of supply.

For termination of PVC cables inside the panels, cable lugs for the type and sizes of cables shall be offered. The cable lugs shall be made of copper tube electro tinned. Longneck crimping lugs shall be supplied for cables of size 300 mm² and above. The contractor shall ensure that no bimetallic action takes place between the Aluminium conductor of the cable and the cable connecting lugs by filling the lugs with suitable compound.

The cable glands made of brass duly electro tinned in order to avoid corrosion and oxidation of the surface, shall be offered. The nipple threads shall be in accordance with IS:12943. Glands shall provide neat, tight, dust and vermin proof termination. Glands shall be provided with rubber ring to hold the cables firmly when check nut is slightly tightened.

Glands shall be complete with suitable washers. Glands shall be of reputed make.

LV Power Cables of sizes over 16mm² & above shall have Aluminium Conductor & below 16 mm² shall have Copper conductors. For CT & PT connections, Copper conductor of size 4 mm² only shall be used.

1.3.9.8.2 XPLE Power Cables

XLPE cables for 11 kV system shall be single core un-armoured for indoor use and armoured for outdoor use, heavy duty, stranded, Aluminium conductor of suitable size and shall be provided with semi-conducting conductor shield, XLPE insulation, semi-conducting insulation shield, copper tapped metallic shield and PVC outer sheath conforming IS 7098 (Part II).

The semi-conducting conductor shield shall ensure perfectly smooth profile and avoid stress concentration. The conductor shield shall be extruded in the same operation as the insulation

The insulation shall be extruded type and manufacturing process shall ensure that insulation is free from voids. The insulation shall withstand mechanical and thermal stresses under steady state and transient operating conditions. The extrusion method shall give very smooth interface between semi-conducting conductor shield and insulation.

A non-magnetic semi-conducting insulation shield shall be applied over insulation to confine electrical field to the insulation. The insulation shield shall be extruded in the same operation as the conductor shield and the insulation by triple extrusion process.

A copper tape / wire metallic shield shall be put over non-metallic insulation shield.

An extruded PVC outer sheath shall be applied over metallic shield with suitable additives to prevent attack by rodents and termites.

The cables shall be subjected to type, routine and acceptance tests as per applicable standard.

1.3.9.8.3 PVC Power Cables

All single core and multi core PVC cables for low voltage AC and DC system shall conform to IS:1554 (Part I). These cables shall be heavy duty, aluminium conductor, heat resistant PVC insulated, colour coded, laid up, un-armoured for indoor use and armoured for outdoor use, inner and outer extruded PVC sheath. The cable glands for all the unarmoured cables within the powerhouse can be of single compression type. The outer sheath shall be of

pecially formulated PVC compound having oxygen index, smoke density, acid gas and flame propagation properties as applicable for standards for FRLS cables. All the materials used for conductor and insulation shall be new and of requisite quality. Necessary tests during the manufacture shall be conducted in conformity with standards.

1.3.9.9 Control Cables

The control cables shall be multi-core, colour coded, annealed, stranded high conductivity copper, single conductor, insulated with HR-PVC insulation, PVC sheathed, un-armoured FRLS type conforming to IS 1554 (part I & II) / relevant IEC. Control cables going outside of power house shall also be armoured, FRLS type. The outer sheath is of specially formulated PVC compound. The conductor shall be made from stranded annealed copper to form compact conductor having a resistance within the limits specified in relevant IS / IEC.

All the cables shall carry manufacturer's data in a permanent, legible manner at an interval of at least 3 metre run. The manufacturer's data shall include the name; cable size, voltage rating together with any other information.

To facilitate easy identification of cores, multi-core control and instrumentation cables shall be colour coded by using PVC insulation of red, black, yellow, blue and grey colours in accordance with IS:1554 (Part I).

Compression type terminals would be offered for control cables. These terminals shall be suitable for crimping to the conductor. The cable lugs shall be made of copper type electro-tinned.

The cable glands shall be double compression type and shall be made of brass duly electro-tinned in order to avoid corrosion and oxidation of the surface. The nipple threads shall be in accordance with IS:12943 / IEC. Glands shall provide neat, tight, dust and vermin proof termination. Gland shall be provided with rubber ring to hold the cables firmly when check nut is slightly tightened. Glands shall be complete with suitable washers etc...

Button Tape (Strap & Stud) consists of perforated cable strapping with holes conveniently spaced for assembly and moulded studs. The strapping shall be made of NYLON Grade 220 or other elastic material to give proper performance. The studs shall be made of 'NYLON'.

Self-adhesive marker in the form of strips of any one character, which can be easily peeled from the backing cards and can be applied on the cable, shall be supplied. The strips shall

be water- proof duly marked with special formulated ink with specific thermo-setting adhesive to withstand high temperature.

Suitable plastic ring type ferrules marked with engraved indelible ink for control cables and sticker type ferrules for power cables shall be supplied. These shall be marked as per cable schedule such that each core of each cable can be identified easily.

Aluminium strip of adequate size for making tags for labels shall be supplied. Good quality PVC tapes, cotton tapes and any other accessories required for laying, termination, testing & commissioning shall be supplied conforming to relevant IS.

Cables passing through different fire zones shall be provided with fire-proof barriers with the same fire rating as the penetrated walls or partitions. The location of such barriers shall be finalized during execution work.

1.3.9.10 *Instrumentation Cables*

The instrumentation cables in addition to meeting the requirements of control cables shall be provided with electrostatic shielding by aluminium tape and screening by annealed tinned copper wire. Each cable shall consist of twisted pairs having an overall screen only or multiple fibres, together with drain wires, fillers, shielding, wire, armour and outer sheath in accordance with relevant IS and IEC standards.

1.3.9.11 *Communication Cables*

The cable shall have braided tinned Copper conductor.

1.3.9.12 *Cable Routing*

For the main cable ways, a system of cable racks and trays as well as cable ducts and trenches shall be provided. The power and the control cables will run on separate trays. The cables for emergency lighting, fire alarm systems, etc..., shall run on separate trays.

The power cables shall be laid on the uppermost rack to prevent spread of fire.

All cables laid by the contractor shall be terminated at both ends. The contractor shall make all electrical connections strictly in accordance with the contractor's cable schedule approved by purchaser and shall provide numbered ferrules at each connecting terminal in order to check connections without any difficulty. Terminal blocks have been provided in various panels / equipment for these terminations. One termination shall mean connecting both ends of one core of a cable to given terminal blocks. The cables shall be terminated by crimping lugs to the ends.

The cables shall be handled with care so as to avoid kinking and damage. Sufficient slack shall be allowed in each run of cable to permit contraction and expansion.

Suitable loops between gland and terminating point shall also be provided.

Contractor shall take proper care in the handling of cables against external damage of any kind. Necessary rollers etc... shall be used while pulling and laying of the cables. Purchaser shall have the right to stop the work in case of improper handling of the cables.

Cables shall be properly clamped at regular intervals with the help of non magnetic / moulded fibre glass strip clamps / PVC sleeved clamps, of suitable size. Contractor shall submit typical drawings along with tender giving proposed clamping arrangement and also give distance of clamping at bends and in regular run of cables.

Power and control cables shall be flame retardant low smoke (FRLS) type. However, fire survival (FS) cables shall be provided for certain essential auxiliaries / areas. Cables to be directly buried shall be essentially armoured type. FRLS cables and FS cables shall meet test requirements as per relevant IS, ASTM, IEC and IEEE Standards.

Derating factors for site ambient and ground temperatures, grouping and soil resistivity shall be considered while determining the size of cables.

Cable installation shall be carried out as per relevant IS and other applicable standards. Power cables and control cables shall be laid on separate tiers. The laying of different voltage grade cables shall be on different tiers according to the voltage grade of the cables with higher voltage grade cables in topmost tier and control cables in bottommost tier. All cables associated with one unit shall preferably be segregated from cables of other units. Cable routes for one set of auxiliaries of same unit shall be segregated from the other set.

A comprehensive philosophy of segregation/ separation of cables of different types / voltages shall be adopted for cable installation. For laying of cables in a power house, a broad based system involving cable gallery, tunnels, trenches, cable racks, shafts etc... shall be provided. In outdoor switchyards, a cable trench system shall be provided. The main considerations / practices shall be:

- Segregation and proper spacing shall be maintained.
- Control, auxiliary low voltage (upto 1.1kV) power and medium voltage (above 1.1kV and upto 66kV) power cables shall be laid in separate trays.
- Proper attention shall be given to ventilation / heat dissipation aspects particularly in case of HV cables.

1.3.9.13 Cable Markers and Cable Binding

Suitable cable markers of aluminium with punch marks shall be provided and suitably tagged to the cable permanently so that cable could be easily identified.

The contractor shall also be responsible for sealing the spare holes and panel circuits with the help of suitable blanking plates or mutually agreed method.

Each cable should be provided with a metal or plastic tag of an approved type, bearing cable reference number indicated in the cable schedule prepared by the contractor, at every 10 metres run and at both ends of the cable, adjacent to the termination as well as where cable enters or leaves the ducts.

When power cables are laid in the proximity of communication cables, the minimum horizontal and vertical separation between them shall be 600 mm. Wherever possible the power and the communication cables shall be located as far from each other as possible.

1.3.9.14 Cable Trays and Support Structure

The contractor shall fabricate and supply the mounting arrangement for the support and installation of all the cable trays on galvanized steel structure including channels, angles, rods etc... at requisite spacing in the suspended cable trays, cable trenches in turbine and generator floors, cable trenches in Switch-gear floor, Interconnection between power house & yard and all other areas requiring supporting arrangement.

The contractor shall provide embedment / anchor fasteners for fixing the supporting structures. These supporting structures shall be fabricated from structural steel members (channels, angles and rods) of the required size. The steel section for fabrication of trays and supports shall be arranged by the contractor himself and steel sections shall be SAIL / TISCO / IISCO make only.

The vertical member of the support will be of ISRO12 threaded rod or ISMC100 channel. The horizontal member of the support will be of angle ISA 50x50x6. For the threaded rod support configuration the horizontal member shall be fixed by welding to the channel.

Trays shall be of ladder type. The side channel (Runners) shall be of size 20x100x20 mm and the cross channel (Rungs) shall be of size 20x40x20 mm. The trays shall be fabricated from Hot Rolled Carbon Mild Steel (conforming to IS 1079, Grade "O", of chemical composition C, Si, Mn, S, Ph) sheet of thickness 2mm. The length of each tray shall be of 2500mm and the spacing between the two rungs shall be 250mm at centre to centre. The rungs shall be slotted and shall be welded to the side channels. The trays shall be Hot Dip

Galvanised after Finish (as per IS 2629 / ASTM: A123-97m). The minimum zinc deposit shall be 460gms / sq.metre and the thickness shall be 56 micron minimum.

Cable trays shall be fixed with support by hold-down clamps. The clamps shall be fabricated from MS sheet of 2 mm thickness and Hot Dip Galvanised.

The contractor shall supply various tray fittings and accessories like coupler plate with fasteners, horizontal tees, vertical and horizontal elbows, vertical and horizontal adjustable connectors required for the mentioned trays. The cable trays shall be part of a modular system having available all required accessories and transition pieces from one to another direction or elevation. All accessories, fittings, elbows and tees shall be Hot Dip Galvanised after Finish. The nuts, bolts and washers shall be cadmium plated or electrolytically galvanised.

The contractor shall install the cable trays in accordance with relevant standards. The contractor's standard practice shall be furnished with the bid. The contractor shall ensure proper earthing of the trays and continuity between tray components. The necessary materials required for the earthing are in the scope of supply. The risers of the main earthing system shall be available for the connection.

For the supporting structure the threaded rod will be supported from roof through anchor fasteners whereas the channel will be supported by welding to the inserted plate (the inserted plate shall be fixed to the roof through anchor fasteners). For the trenches the supports shall be fixed to the sidewall through anchor fasteners. The distance between the two support systems will be 1500 mm. The bidder shall furnish drawings for the various supporting structure as mentioned above.

1.3.9.15 Tests

The Contractor shall submit a copy of test certificates for the type tests as stipulated in IS:1554 (Part I) and relevant IEC, carried out either in the manufacturer's works or any approved Laboratory.

Before dispatch, sample pieces of the cable shall be subjected to all type, routine, acceptance and FRLS tests at the manufacturer's works as stipulated in IS:1554 (Part I) / IEC in the presence of purchaser or his representative.

1.3.9.15.1 Type Test

The following type tests and FRLS tests shall be carried out on the cables. The purchaser may accept type test & FRLS tests certificates in lieu of tests.

- a) *Tests on conductor.*
 - i. *Annealing test (for Cu.)*
 - ii. *Wrapping test (for Al.).*
 - iii. *Conductor resistance test.*
- b) *Test for armouring wires / trips.*
 - i. Nominal thickness (for steel strip).
 - ii. Nominal diameter (for round wire).
- c) *Test for thickness of insulation and sheath*
- d) *Physical test for insulation and outer sheath*
 - i. Tensile strength and elongation at break of insulation and sheath.
 - ii. Ageing in air oven.
 - iii. Shrinkage test.
 - iv. Hot deformation.
 - v. Loss of mass in air oven.
 - vi. Heat shock test.
 - vii. Thermal stability.
- e) *Insulation resistance test.*
- f) *High voltage test (water immersion test).*
- g) *High voltage test at room temperature.*

The following FRLS tests shall be conducted:

- a) HCL gas evolution test (IEC 754.1).
- b) Oxygen Index (ASTM-D-2863).
- c) Temperature Index (ASTM-D-2863).
- d) Smoke density test (ASTM-D-2863).
- e) Flammability test (IEC 332.1).
- f) Swedish Chimney test (SS 4241425).
- g) Ladder test (IEEE 383).

1.3.9.15.2 Routine Tests

Routine tests and acceptance tests as per relevant standards shall be carried out on each cable in presence of the purchaser / purchaser's representative. The Contractor shall carry out including but not limited to the following routine tests:

- a) Conductor resistance test.
- b) High voltage test at room temperature.
- c) Insulation resistance tests.
- d) Annealing test (for Cu.).
- e) Tensile test (for Al.).
- f) Wrapping test (for Al.).
- g) Test for thickness of insulation and sheath.
- h) Tensile strength and elongation at break of insulation and sheath.

1.3.9.15.3 Site Tests

Before commissioning of complete system all cabling system shall be checked as per cable schedule and complete report shall be prepared by Contractor and shall be submitted.

Site test shall include:

- a) Cabling checking.
- b) Continuity checking.
- c) Megger testing in accordance with the applicable codes and standards.
- d) Resistance checking.

1.3.9.16 Crimping Tool

A crimping tool suitable for manual operation for making joints with lugs for Aluminium conductor up to size of 50 mm² shall be included in the offer.

A portable hydraulic crimping tool for making compression terminal on the cable conductor up to size 500 mm² shall also be offered.

1.3.9.17 Spares

The following spares for Power & Control Cables Including Cable Trays under this Contract, shall be supplied.

Description	Quantity
Cable 11 kV	One run of cable.
Cable "Tray of each size	5% of installed quantity.
Cable supports, hardware etc...	5% of installed quantity.

A complete set of spares recommended by the manufacturer as essential for the satisfactory and trouble free operation of the equipment as per Clause 1.1.32 under Section-1 of this specification, needed for 5 years operation of the above equipment, shall be supplied.

1.3.10 Lighting and Grounding

1.3.10.1 Introduction

This section covers the KSEBL's requirements for the design, manufacture, testing at manufacturer works, standard and quality of workmanship, general finish of plant, compliance to the latest published edition (prior to the date of closing of tender) of the international standards and recommendations specified throughout the specifications, supply, insurance, delivery and storing at site, erection, site testing, commissioning, performance and reliability confirmation, warranty confirmation etc... of the lighting, earthing and lightning protection systems of the electrical installations in the powerhouse.

1.3.10.2 Reference Standards and Codes

The Equipment shall be designed, manufactured, tested, installed and commissioned in accordance with the latest revision of applicable IS / IEC or equivalent standards.

The Contractor shall adhere to sound design and construction practices with regard to codes and material specifications in order to warrant operational safety and ease of maintenance of plants as well as simplicity of control and stability in plant operation.

• IS 3043	- Code of Practice for Earthing
• IS 4013	- Dust-tight Light Fittings
• IS 1944	- General Lighting
• IS 6665	- Code of practice for industrial lighting.
• IS 9583	- Emergency Lighting System
• IS 1913	- General and Safety Requirements for Luminaries
• IS 3646	- Illumination and glass index
• IS 694	- Wires
• IS 732	- Wiring installation conditions
• IS 2309	- Code of Practice for the protection of buildings and allied structure against lightning.
• IEC 62305	- Protection against Lightning
• IEC 61140	- Protection against Electric shock
• IEEE 80	- Guide for Safety AC Substation Grounding

- IEEE 665 - Guide for Generating Station Grounding
- IEEE 142 - Recommended practice for grounding of industrial and commercial power systems.

1.3.10.3 *Reference Sections*

- Section 1.1 - General Technical Requirements
- Section 1.3.5 - Control and Monitoring
- Section 1.3.6 - Protection
- Section 1.4.3 - Switch-yard Equipment
- Part - 2 - Specific Requirements for the Project

1.3.10.4 *Submittals and Approvals*

The Contractor shall seek the prior approval of the KSEBL for the following through timely submittals.

- The design data, design calculations and drawings of earthing, lighting and lightning protection systems.
- The Contractor shall purchase equipment from reputed vendors only and the name of vendors shall be submitted for KSEBL's approval.
- Material certificates and test reports
- Erection, testing and commissioning methodology

Before delivery of equipment to site, the contractor shall submit all work test certificates / reports for approval and obtain despatch clearance from the KSEBL's representative.

1.3.10.5 *Deliverable Documents*

- Layout drawings of the power house showing the detailed arrangement of Lighting installations, Earth mat / ground electrodes, protection systems etc... clearly indicating dimensions and all important elevations.
- Design data / calculations for lighting, grounding, lightning protection etc...
- Illumination calculations for arriving at the number of lighting fixtures for different areas & rooms.
- Typical installation details based on the above and bill of materials.

- A complete list giving details of equipment and auxiliaries.
- Operation and maintenance manual covering full details of operation and repair procedure.

1.3.10.6 KSEBL's other Requirements

Other technical requirements shall be as given in Part-2 (Specific Requirements of the Project) of this specification.

The tentative layouts of the powerhouse are given in drawings appended to the specifications.

All equipment shall be neatly arranged and shall be readily and easily accessible for operation and maintenance.

1.3.10.6.1 Scope of Work

Scope of work shall be as per Part-2, Specific requirements of the project. Any item of work not specifically mentioned in the specifications but which are usual and / or necessary for the satisfactory operation of the equipment supplied shall be deemed to be provided by the Contractor and included in the quoted Price. All work shall be complete in all details whether such details are mentioned in the specifications or not.

Earthing System

The contractor shall be responsible to take measurements to determine the soil resistivity of the site to design the ground mat. Based on measured resistivity of the site, the contractor shall make the design and the calculation of the whole grounding system of the powerhouse area, discharge area of tailrace, switchyard area and other adjoining functional areas. The contractor shall supply, install and supervise all grounding conductors, grounding rods, connection material for the complete embedded grounding system. The concreting of the embedded grounding system shall be done by the civil contractor under the supervision of the contractor for the electromechanical lot.

The contractor shall supply and install all grounding conductors, connection materials etc... for the internal connection of all equipment, steel structures and metal parts and all connection to the embedded grounding system.

The earthing system shall mainly consist of:

- An embedded earthing system in the powerhouse area.

- An embedded earthing system in the transformer bay in switch-yard area connected with the power house earthing system.
- An embedded earthing system in the discharge area of the tail-race, connected with the powerhouse earthing system.
- An interconnected above ground / above floor main earthing network at the powerhouse area, switch-yard and to the other places wherever needed shall be laid. From this earthing network, the equipment conductor shall run to all machinery, equipment and other parts, which are to be earthed.
- The earth electrode system as well as other earthing networks shall be designed and constructed for the operating voltages, the short circuit capacities and the corresponding short circuit and earth fault currents.
- Independent earthing system for electronic panels as per requirement of manufacturer.

1.3.10.6.1.1 Earthing System

The Contractor shall design the grounding system for all electrical installations in the powerhouse, transformer bay and switch-yard, based on the actual measurement of soil resistivity and earth resistance at site (minimum 10 locations as approved by the KSEBL). The method adopted for soil measurement shall be submitted to the KSEBL for approval and site measurements shall be made in the presence of KSEBL's representative. The Contractor shall measure the soil resistivity before and after excavation of soil. Detailed grounding system calculation along with all drawings and supporting calculations shall be submitted for KSEBL's approval before executing the work.

All off-site areas shall be interconnected together by minimum two parallel conductors. If separate earth mat is provided for the Powerhouse site and switch-yard due to practical difficulties like larger distance of separation, then the two mats will be joined together through 3 parallel conductors of the same cross section as those of conductors used in the mats. Contractor shall obtain all necessary statutory approvals for the system.

After construction of the grounding system, field measurement of resistance of earthing system and review of step voltage at periphery, internal step and touch voltages and investigation of transferred potential and special danger points etc... shall be done by the Contractor. Modification of the grounding system, if necessary, shall be carried out. All the field measurements shall be done as per relevant standards or guidelines under the presence of KSEBL's Engineers.

Artificial treatment of the soil shall be done, if necessary, for maintaining desired low resistance of the earthing system and KSEBL's approval shall be obtained prior to the work.

The grounding system shall be designed with the following objectives:

- i. To provide low impedance path to fault currents, during ground faults, to ensure prompt and consistent operation of protective devices to effect isolation.
- ii. To keep the maximum voltage gradient during ground faults along the surface inside and around the power house within safe limits.
- iii. To protect the life and property from electrical shocks due to over voltage.
- iv. To stabilize circuit potentials with respect to ground and limit the overall potential rise.
- v. Limiting the induced capacitive transformed voltages on electronic cables, circuits, panels and other equipment to low voltage, weak current.

The grounding system of earth mat comprises of closed current conductor grid of steel laid over the excavated surface of power house and shall extend to the penstock and tailrace, if required to obtain the path of low resistance for passage of heavy currents during the fault. A number of ground rods (32 mm dia. x 3000 mm long) shall be added to the earth mat to obtain consistently lower resistance under all weather conditions. The earth mat shall be connected to the following in powerhouse.

- i. The neutral point of each system / equipment through its own independent earth.
- ii. Equipment framework and other non-current carrying parts.
- iii. All extraneous metallic frame work not associated with equipment.
- iv. The earth point of lightning arrestors; voltage transformers and lightning conductors through their permanent independent earth electrodes.

The conductor shall be of adequate cross-section to safely withstand the system fault current for time duration of fault clearance by the remotest / back up protective system. Also sufficient allowance needs to be provided for corrosion of the embedded conductor on account of chemical properties of soil and also due to galvanic action with other embedded systems.

To protect the power house building, the lightning conductor shall be provided on the top. This may be connected to the station mat by GS flat.

Requirements of Earthing:

a) Conductor Size

The earthing system (earth mat) shall consist of:

- An earthing grid of mild steel conductors of size not less than 32 mm diameter buried in the ground in powerhouse, transformer bay and switch-yard and extended suitably in required areas so that the earth resistance is maintained below 0.5 ohm. Depth of Burial of main earth conductor shall be at least 600mm below grade level. Where it crosses cable trenches, pipes, ducts tunnels, rail tracks, etc..., it shall be at least 300 mm below them.
- An interconnection of main earthing network at the powerhouse, transformer bay, switch-yard and other places, where needed.
- Risers and horizontal runners from the grounding network to each item of machinery and other parts which are to be earthed.
- The system shall be designed and constructed for the operating voltages, the design short circuit capacities and the corresponding short circuit and earth fault currents.
- Adequate protection for personnel against dangerous voltages, currents and arcs.
- All conductor joints shall be joined by electric arc welding, with resistance of joint not less than that of the conductor. Welds to be treated with red lead for rust protection and then coated with bitumen compound for corrosion protection.
- Minimum corrosion rate to be considered shall be 0.25mm per year.

b) Current carrying capacity

Any conductor, electrode or connection used in the grounding system should be large enough to carry the following currents without excessive heating.

- Fault currents of magnitude and duration such as to produce maximum heating effect in the grounding system components,
- Currents caused by direct lightning strokes, or induced by a lightning stroke,
- The current that may be expected to flow in the grounding system as a result of sustained system neutral currents.

c) Control of ground potential and gradients

The grounding system should provide a low impedance path to ground for fault currents, neutral currents and lightning discharges with uniform or near uniform potentials of earth surfaces in the area under consideration. This result shall be accomplished without occurrence of hazardous potential differences between any surfaces on which a person may be standing and any surrounding structures or objects within his reach and also without the imposition of dangerous differences of potential on equipment and circuits.

In situations where the impedance is such that potentials in the vicinity cannot be kept reasonably safe, special arrangements of the grounding system should be devised.

d) Mechanical reliability

The design and installation of conductors, electrodes and connectors of the grounding system should be adequate to minimize the possibility of mechanical damage in order to maintain the reliability and continuity of the grounding system. The earthing system life expectancy shall be minimum 40 years.

e) Electrical reliability

The design and installation of the grounding should be such as to maintain the performance requirements with regard to current carrying capacity and control of ground potentials.

f) Resistance to corrosion

The design and installation should be suitable for preventing deterioration from corrosion. The installation should be compatible with the surrounding soil atmosphere.

g) Low impedance for system operation

The impedance of the grounding system should be sufficiently low to stabilize the system potential with respect to ground, to provide positive operation of the over-current devices, to improve voltage regulation and to restrict potentials to suitably low values in those circuits where the grounding system is required to carry a portion of the neutral current.

h) Provision for testing and inspection

The design of the grounding system should be such as to permit adequate testing and inspection. From the points of safety and interference, the following three basic requirements are applicable for grounding system.

- It shall provide safety for personnel by connecting to a common earth all metallic items of the plant, which could otherwise acquire a different potential in the event of an insulation breakdown.
- It shall limit the touch and step voltages and the conductive interferences that could arise from the worst-case fault condition to acceptable levels.
- It shall, by appropriate design layout, limit its own internal voltage drops and be utilized where necessary to provide screening for auxiliary cables against inductive interferences.

i) Connections

- All the metallic parts of the equipment and installations in the powerhouse, transformer bay, switch-yard, auxiliary equipment and systems etc... shall be connected to the grounding system as prescribed in the relevant standards and guidelines.
- All Junctions (crossing of the steel electrodes) while forming the earth mat and taking risers from the earth-mat for giving earth connections to equipment, steel structural conducts, cable sheaths shall be properly welded.
- Welding done shall be given a coat of black asphaltic varnish and then covered with hessian tape to avoid rusting.
- The risers taken along the main switch-yard structures and equipment structures (up to their top) shall be clamped to the structure at an interval of not more than one metre with ground connectors.
- Enclosures of all electrical equipment as well as all cabinets / boxes / panels / etc... shall be earthed by two separate and distinct earth connections. Metallic pipes, conduits, cable tray section, etc... shall be bonded to ensure electrical continuity and earthed at regular intervals as well as at both ends. Metallic conduits, pipes, steel supporting structures etc... shall not be used as earth continuity conductor. All hinged doors shall be earthed by flexible braids of adequate size.
- 75 x 8 mm ground conductor shall run in cable trenches and shall be connected to the ground mat at an interval of 5 metres.
- The grounding electrodes shall be driven into the ground and their tops shall be welded to a clamp and the clamp together with the grounding shall be

welded to the ground conductor.

- Structures shall not be used as a means of earthing. All steel structures shall be individually earthed. Metallic sheaths and armour of all multi-core cables shall also be earthed at both equipment and switchgear end. Earthing conductor shall be buried at least 2000 mm outside the fence of electrical installations. Every alternate post of the fences and all gates shall be connected to earthing grid by one lead. Earthing conductor embedded in the concrete floor shall have at least 50 mm concrete cover.
- Earthing connections with equipment earthing pads shall be bolted type with at least two bolts, and joint surfaces shall be galvanized. The connections shall be painted with anti-corrosive paint after testing and checking.
- Transformers and L.A's and single phase potential transformer shall be provided with earth pits near them for earthing and these earth pits in turn shall be connected to the earth mat.
 - Neutral of power transformers shall be directly connected to two rod electrodes in treated earth pits, which in turn shall be connected to station earthing grid. Neutral earthing and body earthing of power transformers shall be connected to separate earth electrode.
 - Neutral connection earth pipe shall never be used for the equipment earthing.
 - The earthing terminal of surge arresters and voltage transformers, and lightning protection down conductors shall also be connected to station earthing grid through separate rod electrode.
 - A separate earth electrode shall be provided adjacent to the structures supporting Lightning Arrestors. Earth connection shall be as short and as straight as practicable. For arrestors mounted near for protecting transformers earth conductors shall be connected directly to the tank.
- An Earthing pad shall be provided under each operating handle of the isolator and operating mechanism of the circuit breakers. Operating handle of the isolator and supporting structures shall be bonded together by a flexible connection and connected to the earthing grid.
- Special attention shall be made for grounding of HV-GIS equipment (if provided), computer networks and communication equipment as per the

manufacturer's recommendations.

- The switch-yard surface area shall be covered by a layer of crushed rock of size 25 x 40 mm to a depth of 100mm.

1.3.10.6.1.2 Lighting System

A comprehensive illumination system shall be provided in the entire project i.e. all areas within the plant boundary. The system shall include lighting fixtures, distribution boards, lighting panels, junction boxes, lighting poles, receptacles, switchboards, cables and wires, conduits, poles and masts, etc... The system shall cover all interior and exterior lighting such as area lighting, yard lighting, street lighting, security lighting, etc...

Adequate illumination shall be provided as per relevant IS. Apart from normal AC illumination system, emergency AC and DC illumination at strategic locations shall also be provided. DC illumination shall be provided to enable safe movement of personnel and access to important control points during an emergency.

Energy conservation measures shall be adopted, while designing the lighting system. Sodium vapour (high pressure) or other more efficient latest technology lighting fixtures shall be preferred for outdoor lighting of areas such as switch-yards, storage yard, parking areas etc... Automatic switching via photo electric cells can be adopted for outdoor lighting to optimise power consumption.

Metal halide fixtures shall be used for certain indoor areas such as erection bay, generator hall, machine hall, turbine pit and other high bay areas where proper colour rendition is needed and long-life is essential.

Incandescent lamps shall be used only for battery powered emergency lights and for certain places where lights shall not be turned on continuously or where fluorescent fixtures are impractical.

Design Criteria

The illumination system shall be designed on basis of best engineering practice and shall ensure uniform, reliable, aesthetically pleasing, glare free illumination. The design shall prevent glare / luminous patch seen on VDU screens, when viewed from an angle.

Power supply shall be fed from 415 / 240 V normal AC power supply, station service board, and 110 V DC supply for emergency lighting. Lighting panels shall be located at different convenient locations for feeding various circuits. These panels shall be robust in construction with lockable arrangements and MCB for different circuits.

Illumination system shall be provided for the powerhouse, transformer bay and switch-yard. The lighting system and electrical installations shall consist of:

- Indoor lighting system
- Outdoor lighting system
- Emergency lighting system
- Power outlet at various locations

1.3.10.6.1.2.1 Normal Lighting System

Indoor lighting system shall be provided in the following areas:

- Machine floors
- Control room
- Main inlet valve gallery
- Offices, workshop and store

Outdoor lighting system shall be provided in the following areas:

- Entrance
- Walkways
- All roads inside project area
- Switch-yard outdoor area

The illumination levels in various areas shall be maintained as per the IS standard. All fittings and fixtures shall be of the type to facilitate easy replacement from indigenous market during operation and maintenance stage. Fluorescent and HPMV lamps shall be provided for good efficiency of the luminaries.

All outdoor fixtures shall be weather proof type. Fluorescent fixtures, installed in other than control room areas shall have electronic ballasts. For control rooms, the ballasts shall be copper wound inductive, heavy duty type, filled with thermo-setting insulating moisture repellent polyester.

All luminaries and their accessories and components shall be of the type readily replaceable by the available Indian makes. All fixtures and accessories shall be of reputed make and non-corrosive type. Acrylic covers / louvers shall be of non-yellowing type.

The constructional features of lighting distribution boards shall be similar to AC / DC distribution boards described elsewhere. Outgoing circuits in the Plant Lighting System

shall be provided with MCBs of adequate ratings.

Wiring shall be by multi-stranded PVC insulated colour code cable laid in GI conduits. Wiring for lighting circuits of AC and DC systems shall be run in separate conduits throughout. Minimum size of the wire shall not be less than 1.5 sq.mm copper or 4 sq.mm aluminium. Wire shall conform to IS: 694 and wiring installation shall be as per IS: 732.

Conduits shall be of heavy duty type, hot dip galvanized steel conforming to IS: 9537. In corrosive areas, conduits shall have additional suitable epoxy coating.

At least one 5 / 15A, 230 V universal socket outlet shall be provided in offices, stores, cabins, etc... 20A 230 V AC industrial type receptacles shall be provided strategically in all other areas. All these receptacles shall be 3-pin type and controlled with a switch. Suitable numbers of 63A, 3 phase, 400V AC industrial type receptacles with control switches shall be provided for the entire plant for welding purposes, particularly near all major equipment and at an average distance of 50 m. At least one 63 A receptacle shall be provided in each off-site building.

Suitable number of ceiling fans in areas not covered by air-conditioning and ventilation system shall be provided. Street lighting shall be with swaged / steeped tubular steel poles of swan new construction. The poles shall be coated with anti-corrosive treatment and paint.

Area lighting shall be with suitable lighting masts. Masts of adequate height shall have lattice structure with ladder, cage and top platform. Alternatively they shall have lantern carriage of raise / lower type with electrical winch provided inside the tubular mast.

All outdoor lighting systems shall be automatically controlled by synchronous timer or photocell. Arrangement shall be provided in the panel to bypass the timer/photocell for manual control.

Minimum Illumination Levels and Recommended Type of Fixtures and Luminaries

Location	Average Illumination level (Lux)	Recommended Fixture type
Machine Hall	200	Metal Halide / LED / medium bay Industrial trough type fluorescent
Switch-gear rooms	200	Mirror optics with anti-glare feature
Control room, computer room	300	Decorative mirror optics type
Offices, conference rooms etc...	300	Decorative mirror optics type
Battery rooms	100	Totally enclosed corrosion resistant / vapour proof.

Location	Average Illumination level (Lux)	Recommended Fixture type
Switch-yard	10 (general) 50 (on eqpt)	HPMV /LED flood light, weather proof
Compressor room, pump house, etc...	150	LED medium bay / industrial trough type fluorescent.
Turbine, auxiliaries like OPU etc...	150	Flame proof fluorescent fixtures suitable for hazardous area.
Cable galleries	50	Industrial trough type fluorescent
Street lighting roads	20	LED street lights
Outdoor storage handling	100	LED flood light, weather proof.
Permanent stores	150	Industrial trough type fluorescent
Workshop, general work bench	300	Mirror optics fluorescent
Garage / Car parking	70	Industrial trough type fluorescent

1.3.10.6.1.2.2 Emergency Lighting System (LED Type)

To maintain essential lighting in the powerhouse, an emergency lighting system operated from the 110V battery shall be provided. The battery capacity shall be decided with 10% design margin and ageing factor as applicable. The battery shall have sufficient capacity to provide 3 hours requirement of uninterrupted emergency illumination independently.

110 V DC emergency lighting shall be provided in following areas:

- a) Generator room - 20 lux
- b) Operating floors of turbine hall - 20 lux
- c) Switchgear room - 15 lux (min. one lighting fixture between two rows of switchgear)
- d) Control and relay room -100 lux
- e) Cable spreader room - at least 10% of illumination (min. one lighting fixture at a convenient location.)
- f) Battery room - at least 10% of illumination
- g) Exit points and stair cases - One light fixture
- h) All other strategic locations for safe personnel movement during any emergency.

DC lighting shall come on automatically on failure of normal AC supply. These shall be switched off automatically after the normal AC supply is restored and luminaries have attained their full glow. In off-site areas / buildings DC lighting is to be provided through self

contained 4 hour duration fixtures located strategically. It shall be provided with Ni-Cd battery.

Lighting panels, fixtures, receptacles, poles, masts, distribution boards, switch boxes, conduits, junction boxes etc... shall be properly installed and earthed.

One 110V DC distribution board shall be provided for the powerhouse, equipped with sufficient feeders, moulded case circuit breakers, etc... complete with all necessary auxiliary equipment.

The DC battery, battery charger, and emergency DCDB shall be placed at a floor higher than that of machine hall.

1.3.10.6.1.2.3 Lighting Protection

Suitable lightning protection shall be provided to the powerhouse building and yard equipment. The lightning protection scheme must be got approved by the Board before executing the work.

The lightning protection system shall be designed as per IS: 2309. It shall cover all buildings and structures in the plant, and switch-yard areas. It shall comprise horizontal / vertical air terminations, down conductors, test links and earth connections to the station earthing grid. All conductors shall be of minimum 25x6 mm size and shall be of galvanized steel only.

The down conductors of lightning protection system shall have a test joint at about 1500 mm above ground level. Each down conductor shall be connected to a 40 mm dia, 3 m long mild steel earth electrode as well as station earthing grid.

The lightning protection system shall not be in direct contact with underground metallic service ducts and cables, and shall not be connected above ground level to other earthing conductors.

All joints in the down conductors shall be of welded type. Pulser system for lightning shall not be accepted.

Hazardous areas handling inflammable / explosive materials and associated storage areas shall be protected by a system of aerial earths as per IEEE: 142.

All conductor joints shall be joined by electric arc welding, with resistance of joint not less than that of the conductor. Welds to be treated with red lead for rust protection and then coated with bitumen compound for corrosion protection.

1.3.10.7 Testing

The Contractor shall conduct shop tests on dates agreed with the KSEBL and make arrangements for the KSEBL's representative to witness the tests.

All testing envisaged in IS / IEC shall be carried out. The Contractor shall make all arrangements, equipment, material and consumables to the tests and prove compliance of the equipment with the standards at shop and at site.

The test reports shall be got approved by the KSEBL before despatch clearance of any item.

1.3.10.8 Spares

The spares recommended by the manufacturer as essential for the satisfactory and trouble free operation of the equipment, as per Clause 1.1.32 of this specification, for 5 years shall be supplied.

1.3.11 EOT Crane

1.3.11.1 Introduction

This section covers the KSEBL's requirements for the design, manufacture, testing at manufacturer works, standard and quality of workmanship, general finish of plant, compliance to the latest published edition (prior to the date of closing of tender) of the international standards and recommendations specified throughout the specifications, supply, insurance, delivery and storing at site, erection, site testing, commissioning, performance and reliability confirmation, warranty confirmation of the overhead travelling crane equipped with main and auxiliary lifting equipment and other general requirements as per **Section 1**.

1.3.11.2 Reference Standards and Codes

The Cranes shall be designed, manufactured, tested, installed and commissioned in accordance with the latest revision of applicable IS / IEC or equivalent standards.

The Contractor shall adhere to sound design and construction practices with regard to codes and material specifications in order to warrant operational safety and ease of maintenance of plants as well as simplicity of control and stability in plant operation.

IS 807	Code of Practice for Design, Manufacture, Erection and Testing of Cranes and Hoists.
IS 3177	Code of Practice for Electric Overhead Travelling Cranes and Gantry Cranes other than Steel Work Cranes.
IS 2365	Steel Wire Suspension Rope for Lifts, Elevators and Hoists.
IS 325	Three Phase Induction Motors.
IS 3443	Crane rail section
IS 4475	Crane – Suspended ladles for foundries
IS 13572	Crane Driving Manual
IS 1438	Crane weighing machines
IS 14474	Mobile Cranes
IS 2266	Steel wire ropes for general engineering purposes.

1.3.11.3 Reference Sections

Section 1.1

General Technical Requirements

Part - 2

Specific Requirements for the Project

1.3.11.4 Submittals and Approvals

The Contractor shall seek the prior approval of the KSEBL or the KSEBL's Representative at the following points of works execution using timely submittals.

- For the design, drawings and circuit diagrams at agreed stages
- For the material certificates and test reports
- For the list of manufacturers / suppliers
- For the erection methodology
- For the alignment of embedded parts before grouting

Before delivery of equipment to site, the contractor shall submit all work test certificates for approval and obtain despatch clearance from the KSEBL's representative.

1.3.11.5 Deliverable Documents

- Layout drawings of the power house showing the overall dimensions and layout of EOT crane etc...,clearly indicating dimensions and all important elevations.
- Schematic drawings, circuit diagrams and specifications
- Design calculations
- A complete list giving details of equipment and auxiliaries
- Operation and maintenance manual covering full details of repair procedure.

1.3.11.6 KSEBL's Other Requirements

Other technical requirements shall be as given in Part-2 “**Specific Requirements for the Project**” of this specification.

The tentative layouts of the powerhouse are given in drawings appended to the specifications.

- The category of cranes shall be M5 as per relevant Indian standard.
- The overhead electrically operated travelling crane shall serve the powerhouse machine hall and service bay.
- The crane shall be capable of hoisting any equipment, in any level or floor of the powerhouse and bring it to the service bay for maintenance.
- The main hoist shall be capable of hoisting the heaviest plant component with a

reserve capacity of 25%. The hook capacity shall be taken as 25% more than the maximum weight to be lifted inclusive of the weight of the lifting beam. If the maximum weight to be lifted is more than 300 Tonnes, two cranes each of equal capacity shall be deployed to lift the heaviest package in tandem operation.

- The crane shall have a service life of more than 50 years.
- The crane shall have enough clearance to move any piece of equipment over the generators. The span of the crane shall be fixed in such a way that the travel and lift of the main and auxiliary hooks of the crane as well as the hook limits shall be adequate for the assembly and disassembly of the main equipment in the power house. The lift above the service bay (upper limit) shall be adequate to hoist and carry the rotor of the generator and to assemble and disassemble the transformer. The lift below the service bay (lower limit) shall be fixed in such a way as necessary for assembly and disassembly of the turbine and Main inlet Valve.
- All motions should be terminated with limit switches at end of travel.

All equipment shall be neatly arranged and shall be readily and easily accessible for operation and maintenance. Necessary walkways, handrails, ladders, chequered plates, platforms, etc... required should be provided by the contractor.

1.3.11.6.1 Scope of Work

The Scope of work shall be as given in Part-2 “**Specific Requirements for the Project**” of this specification. Any item of work not specifically mentioned in the specifications but which are usual and / or necessary for the satisfactory operation of the Crane shall be deemed to be provided by the Contractor and included in the quoted Price. All work shall be complete in all details whether such details are mentioned in the specifications or not.

1.3.11.6.2 Description of Equipment

1.3.11.6.2.1 Operating Speeds

The operating speeds for various motions of the crane shall not exceed the following limitations:

Main hoist	-	1.0 m / minute
Bridge travel	-	15 m / minute
Trolley travel	-	10 m / minute

The following data shall be furnished by the Bidder / Contractor:

- a) Hoist normal speed (m / minute)
- b) Cross travel speed (m / minute)

- c) Long travel speed (m / minute)
- d) Crane span (m -Approx.)
- e) Runway length (m -Approx.)
- f) Height of top of crane rail (as per civil details) above generator floor (m -Approx.)
- g) Vertical travel of Hook (m).

1.3.11.6.2.2 Safeguards during Earthquake

The crane shall be designed to withstand seismic forces. Clamping necessary to contain the movement of the crane during earthquake shall be provided. The locking shall be designed to put it on and off easily.

1.3.11.6.2.3 Mechanical Equipment

i. Crane Bridge

The bridge shall consist of two girders supported on end trucks. The girders shall be designed to safely carry the full rated load without undue vertical or lateral deflection or vibrations. The design shall take into account all conditions of operations and tests at works and site as per IS: 3177 - 1977. The girders shall be of the box type construction reinforced by stiffening ribs. Suitable stops shall be welded near the end of each girder to engage bumpers on the trolley to prevent it from leaving the bridge.

Rails for the trolley shall be supported centrally on the girders and shall be held in place by rail clips. The clips shall be locked in position to prevent the rails from creeping.

ii. End Carriages (Trucks)

The end trucks shall be constructed of cast steel, structural steel sections or plates welded and shall be of box type with openings at each end for receiving the truck wheels. Each truck shall be fitted with double flanged rail wheels with roller bearings, running on suitable axles, wheel fracture props, buffer etc...

All trucks shall be provided with suitable track sweeps at each end of trucks so as to be effective in both directions of travel. Safety lugs shall be provided which shall extend below the top of rail on both sides to prevent the trucks from leaving the rails. Lugs shall be provided on the truck frames to permit a drop of not more than 25mm in case of broken axle. The end stops shall be provided and they shall contact the face of the end truck and not the wheels. The stops shall be attached at each end of runway rails.

Suitable jacking pads shall be provided for maintenance of wheels.

iii. The Wheels and Axles

The bridge shall be carried on sufficient number of wheels on each side. All wheels shall be double flanged with treads machined or ground to size and shall be of forged or rolled steel. The flanges shall be tapered to prevent derailment.

The truck axles shall be made of forged carbon or alloy steel. The journal bores of all the truck wheels shall be drip proof and shall be provided with roller bearing with high pressure grease lubrication.

iv. Bridge and Trolley Drive, Hoisting Machinery

The bridge and cross travels of the crane shall be effected electrically through push buttons on pendant. The travels will be steady and free from vibration or rocking in any part of the structure while traveling under maximum load. There shall be no tendency for the crane structure to get out of line while traveling along the runway under any condition.

The trolley shall be equipped with a hoist. The hoist shall be driven by suitable motor and gears to obtain the required hoisting speed. The hoist shall be provided with brakes and retarding devices as stated elsewhere.

v. Hook and Block

The hook and block shall be arranged to lift without twisting and sidewise pull of load end and dead end rope. The hook shall be swiveled on antifriction thrust bearings of an approved type and shall have ample capacity for the maximum loads. The hook shall be made of annealed forged alloy or carbon steel or may be cut from rolled stock.

The sheave pins shall be made of annealed carbon or alloy steel and shall have ample sheave bearing area. The bottom blocks shall be constructed so as to guard the hoisting ropes fully and prevent them leaving the sheaves under the conditions of operation.

vi. Rope Drum, Sheaves and Rope

The winding drum shall have machined grooves to receive the full hoisting rope without over-lapping and the drum shall be of such size that there will be not more than one layer of rope on the drum, when the rope is in fully wound position. All rope sheaves shall be made of cast iron, cast steel or mild steel and shall be machine grooved to a depth of not less than 1.5 times the diameter of the rope. The hoisting rope shall be flexible plough steel wire type with fiber core and internal lubricant. The factor of safety of hoisting rope shall not be less than 5 (five). The rope system shall be equalized and arrangements entailing reverse bends shall be avoided as far

as possible.

vii. Gears, Bearings and Lubrication

All gears shall be machine cut and shall conform to relevant Indian Standards. Gearboxes shall be so designed that the gears which they enclose will be automatically lubricated. The gears shall be readily removable and the gearboxes shall be oil tight.

All bearings shall be of the roller, ball or sleeve type with removable and bronze linings preferably flanged at both ends. All bearings shall be designed so as to be replaceable easily. Bushings at ends of shaft shall be sealed properly to prevent dripping of lubricant.

Oil lubrication shall be provided for all gear trains, sleeve bearings on motor and bearings for truck wheels. Lubrication for all mechanically operating parts shall be by means of biodegradable oil and industrial button type fitting shall be used.

viii. Walk-ways and Ladders

Ladders, platforms, walkways, hand holds, foot holds etc..., necessary to give safe access to bridge drive and trolley drive mechanisms and all other components of the crane, needing inspection, maintenance and repair shall be provided for. The walkways shall be of steel required plate extending to the entire length of the bridge.

ix. Rails

Two runway rails for the bridge travel will be furnished by the contractor for the full length of powerhouse. The trolley rails shall be of the same size as those used on runway. The stoppers at each end with sole plate clips for crane run to cover the full length of powerhouse shall also be supplied.

x. Bumpers

Rubber bumpers shall be attached to the bridge trucks and on the trolley. The bridge shall have four bumpers, one at each corner arranged to meet the crane stop squarely. The trolley shall have two bumpers on each side placed to meet the truck stops squarely at the end of track.

xi. Slings

The contractor shall deliver suitable wire rope slings in pairs having a safety factor of not less than five when lifting specified loads. Each sling shall have a ring at one end and a ring or hard eye at the other end with matching shackles.

1.3.11.6.2.4 Electrical Connections and Motors

i. General

All equipment and wiring shall suit the requirements and shall be in accordance with the latest standards unless otherwise specifically stated in the specifications. Mats, railings, screens and other accessories which are external to the apparatus, but which may be required to meet these codes for installed equipment shall be furnished by the contractor.

The main runway conductor system for supplying 415 V, 3 phase, 4 wire, 50Hz power supply for the crane shall consist of insulated rigid conductors, accessories and collectors. The conductor system for transmitting power and control commands to the trolley mounted equipment shall be of either festooned cable or insulated rigid conductors.

A circuit breaker with overload and short circuit magnetic releases shall be provided in the incoming power supply.

ii. Electric Motor

All electric motors shall be of ample capacity for the duties and speeds specified, and shall conform to IS: 325 - 1970. The motors shall also meet the requirements as specified in IS: 3177 - 1977. All motors shall be induction type, minimum 60 minutes rated with water tight terminals, anti-friction bearings and built-in totally enclosed fan ventilated enclosures, incorporating epoxy clad windings for protection from fungus growth, vermin and high humidity. Creep speed motors shall also be continuously rated.

The rated capacity of the motors shall be such that their full load torque shall not be exceeded in giving the specified performance. The motors shall be suitable for operation at 415 volts, 50 HZ, 3 phase, 4 wire supply system, with:

- a) Voltage variation of + 10 %
- b) Frequency variation of + 3%
- c) Any combination of (a) & (b)

The synchronous speed of the motors shall not exceed 1000 rpm. The pull out torque of the motors shall not be less than 225 percent of full load torque of motors with rated voltage and frequency applied. Motors shall be provided with class 'F' insulation and rated on the basis that under the specific service conditions, the temperature rise will not exceed the limits specified in Table - 1 of IS: 325 - 1970. Protective gear for the motor shall be provided as per the requirements indicated in IS: 3177 – 1977.

The motors shall be subjected to type and routine tests as specified in IS: 325 – 1970 and the copies of the test reports shall be furnished by the Contractor.

1.3.11.6.2.5 Controls and Braking**i. Controls**

Master controllers shall be located in the operator's cabin. Indication and protection shall be provided on the control panel. An electrically operated gong shall be provided. The operator cabin shall be ergonomically designed, give direct view of operating area, lighted and provided with fan for ventilation. The crane shall have spotlights to give accurate visibility to the operator.

All the hooks shall be 360° swivel type rotating on anti-friction bearings.

All movements shall take place smoothly and positively without slippage or creeping of loads. Both hoists shall be test loaded including the specified overload.

In case pendant control is provided, control of the hoist for raise and lower of the load may be done by a person standing at the floor of the power house by means of a pendant controller connected through a sufficient length of suitable cable. Adequate length of the cable with control mechanism shall be supplied in addition.

The provision of radio remote control and variable voltage variable frequency (VVVF) drive for various crane motions for the purpose of precision speed control shall normally be made for cranes having capacity 100 Tonnes and above.

The radio remote control equipment, wherever provided shall conform to all applicable Government rules and regulations. The frequency of operation shall be in the requisite frequency band as per relevant standards.

The motor controllers shall be of fully magnetic reversing type to provide gradual acceleration. They shall be designed so that it will be possible to limit the vertical movement of the hooks with full rated load and when starting from standstill to within 6 mm. Hoist motor controller shall have at least two speed control points in each direction of operation. At lowering with full load, it shall be possible to achieve a continuous speed not more than 10% of rated full load hoisting speed. Controls for the bridge travel and trolley travel motors shall also be provided in the pendant.

A push button for emergency stop shall be provided. The push button shall be so arranged as to immediately cut OFF the main supply and apply electro magnetic brake simultaneously, irrespective of controller position.

The control and lighting supply circuits shall be protected through circuit breakers and fuses of appropriate rating.

ii. Brakes for Hoist Motion

All travels and hoists shall be generally provided with at least two sets of brakes working on different principles viz., electromagnetic, thrust, eddy current braking

system etc... At least one set of brakes shall set in when the current is cut off and shall be released when the current is applied.

Solenoid operated electro-magnetic brakes shall be provided for hoisting motor. The brake shall be applied immediately irrespective of controller's position, on operating an emergency stop push button. The electro-magnetic brake shall be complete with the rectifier equipment to obtain D.C. supply for the solenoid.

In addition to electro-magnetic brake, electro-hydraulic thruster brake shall also be provided.

iii. Limit Devices

Limit switches of gear or cam type for 'UP' and 'DOWN' limits for the hook block shall be provided. Suitable limiting devices shall also be provided to limit the travel of the trolley at the ends of the crane girders.

iv. Wiring, Conductors and Collectors

All wiring shall be in metal conduit hot dip galvanized. All conductors for primary power and lighting shall be insulated for not less than 600 volts and shall have standard moisture resisting double braid coverings. The control and lighting conductors shall be of standard and suitable sizes in copper.

The main runway conductors shall be rigid type and shall consist of four lengths of hard drawn copper wire with end brackets, intermediate brackets and insulators etc..., to suit the power house building. The trolley conductors shall be of the rigid type.

The collector shall be designed to reduce the sparking between collectors and conductors to the minimum and shall be readily renewable.

v. Lighting

The permanent 240 volts lighting system on the crane shall consist of two 250 watts high bay lighting units to illuminate uniformly the area under the crane. Suitable convenience outlets shall also be provided.

1.3.11.7 Testing

The Contractor shall conduct shop tests on dates agreed with the KSEBL and make arrangements for the KSEBL's representative to witness the tests.

All testing envisaged in IS 3177 shall be carried out. They will include running tests, load tests, deflection tests, brake tests and other electrical equipment tests envisaged in Clause 37 of IS 3177. The Contractor shall make all arrangements, equipment, material and consumables for the tests and prove compliance of the crane and hoists with the standards at shop and at site. Use of the crane during construction will be subject to agreed

conditions.

The test reports shall be got approved by the KSEBL before requesting despatch clearance of any item.

1.3.11.8 Spares

The following spares for 5 years operation and maintenance of the crane shall be supplied.

Contactors and springs for controller	-	1 set of each type
Brake solenoid coils complete	-	1 set of each type
Limit switches of each type used	-	1 set
Brake lining complete with rivets etc...	-	1 set of each type
Fuses	-	1 set of each type

Any other spares recommended by the manufacturer as essential for the satisfactory and trouble free operation of the equipment as per Clause 1.1.32 of this specification.

1.3.12 Communication

1.3.12.1 Introduction

This section covers the KSEBL's basic requirements for the design, manufacture, testing at manufacturer works, standard and quality of workmanship, general finish of plant, compliance to the latest published edition (prior to the date of closing of tender) of the international standards and recommendations specified throughout the specifications, supply, insurance, delivery and storing at site, erection, site testing, commissioning, performance and reliability confirmation, warranty confirmation of the complete Communication system in the powerhouse and Switch-yard.

1.3.12.2 Reference Standards and Codes

The Equipment shall be designed, manufactured, tested, installed and commissioned in accordance with the latest revision of applicable IS / IEC or equivalent standards.

The Contractor shall adhere to sound design and construction practices with regard to codes and material specifications in order to warrant operational safety and ease of maintenance of plants as well as simplicity of control and stability in plant operation.

- IS 9482 - Power line carrier terminals
- IS 9528 - Manual for Planning of (SSB) PLC Systems
- IEC 60495 - Single Side Band Power Line Carrier Terminals
- IEC 60834 –1 - Tele-protection equipment of power systems - Performance and testing - Part 1: Command systems.
- IS 8997 - Coupling devices for PLC systems
- IS 5802 - Coaxial cables
- IS 8793 - Methods of tests for line-traps
- IS 5561 - Electric power connectors
- IS 3043 - Code of Practice for Earthing
- IS 13241 - Code of Practice for installation and maintenance of indoor PLC Equipment.
- IS 9859-1 - Code of Practice for installation and maintenance of outdoor PLC Equipment – Part-1: Line traps.
- IS 9859-2 - Code of Practice for installation and maintenance of outdoor PLC Equipment – Part-2: Coupling devices.

- IS 9859-3 - Code of Practice for installation and maintenance of outdoor PLC Equipment – Part-3: Coupling capacitor / CVT.

1.3.12.3 Reference Sections

- Section 1.1 - General Technical Requirements
- Section 1.3.5 - Control and Monitoring
- Section 1.4.4 - Switch-yard Control, Protection & Instrumentation
- Part - 2 - Specific Requirements for the Project

1.3.12.4 Submittals and Approvals

The Contractor shall purchase equipment from reputed vendors only and the name of vendors shall be submitted for KSEBL's approval.

Before delivery of equipment to site, the contractor shall submit all work test certificates / reports for approval and obtain despatch clearance from the KSEBL's representative.

1.3.12.5 Deliverable Documents

- Layout drawings of the power house showing the detailed arrangement of communication equipment.
- A complete list giving details of equipment and auxiliaries.
- Operation and maintenance manual covering full details of testing, trouble shooting and repair procedure.

1.3.12.6 KSEBL's Other Requirements

Other technical requirements shall be as given in Part-2 (Specific Requirements of the Project) of this specification.

The tentative layouts of the powerhouse and switch-yard are given in drawings appended to the specifications.

The communication equipment shall be designed for maximum reliable performance under severe conditions of electromagnetic interference, temperature varying from 15°C to 45°C, and 100% relative humidity.

A good and effective earthing system shall be provided for the Communication system. Artificial treatment of the soil shall be done, if necessary, for maintaining desired low resistance of the earthing system and KSEBL's approval shall be obtained prior to the work.

All the metallic parts of the Communication equipment and installations in the powerhouse, switch-yard etc.. shall be connected to the grounding system as prescribed in the relevant standards and guidelines.

All equipment shall be neatly arranged and shall be readily and easily accessible for operation and maintenance.

1.3.12.7 Scope of Work

The scope of work shall be as specified in Part-2 Specific requirements for the Project. Any item of work not specifically mentioned in the specifications but which are usual and / or necessary for the satisfactory operation of the equipment supplied shall be deemed to be provided by the Contractor and included in the quoted Price. All work shall be complete in all details whether such details are mentioned in the specifications or not.

1.3.12.7.1 Intercom Telephone Exchange

The communication system shall consist of:

- One (1) EPABX telephone exchange suitable for twelve (12) number of extensions and four (4) trunk lines complete with distribution frame and power supply unit.
- Twelve (12) number of push button type telephone sets.
- Complete set of cables, fixing and erection material for telephone exchange at powerhouse.
- One set of tools, handling devices, testing cables / probes including connectors, testing instruments and equipment for erection, testing and maintenance of the complete system.
- Any other item not specified above, but necessary for the satisfactory operation / maintenance of the system shall deemed to be provided by the Contractor.

The EPABX with necessary interface and telephones shall be as per relevant standards. The exchange shall be compatible for interconnection to other similar exchanges through microwave radio link as well as overhead line alignment for trunk working.

The exchange shall incorporate a built-in diagnostic unit, which shall assist in identification and localisation of various system faults. Visual and audible alarm shall be provided in the system for fault indications.

The subscribers shall be located at various vulnerable positions to facilitate the communication. Standard PVC cables shall be laid for these subscribers. Some of the

important locations for subscribers may be as follows.

- a) Control room
- b) Switchgear room
- c) Machine hall
- d) Unloading / Erection / Service bay
- e) Drainage / Dewatering motor starter panel
- f) Switch-yard
- g) Fore Bay
- h) Pump house
- i) Security gates
- j) Offices

1.3.12.7.2 PLCC System

Power Line Carrier Communication system will allow the transmission of information (Voice, tele-protection and data) between important stations.

The PLCC system shall be of twin channel type with protection coupler for four commands and data modem, suitable for phase to phase coupling on HT / EHT line.

The PLCC equipment shall be suitable for matching with the same provided at the other ends of HT / EHT feeders.

The PLCC system shall have:

1. Power line carrier terminals
2. Protection Coupler
3. Electronic PLCC exchange with subscriber capacity and trunk lines ports as indicated in Part-2 of this specification (Specific requirement of the project) with required quantity of telephone subscriber set.
4. Line trap
5. Composite line matching unit
6. Co-axial cable
7. 48V DC Battery set and Charger
8. Test instruments

9. Spares

1.3.12.7.2.1 PLCC Equipment

The PLCC equipment shall be suitable for transmission of speech, data, protection, fax messages etc... PLC terminals shall be fully coordinated to match with the specific requirements because of strict requirements of high speed of operation, security, reliability and efficient operation of protection channel along with the carrier terminal. Bidder shall ensure complete foolproof coordination of the PLC and protection equipment, if provided. It shall therefore be necessary to have a provision of mounting the protection coupler in the same rack of PLC terminal without any mismatch or necessity of any wiring or any intermediate coordination unit.

The PLC terminal shall use amplitude modulation with suppressed carrier, single side band, multi-purpose, 4KHz band and shall be site programmable for Audio frequency, Carrier Frequency, Pilot Frequency and transit band pass filters. The equipment shall be suitable for duplex working and shall use the latest technology using Digital Signal Processor.

The PLC terminal shall have common AF bus so that Protection coupler, Data modem (if necessary) etc... can be inserted in reserve slots of PLC terminal in future without any necessity of wiring or any intermediate unit. There should be provision for the Data modem to draw required power for its working from the power bus of the PLC equipment itself.

PLCC terminal shall confirm to the latest IEC 60495. The type test report confirming to this shall be enclosed along with the bid. The equipment shall confirm to the Voltage withstand and electromagnetic compatibility test as per IEC. The type test report confirming to this conducted in presence of third party shall be enclosed along with the bid. In absence of this report the bid will be considered as incomplete and may be rejected. The equipment shall also confirm to the electrostatic discharge test for test points on front panel as per IEC. The type test report conforming to this shall be enclosed.

PLC equipment should have two 4KHz bands. PLC equipment shall be capable of being expanded by addition of channels to a link (i.e. upgrade to 4 channels as appropriate). The PLC equipment shall be modular in construction and shall permit such upgrading to be carried out. The bidder shall describe how the single channel equipment will be upgraded to higher channels.

The PLC terminal shall use multiple modulation / demodulation techniques so as to have better selectivity and overall frequency response.

The equipment shall be suitable for use with E&M signalling between telephone exchanges

at both the ends of the line. Signalling shall be done by shifting the pilot frequency so that a separate band for signalling is not required.

The PLC equipment shall be suitable for remote subscriber operation.

The PLC equipment shall be suitable for 20 watts output power at coaxial terminal, which can be adjusted if required at site to 40 watts.

PLC equipment shall be designed to operate over a frequency band of 40 to 500 kHz, fully programmable at site.

The carrier frequency output impedance shall be suitable for 75 Ohms or 125 Ohms unbalanced. The return loss within the nominal carrier frequency band in the transmit direction shall be not less than 12dB.

The maximum permitted level of spurious emission shall meet the requirements of relevant IEC.

The generation of carrier frequencies shall be fully synthesized. It shall be possible to select any carrier frequency within the whole carrier frequency range in discreet steps of 4KHz. Carrier frequency stability shall be $\pm 10 \times 10^{-6}$ ($\leq \pm 5\text{Hz}$). Further there should be synchronization between transmitter and receiver. Bidder shall describe how the synchronization is done between the PLC terminals.

Each of the PLCC Channels shall be suitable for the following:

- Nominal bandwidth shall be 300 – 3600 Hz and shall be suitable for transmission of facsimile messages preferably at 2400 baud.
- One speech channel 300 – 2000 Hz plus a band of 2000 – 4000 Hz for the transmission of data. Data signalling rates of 50, 200, 300, 600, 1200 baud shall be possible.

1.3.12.7.2.1.1 Transmission for Speech and Protection Channels

Protection channels shall be suitable for coded as well as un-coded transmission and should have in-band signalling i.e. trip signal frequencies shall be transmitted within the speech band without any necessity for separate band for protection.

The equipment shall preferably be capable of operation in all the above modes without the provision of additional module and components.

1.3.12.7.2.1.2 Transmitter Characteristics

The transmitter shall have 2-wire / 4-wire interface. The nominal level for 2-wire shall be

0dBr across 600 Ohms balanced impedance. The input level range shall be adjustable from –16dBr to + 6dBr.

Nominal input level for 4-wire should be –3.5dBr across 600 Ohms balanced impedance. The input level range shall be adjustable from –20dBr to + 10dBr.

The AF band shall have the programming facility so that it can be programmed at site for any of the following bands:

- 300 – 2000 Hz
- 300 – 2200 Hz
- 300 – 2400 Hz
- 300 – 3400 Hz

The data band shall be adjusted accordingly for the following bands:

- 2160 – 3600 Hz
- 2400 – 3600 Hz
- 2640 – 3600 Hz

All the PLCC terminals shall be equipped for transit band pass filter so as to bypass the data signals at the intermediate stations. The transit band pass filter should be suitable for programming at site so that the required pass band can be selected at site.

1.3.12.7.2.1.3 Receiver Characteristics

The receiver shall have 2-wire / 4-wire interface. The nominal output level for 2-wire should be –7dBr across 600 Ohms balanced. It shall be possible to adjust this level from – 16dBr to + 6dBr.

The nominal output level for 4 wire shall be – 3.5dBr across 600 Ohms balanced and shall be adjustable from – 20dBr to + 10dBr.

The near and far end cross talk should be ≤ -50 dBmOp. The group delay distortion shall confirm to IEC 60495.

The Compander shall be a built-in function and shall have the characteristics as per ITU – TG162.

Automatic gain control shall be provided so that AF output should remain constant within + 0.5dB for a +14 / -26dB variation in the RF input level. AGC Time constant shall be 0.5 dB / sec. for level increase or decrease.

Frequency response equalization range of the receiver shall be ± 6 dB.

1.3.12.7.2.1.4 Supervision and Alarm

A supervision facility shall be provided for supervising the PLC terminal so that it can automatically check the functioning of the PLC terminal and in case of any failure of module or any other condition affecting the correct operation of individual components, the same shall be displayed on the front panel with suitable error code.

Alarm shall be given under following conditions:

- Loss of transmitter signal
- Loss of receiver signal
- Low SNR in Speech and Tele-control channels
- Loss of auxiliary supply
- Excessive impulse interference

1.3.12.7.2.1.5 Test Facilities

Local and remote testing of PLCC channels shall be possible. A Local loop test facility shall be provided so that the equipment can be tested locally. A Remote loop test facility shall be provided so that equalization can be done at site from one end by looping back the signal at the other end without deputing an Engineer at the other end.

The PLC terminals shall be designed to give guaranteed performance from 0 to 50°C ambient temperature. Ventilation fans shall be provided for circulation of air inside the cabinets. PLC terminals shall be housed in floor mounting sheet metal cabinets suitable for mounting on concrete plinth as well as channel frame by means of nuts and bolts or welding. The cabinet shall be properly cleaned and spray-painted with two coats of synthetic enamel paint. Exterior of the cabinets shall be painted with smoke Grey glossy finish and shall confirm to a colour shade of 693 of IS5. Interior of the cabinets shall be painted with white enamel paint with glossy finish. All the panels shall be properly earthed to the user's earthing grid. Contractor shall submit the detailed drawing of the cabinet.

All cabinets having PLC terminal shall be provided with lamps of sufficient wattage for interior illumination with switch.

A nameplate shall be provided on the front door of each cabinet indicating channel function, transmitter frequency, and direction etc...

Each PLC terminal for speech as well as for protection purpose shall be provided with a plug in type service telephone (handset) and buzzer. The handset shall be suitable for mounting in a cabinet and shall be used for speech communication on point-to-point basis.

The PLC terminal should have in built test meter for carrying out tests at site. It should have a facility to generate at least 3 tones of different frequencies.

1.3.12.7.2.2 Protection Coupler

The bidder shall offer voice frequency transmission equipment, which shall work on frequency shift or coded signal principle for transmission / reception of protection signals. The equipment is to be used together with the PLC equipment. It shall comprise modules which are directly plugged into reserved slots of PLC terminal so as to avoid any wiring / mismatch between PLC terminal and protection coupler. As such the protection coupler shall derive input power from the PLCC rack itself. Protection channels shall be suitable for coded as well as un-coded transmission and should have in-band signalling i.e. trip signal frequencies shall be transmitted within the speech band without any necessity for separate band for protection.

The equipment shall be suitable for permissive, blocking signals as well as direct trip signal.

The voice frequency transmission equipment shall not only be insensitive to corona noise but shall also remain unaffected by impulse type of noise which is generated by electrical discharge and by opening and closing of circuit breakers, isolators, earthing switches etc...

The equipment shall be unaffected by spurious tripping signals.

The equipment shall be designed in accordance with IEC 60834–1. The type test report confirming to this shall be enclosed along with the bid.

The protection coupler shall be suitable for transmission/reception of two or four commands. Further when the protection coupler is equipped for four commands, it shall be possible to program them as two coded and two un-coded commands.

Irrespective of whether coded or un-coded transmission the trip signal frequency should fall within the speech band without any necessity of separate band for protection commands. Whenever the protection coupler receives the command, it shall disconnect the speech. This interruption will continue for a short period of the Tele-protection command after which the normal operation of the carrier equipment will be restored. During transmission of Tele-protection signals or when a fault has been detected by the protective relays the entire output power of the carrier will be made available for transmission of Tele-protection signals. Bidder shall specify the transmitting frequencies for un-coded as well as coded

command transmission.

The total transmission time for Tele-protection signals shall not exceed 20ms for permissive trip and 30ms for direct trip.

The protection coupler shall use microprocessor techniques with digital signals processing to meet the stringent requirements for command transmission over PLC links even under adverse channel conditions.

The digital counters shall be provided for counting of transmitted and received commands.

1.3.12.7.2.1 Test Facilities

The equipment shall be constructed such that operational reliability of protection channels may be checked over the carrier link by means of local and remote loop test. It shall be possible to carry out the above test from either end of the carrier link. During healthy condition of the transmission line the loop test shall not initiate a tripping command. In the event of a system fault, while loop test is in progress, protection signal shall override the test signal. The test procedure must not initiate tripping command.

The remote loop test shall be initiated either automatically after a particular time interval or manually by means of test buttons.

1.3.12.7.2.3 Electronic Automatic PLCC Exchange

The 12-line EPAX with four trunk lines shall be manufactured to state of the art technology and employ stored program control technique by utilising the principles of time division multiplexing / PCM technology. It shall support single, two or three digit numbering scheme. The telephone sets shall be push button type with DTMF facility. Ringer, priority facility etc... shall also be provided.

1.3.12.7.2.4 Line Trap

The Contractor shall conduct shop tests on dates agreed with the KSEBL and make arrangements for the KSEBL's representative to witness the tests.

All testing envisaged in IS / IEC standards shall be carried out. The Contractor shall make all arrangements, equipment, material and consumables to the tests and prove compliance of the equipment with the standards at shop and at site.

The test reports shall be got approved by the KSEBL before requesting despatch clearance for any item.

1.3.12.7.2.5 Composite Line Matching Unit

The line matching unit shall be outdoor type of continuous rating 100 W, line impedance 600 ohms, equipment impedance 75 / 125 / 150 ohms and pass band 50-500 kHz.

1.3.12.7.2.6 Co-axial Cable

Co-axial cable shall be of 1100 V rating, outdoor service duty type cable of characteristic impedance 125 ohms.

1.3.12.7.2.7 48V DC Battery set and Charger

One lead acid type battery set (Plante type), 48 V, with a rating as per Part-2 and along with a battery charger and DC DB having sufficient number of MCB protected feeders shall be supplied for meeting the D.C Load of Communication system. The above shall be guaranteed for successful operation for a period of 24 months from the date of commercial operation.

Under normal operating conditions the charger will cater to the normal equalising and float charge requirements and also supply the load. The charging system shall be equipped with facilities for manual as well as automatic switching from the floating voltage to equalizing voltage or vice versa when it requires. The charger should be also capable of giving the required Boost charging to the battery while catering to the Load. The load voltage should not exceed the permissible limits while the charger is in the Boost mode of operation. The charger shall be rated for operation on a 230 V, 1 ph, 50 Hz AC system.

The battery charger shall be complete with all auxiliary equipment including alarms for AC Input fail, Charger fail, Under / Over Voltage, Earth Fault, DC Output Fail, Overload, Battery Under voltage etc... Status Indications, Metering and associated controls. Potential free contacts shall be provided for remote alarming of AC input fail and DC Output Fail conditions.

MCB's shall be used for protection in the chargers. An alarm will be provided for MCB tripped condition. In case protection fuses are used internally inside the chargers, these fuses have to be provided with auxiliary alarm contacts for local and Remote Alarm.

The battery charger compartment shall be provided with a door operated light for internal illumination.

The rating / capacity of the Battery specified in Part-2 (Specific requirement of the project) is a minimum for giving a base line. The Bidder should ensure that the Capacity of the offered Battery and Charger is sufficient to take care of the load requirements of the

equipment offered for the concerned project. Any increase in Capacity during detailed engineering stage will not entitle the Successful Bidder / Contractor for any extra charges. Detailed calculations for the determination of the capacity of the Battery shall be submitted by the contractor for approval by KSEBL.

The battery shall conform to the requirement of the relevant ISS. The battery shall be supplied complete with all accessories, inter-connectors, separators, battery stand, electrolyte for first filling, tools, handling devices, testing and commissioning equipment etc... The battery charger compartment shall be provided with a door operated light for internal illumination.

1.3.12.7.2.8 Test Instruments

The following test instruments of reputed make (list of suppliers shall be submitted, prior to procurement, to the KSEBL / Engineer-in-Chief for approval) shall also be provided.

1. Selective level meter - 1 No. (200 Hz to 620 kHz)
2. 7-digit frequency counter - 1 No. (Resolution 1 Hz)

1.3.12.7.3 Acceptance

When all documentation has been approved and all tests have been successfully passed, a final examination of the equipment will be made, and if it is found to be in compliance, the equipment shall be accepted.

1.3.12.7.4 Training

Training of the personal of the KSEBL shall be arranged by the Contractor at the project site to become self-sufficient in all aspects of operations, system and hardware maintenance to the Board (PCB) level. The successful bidder shall submit an outline of the training procedure including the duration, schedule, content etc... to the KSEBL. Training material shall be handed out to the trainees during the training.

1.3.12.7.5 Spares

A complete set of spares recommended by the manufacturer as essential for the satisfactory and trouble free operation of the equipment as per Clause 1.1.32 of this specification, needed for 5 years operation of the above equipment, shall be supplied.

1.3.13 Auxiliary Mechanical Equipment

1.3.13.1 Introduction

The scope of these specifications is to stipulate the basic general guidelines to the Bidder / Contractor for the design, manufacture, testing at manufacturer works, standard and quality of workmanship, general finish of plant, compliance to the latest published edition (prior to the date of closing of tender) of the international standards and recommendations specified throughout the specifications, supply, insurance, delivery and storing at site, erection, site testing, commissioning, performance and reliability confirmation, warranty confirmation of the complete equipment and other general requirements as per **Section 1.1**, which are required for the plant / equipment being provided under the scope of this tender / contract.

Any item of work not specifically mentioned in the specifications but which are usual and / or necessary for the satisfactory operation of the equipment / system shall be deemed to be provided by the Contractor and included in the quoted Price. All work shall be complete in all details whether such details are mentioned in the specifications or not.

This section covers the KSEBL's requirements for the auxiliary mechanical equipment in the powerhouse.

1.3.13.2 Reference Standards and Codes

The Equipment shall be designed, manufactured, tested, installed and commissioned in accordance with the latest revision of applicable IS / IEC or equivalent standards.

The Contractor shall adhere to sound design and construction practices with regard to codes and material specifications in order to warrant operational safety and ease of maintenance of plants as well as simplicity of control and stability in plant operation.

- I S 325 - Three phase induction motors
- I S 9046 - AC Contactors
- I S 13947 - Low voltage switchgear and control gear
- I S 4503 - Heat exchangers
- IS 11465 - Reciprocating air compressors up to 25 kW
- IS 10962 - Reciprocating air compressors above 60 kW
- IS 5456 - Testing of air compressors
- I S 13118 - Circuit breakers

- IS 7613 - Air filters
- IS 8148 - Packaged air conditioners
- IS 1391 - Room air conditioners
- IS 3103 - Code of Practice for Industrial Ventilation
- IS 4720-82 - Practice for Ventilation of Surface Hydel Power Stations
- IS 2825 - Code for unfired pressure vessels
- IS 1646 - Code of practice for fire safety of buildings (general):
Electrical installations
- IS 3034 - Fire safety of Industrial buildings: Electrical Generating and
Distributing Stations – Code of Practice
- IS 1948 - Specification for Aluminium doors, windows and Ventilators
- IS 4721–2000 - Code of Practice for Drainage and Dewatering of Surface /
Underground hydro Electric Power Stations.
- IS 6595-2 - Horizontal centrifugal pump.

1.3.13.3 *Reference Sections*

- Section 1.1 - General Technical Requirements
- Section 1.3.1 - Turbines
- Section 1.3.3 - Generators
- Part - 2 - Specific Requirements for the Project

1.3.13.4 *Submittals and Approvals*

The Contractor shall seek the prior approval of the KSEBL for the following through timely submittals.

- The design and drawings of the Auxiliary system and Equipment as detailed below in Cause 1.3.13.5.
- Calculations for HVAC, Cooling Water systems, Dewatering & Drainage systems, Compressed Air Pressure systems, Fire fighting systems etc...
- **Vendor List - The Contractor shall purchase equipment from reputed vendors approved by the KSEBL only and the name of vendors shall be submitted for KSEBL's approval prior to sourcing the equipment.**

- Material certificates and test reports
- Erection, Testing, Commissioning methodology etc...

Before delivery of equipment to site, the contractor shall submit all work test certificates / reports for approval and obtain despatch clearance from the KSEBL's representative.

1.3.13.5 Deliverable Documents

- Layout drawings of the power house showing the detailed arrangement of Auxiliary systems, clearly indicating dimensions and all important elevations.
- Layout and General Arrangement Drawings of the Cooling Water system, Dewatering and Drainage systems etc... showing details of pipes and fittings and installation details of pump-motor sets.
- Layout & General Arrangement Drawings of panels, circuit diagrams and specifications
- Typical General Arrangement Drawing of Pump – motor sets.
- Catalogues of self cleaning strainers.
- General Arrangement drawings of self cleaning strainers.
- General Layout drawing of compressed air system showing details of pipes and fittings and installation details of compressors.
- General Arrangement Drawing of compressor set.
- General Arrangement Drawing of pressure receivers.
- Electrical Schematic, wiring and terminal connection Drawing of Control Panels.
- Catalogues of level controllers, Strainers, compressor, moisture separator and pressure reducer etc...
- Bill of Materials, Design / Sizing calculations etc...
- Erection, Testing and Commissioning methodology
- Test report / Performance Data
- A complete list giving details (including their make, type, ordering specifications / code, ratings etc...) of equipment and auxiliaries.
- Erection Procedure, Pre-Commissioning and Commissioning Procedures.
- Operation and maintenance manual covering full details of operation, trouble

shooting and repair procedure.

- As-Built Drawings of various systems.

1.3.13.6 KSEBL's other Requirements

Other technical requirements shall be as given in Part-2 (Specific Requirements of the Project) of this specification.

The existing layout of the powerhouse is given in drawings appended to the specifications.

1. The unit cooling system is individual for the unit with cooling water sourced by pumping the water drawn from the tail pool / draft tube.
2. A common drainage system for all leakages, seepages, surface water, floor wash etc... from powerhouse and drainage gallery shall be provided.
3. De-watering system shall have provision for a de-watering sump by the side of the drainage sump for de-watering of penstock, spiral casing and draft tube during inspection and maintenance.
4. All motor starters shall of VFD type with facility for connecting to SCADA.

All equipment shall be neatly arranged and shall be readily and easily accessible for operation and maintenance.

1.3.13.7 Scope of Work

Scope of work shall be as per Part-2, Specific requirements of the project. Any item of work not specifically mentioned in the specifications but which are usual and / or necessary for the satisfactory operation of the equipment supplied shall be deemed to be provided by the Contractor and included in the quoted Price. All work shall be complete in all details whether such details are mentioned in the specifications or not.

Any ratings, if mentioned, are indicative only and are a minimum for giving a base line. The Bidder should ensure that the ratings of the various equipment are sufficient to take care of the design requirements of the equipment offered for the concerned project. Any increase in rating during detailed engineering stage will not entitle the Successful Bidder / Contractor for any extra charges. The Contractor should submit for approval the calculations for arriving at the ratings of the various equipment.

The auxiliary mechanical system shall consists of:

- Cooling Water System
- Drainage and Dewatering System
- Station Compressed Air System
- Oil Handling System
- Fire Fighting System
- Air Conditioning and Ventilation System
- Water level measuring and transmitting device

The **Cooling water system** shall comprise of:

- Two (2) centrifugal type pumps with starter panels.
- Minimum Two (2) Nos. magnetic water flow meters cum switches permanently installed for local display and remote monitoring.
- Necessary pressure and temperature sensing devices etc... for remote indication.
- Differential Pressure Gauges to provide control during operation of Duplex strainers.
- Two (2) Nos. duplex strainer with associated accessories complete bypass arrangements & auto-changer over of filters etc...
- Necessary Piping including fittings, valves, flow meters, maintenance valves and other accessories.

The **Drainage and de-watering systems** shall comprise of:

- Two (2) Submersible pumps with starter panels for power house drainage sump.
- Two (2) Submersible pumps with starter panels for de-watering sump.
- Necessary Piping including fittings, non return valves, level switches, flow meters, maintenance valves, submersible cables and other accessories.
- Other items not specified but required to complete the system in all respects.
- Spares.

Water level Measuring System

Water level measuring & transmitting device for intake and tail race channel shall comprise of the following:

- Level transducer with transmitting device for intake with complete mounting

arrangement.

- Level transducer with transmitting device for tail-race with complete mounting arrangement.
- Water level signals receiving and processing device with mounting arrangement.
- Interconnecting cables between sensors, transmitters and control unit.

Radar type water level measurement system for intake and tail race channel is also acceptable.

Any item of work not specifically mentioned in the specifications but which are usual and / or necessary for the satisfactory operation of the equipment / system shall be deemed to be provided by the Contractor and included in the quoted Price. All work shall be complete in all details whether such details are mentioned in the specifications or not.

1.3.13.7.1 Cooling Water System

1.3.13.7.1.1 General Requirements

The cooling water requirements of generator air coolers, shaft seal, turbine and generator bearings of each unit and generator transformer shall be met either by pumping the water drawn from the tail pool / draft tube or providing a penstock tapping for the same. The penstock tapping shall not be considered in case of high head installations i.e. where the penstock pressure is more than 10 kg/cm². If the penstock tapping results in a pressure of upto 10 kg/cm², a suitable pressure reducer depending on the requirement of net cooling water pressure (usually 3 to 5 kg/cm²) shall be provided. However, as far as possible the penstock tapping for cooling water requirement shall be avoided if the same is not specified in Part-2.

If penstock tapping is specified in Part-2 for Powerhouses with multiple units, then the system requirement is generally as follows. Cooling water system shall be common for all the units. Cooling water will be tapped from penstocks of both turbines through embedded pipes and connected to a common header through isolating valves. One main pump motor set for each unit and one standby shall be used to supply adequate cooling water to generator air coolers and guide bearings of the units. The system shall provide 100 % redundancy operation of the unit pumps. Cooling water requirement of one unit shall be met by one pump. The reserve pump shall be used as standby pump for both units. Cooling water after passing through strainers will be fed to a common header and distributed to

each unit.

The pumps shall be centrifugal type directly driven by 3 phase 415VAC squirrel cage induction motors. The pump motor shall be mounted on common base plate. The impeller of pumps will be made in stainless steel, pump casing in steel casting and shaft in stainless steel. The discharge capacity of each pump shall meet the total requirement of cooling water of one unit.

Suitable Emergency cooling water supply system shall also be provided to care of any instance of failure of both the main and standby pumps. In case of failure of both the main as well as standby pumps, a motorized valve on the supply line from emergency water tank is automatically opened in order to supply enough cooling water for the units to come to a complete stop without overheating. The scheme for the same shall be submitted to the KSEBL for approval.

Motorized self cleaning strainer with discharge capacity 1 ½ times the pump discharge shall be provided after each pump to supply silt free clean water to various cooling circuits. The strainers shall be cleared off accumulated silt automatically through a motorized rotating arm mechanism. Cleaning operation will be operable through pressure differential switch and timers.

Servo operated hydro valve controlled by DC solenoids or motor operated valve shall be provided on feeding line of each unit to control cooling water supply during starting / shut down of units.

Control of the pumps shall be built in Unit Control Panels and their starter panels will be located near the pumps. Control from Central Control system shall be also possible.

All gate valves and non-return valves shall have housing in steel casting and valve seat in stainless steel. Piping shall be complete with sufficient number of bends, elbows, tees, clamps, flanges and fasteners.

The duplex strainer (2 in nos.) shall be fitted with pressure switches to give alarm in case the pressure differential across it exceeds a pre-set value. Pressure gauges shall also be provided to indicate water pressure at its inlet and outlet. The pumps shall be of centrifugal type.

The cooling water system, including the emergency water tank shall be so designed, sized and supplied as to cater to the complete requirement of all the turbines, generators, power transformers and connected equipment, including future additions, if any. The cooling water pressure shall be such that it shall be possible to discharge the outlets from the coolers directly into the tailrace even under conditions of maximum tailrace level.

The cooling water supply scheme shall be of flexible type such that any combination of booster pump and duplex strainer can be used for any of the unit in operation while the other is in shutdown and any of the booster pump can be kept as standby while both the units are in operation. The motors shall be suitable for working on 415 Volts, 3 Phase, and 50 Hz.

For cooling water systems employing the philosophy of pumping the water drawn from the tail pool, the system requirements is generally as follows. The system shall provide cooling water to various turbine-generator components of the units and to water tank upstream of the powerhouse used as emergency cooling water supply. It shall also be possible to expand the system for the future addition of any units, if specified in Part-2 of this specification (Specific requirements of the project).

Each unit shall have its own cooling water pump and duplex strainers. In addition, a common standby pump shall also be provided to meet the cooling water requirement of the units in case of failure of the main cooling water pumps. In case of failure of both the main as well as standby pumps, a motorized valve on the supply line from emergency water tank is automatically opened in order to supply enough cooling water for the units to come to a complete stop without overheating.

The cooling water system, including the emergency water tank shall be so designed, sized and supplied as to cater to the complete requirement of all the turbines, generators, power transformers and connected equipment, including future additions, if any. The cooling water pressure shall be such that it shall be possible to discharge the outlets from the coolers directly into the tailrace even under conditions of maximum tailrace level.

If possible, the cooling water pumps shall be positioned below the minimum tail water level so that no priming is required. Otherwise, the cooling water pumps shall be primed through a motorized valve installed on a bypass supplied by the water tank.

Water is pumped from a sump connected to the tailrace of the powerhouse to a pump room through inlet baskets pre-filtering the water at 25mm. Water is then filtered at 1.5mm through the duplex filters and then distributed to the units and water tank before being discharged back to the tailrace. Each pump shall have its own separate suction line whereas the discharge pipe of each pump shall be connected to a common header through duplex strainer.

The common header shall be connected to the emergency cooling water tank provided outside the powerhouse to meet the cooling water requirements in case of emergency. The common header shall also be suitable for extending to the additional units in future, if any

as specified in Part-2.

The duplex strainer shall be a complete unit with suitable isolating valves at the inlet and outlet, being controlled by a single hand-wheel and gears. The strainer design shall be such that there is smooth flow of water without excessive losses inside the strainer. A differential pressure gauge across the strainer, fitted with pressure switches to give alarm in case the pressure differential across it exceeds a pre-set value, shall be provided. Pressure gauges shall also be provided to indicate water pressure at its inlet and outlet.

Pressure reducers shall also be provided wherever the cooling water is required at reduced pressure.

The system shall be complete with centrifugal pumps, three phase induction motors, pressure gauges, pressure switches, flow relays, flow meters, valves, control panels etc... The system shall be suitable for automatic operation.

One back-flushing connection shall be connected to the standby pump complete with necessary piping and valves in such a way that the coarse intake screen meshes can be cleaned off. The cooling system of each unit shall be connected to the common header and each system shall comprise of the following:

- One automatic valve operated by electric actuator and taking its signals from the station control system.
- Delivery and return connections to and from each of the turbine and generator enclosures. One set of isolating valves on the supply and return line in each enclosure.
- One flow relay with indication and contacts mounted in parallel on each return line from each equipment enclosure.
- The embedded pipes, if any, which are not accessible to maintenance, shall be of superior material ensuring at least 35-40 years of service without maintenance.
- One set of special tools, devices and instruments for assembly, dismantling and testing etc...
- Suitable provision for automatically taking emergency cooling water from the emergency cooling water tank including all piping, valves etc...
- One set of spares suitable for five years of normal operation.

Any other item not specified above, but required for satisfactory operation of the system shall also be included. The offered system should be complete in all respects and any

additions in ratings / equipment arising during detailed engineering stage will not entitle the Successful Bidder / Contractor for any extra charges.

1.3.13.7.1.2 Tests

1.3.13.7.1.2.1 Shop Tests

The shop tests on cooling water system shall include:

- Dielectrics and insulation tests on all electric motors.
- Routine operational tests including starting current, torque/speed characteristics, output torque Vs current characteristics, noise, vibrations on electric motors as per Indian Standard or International standard.
- Operational tests and tests for verification of Performance Characteristics offered of pumps as per Indian Standard/ International standard. Pumps will be tested with at least one actual motor tested and supplied for each type of pump motor set.
- Hydro-static and leakage tests on all valves at 1.5 times the rated pressure.
- Operational tests of self cleaning strainers.

1.3.13.7.1.2.2 Field Tests

Following testes will be carried out at site after installation:

- Dielectrics and insulation tests on all electric motors.
- Operational tests on Pump Motor sets for determination of pump capacity, power drawn at full discharge, vibrations and noise.
- Operational tests on Pump Motor sets for minimum 8 hrs continuous operation to establish trouble free operation.
- Operational tests on control panels and instruments.
- Operational tests on self cleaning strainers.

1.3.13.7.2 Drainage and Dewatering System

Dewatering system will be installed if the same is specifically mentioned in Part-2 of this specification (Specific requirement of the project).

Dewatering system, if envisaged, will have the following features:

The dewatering system shall be designed to dewater the complete unit and penstock in a

period of 2 to 3 hours.

The system shall be of the dry sump closed circuit type. Dewatering of the units will be done by the pumps mounted on the dewatering header in a pump pit located at the lowest point below the draft tube. The water is discharged into the tailrace beyond the draft tube gate above the maximum flood level. Gate valves, check valves and flag valves shall be provided.

The powerhouse, transformer bay, cable tunnels, etc... shall be provided with drainage system for discharging outside, the water coming from seepage and equipment leakage. The design of the pump shall include the leakage from various equipment. Each drainage pump shall provide 100% redundancy. Each pump of drainage or dewatering system shall be capable of working as single unit or in parallel with the other.

If no dewatering pumps are envisaged for the power station, the powerhouse, transformer bay, cable trenches etc... shall be provided with natural drainage system for discharging the seepage and leakage water to the tailrace outside the powerhouse. It is presumed that leakage waters shall be drained to the tailrace by gravity flow. However, if the Contractor feels that dewatering system is necessary, the cost should be included under this head.

Suitable dewatering submersible pumps shall be provided to pump out the water trapped between the penstock gate / main inlet valve and draft tube gate in case of Francis and Kaplan turbines to the dewatering sump when maintenance on the turbine of any unit is required to be carried out. The capacity of the pump shall be chosen in such a way that a single unit can be dewatered within 2-3 hours operation without raising the level in the sump.

All the drainage water within the power house shall be collected inside the drainage sump constructed near the dewatering sump. The drainage water shall be allowed to flow out to the tail race above the maximum tail water level using pumps, if required.

The drainage and dewatering sumps shall be inter-connected by means of gate valve and non return valve which allows the flow of water from the drainage sump to the dewatering sump only. The spindle of the gate valve shall be extended up to the turbine floor so that it is possible to operate it from the turbine floor.

A suitable pressure hatch shall be provided to prevent any flow of water from dewatering sump into the power house. Drainage sump shall not have any pressure hatch.

1.3.13.7.2.1 Scope of Supply

- Vertical Turbine / Submersible Pumps for dewatering - one or two sets

- Level Controller for dewatering pit - one set
- Vertical Turbine / Submersible Pumps for Drainage - two sets
- Level controller for drainage pit - 1 set
- Pipes, valves & fittings - 1 lot
- Special tools and devices for assembly / dismantling of pumps

NOTE :-

1. Dewatering system is not normally required for surface power houses utilizing Pelton, cross flow, tubular and small horizontal Francis type of turbines.
2. Capacity of pumps shall be adequate for the power station.
3. Submersible type pump-motor sets may be offered as alternative in place of Vertical Turbine pumps.

1.3.13.7.2.2 General Design & Constructional Requirements**1.3.13.7.2.2.1 De-watering System**

For de-watering the underwater parts, there shall be provision for a de-watering sump by the side of the drainage sump for de-watering of penstock, spiral casing and draft tube during inspection and maintenance. This sump will be connected to the bottom of the draft tubes of the unit through appropriate size piping and fittings, valves etc... where the drain box is fitted at lowest point of the draft tube to permit flow of water by gravity to the sump by opening a long spindle type gate valve provided at the sump. The de-watering sump shall contain two submersible pumps each having the capacity to handle the de-watering requirement of the units. Piping including fittings, non-return valves, level switches, flow meters, maintenance valves, submersible cables and other accessories shall also be provided with the pumps to be installed for the de-watering sump. One set of local control panel for automatic / manual operation of pumps shall also be provided with pumps. The drainage and de-watering sumps shall be interconnected with each other by means of appropriate size piping and valves so that both systems can supplement each other whenever required.

The dewatering will be done first by allowing the water in the penstock and spiral casing to flow into the tailrace either through the wicket gates or by opening the penstock drain valve till the water in the penstock reaches the tail water level and then by opening the drain valve in the sump for draft tube dewatering after closing the draft tube gate. The dewatering

sump shall be provided one sealed cover and covered man-hole.

The covers, pump base and level sensor's base shall be designed to withstand full tail race water pressure.

Dewatering system shall consist of two numbers of vertical turbine pump sets or some other type such as submersible type with bronze impellers of sufficient number of stages to pump the water out of the sump into the tailrace above maximum tail water level, one set of level controllers, pipe lines and valves. Each pump should have adequate capacity so as to be capable of dewatering the turbine in 2 – 3 hrs. Level controllers shall be provided in the dewatering sump to start / stop the pumps automatically & to give alarm at a preset level. Leakage of water from intake & Draft tube gates may be assumed as 0.15% of rated discharge of turbine. The pump shall discharge into tail race above the maximum tail water level. Suitable wall mounted control panel with starter, etc..., shall be supplied. Provision for manual operation shall be made on the control panel. The pumps shall be driven by vertical shaft totally enclosed, fan cooled, squirrel cage induction motor.

1.3.13.7.2.2 Drainage System

A common drainage system for all leakages, seepages, surface water, floor wash etc... from powerhouse and drainage gallery shall be provided. All the seepage and leakage water (including water resulting from any fire fighting operation) from different floors of the powerhouse shall be canalised into a common drainage trench through different drainage headers. From drainage trench water shall flow to a drainage sump of powerhouse. The sump shall have the capacity to handle the drainage of floors and seepage water etc... The sump shall have two (2) continuous duty submersible pumps with suitable water level switches for auto-starting and stopping of pumps. The water from drainage sump shall be pumped in the tail-race channel. Piping including fittings, non-return valves, level switches, flow meters, maintenance valves, submersible cables and other accessories shall also be provided with the pumps to be installed for the sump. One set of local control panel for automatic / manual operation of pumps shall also be provided with pumps.

The equipment for the station drainage system shall be similar to that for the dewatering system described above, except that each of the turbine pump of the drainage system shall have sufficient rating to cope with the station drainage comprising leakages / seepage from downstream, walls, pipes, etc... The motor, pipes, valves etc... shall be suitable for the pump rating.

Floor drains shall be provided at all floors and drain discharge pipes shall be properly sized

taking into account the fire water sprinkler system wherever provided.

A suitable drainage sump will be provided by the Contractor so as to permit drainage by gravity into this sump. The water from the drainage sump shall be discharged into the tailrace above the maximum tailrace water level. The dewatering and drainage sumps shall be inter-connected through a gate valve and non-return valve to allow rising water in the drainage sump to be drained into the dewatering sump on failure of both drainage pumps to cope with station drainage water.

The drainage system (common for Power house) shall consist of two vertical turbine / submersible pumps (one main & one stand by), one set of level controllers, pipe lines and valves. The pumps shall be of adequate capacity to remove normal seepage & drainage water. The electric motor, pipes & valves shall be suitable for the pump rating. Automatic control of the pumps shall be arranged through level electrodes. Provision for manual operation shall be made on the control panel. Control of the pumps shall be built in Unit Control Panels and their starter panels will be located near the pumps.

1.3.13.7.2.2.3 Pump-Motor Sets

The pumps shall be of submersible type having discharging capacities appropriate for the purpose i.e., Drainage system or De-watering system. The impellers of vertical turbine pumps shall be manufactured from stainless steel and the casing of impeller from steel casting. The pump casing and impellers shall be provided with removable type of stainless steel liners. The shaft shall be of alloy steel with stainless steel sleeves where it passes through bushes. The electric motors shall be squirrel cage induction motors with hollow shaft and ratchet arrangement to prevent reverse rotation. The enclosure of the motors shall be drip proof type. The contractor shall do necessary calculations for selecting the rating of pumps etc... The pumps shall be suitable for continuous operation, capable of pumping water with heavy silt, directly driven by electric motor, rotational speed of which shall not be more than 1450 /1500 rpm.

1.3.13.7.2.2.4 Valves, Pipes and Fittings

All gate valves and non-return valves shall have housing in steel casting and valve seat in stainless steel. All piping shall be of seamless steel, heavy-duty class. Piping shall be complete with sufficient number of bends, elbows, tees, clamps, flanges and fasteners. Valves shall be located in accessible positions. All piping shall be routed at a clear height of minimum 1.5 m from the nearest access level for clear man movement. Best engineering practices shall be adopted for keeping the minimum clear working space around equipment

and clear headroom within main structures and cable trays etc...

1.3.13.7.2.3 Tests

1.3.13.7.2.3.1 Shop Tests

The shop tests on drainage / dewatering system shall include:

- a) Dielectrics and insulation tests on all electric motors.
- b) Routine operational tests including starting current, torque / speed characteristics, output torque Vs current characteristics, noise, vibrations on electric motors as per Indian Standard or International standard.
- c) Operational tests and tests for verification of Performance Characteristics offered of pumps as per Indian Standard / International standard. Pumps will be tested with at least one actual motor tested and supplied for each type of pump motor set.
- d) Hydrostatic and leakage tests on all valves at 1.5 times the rated pressure.
- e) Operational tests on level controllers.

1.3.13.7.2.3.2 Field Tests

Following testes will be carried out at site after installation:

- a) Dielectrics and insulation tests on all electric motors.
- b) Operational tests on Pump Motor sets for determination of pump capacity, power drawn at full discharge, vibrations and noise.
- c) Operational tests on Pump Motor sets for minimum 8 hrs continuous operation to establish trouble free operation.
- d) Operational tests on control panels and instruments.

1.3.13.7.3 Measures to Prevent Flooding of Powerhouse

Following provisions shall be made for protection of Power House against flooding:

- i. In addition to drainage and dewatering pumps as per above clause, suitable number of submersible pumps with provision for automatic starting by means of level switches / suitable means for draining flood water in MIV area shall be provided at main inlet valve (MIV) floor.
- ii. The control panels for dewatering and drainage pumps shall be located at a floor higher than that of turbine floor.

- iii. Suitable float switches shall be provided in power house building to give closing signal to the MIV in the event of inundation of power house due to any reason including penstock rupture or leakage in penstock or for some other reasons.

1.3.13.7.4 Station Compressed Air System (HP and LP)

High pressure (HP) compressed air system shall be provided to meet the compressed air requirement of turbine governing system and MIV. The pressure of HP air compressor shall be 1.1 times the governor working pressure. However, the HP compressed air system shall not be required in case the high pressure nitrogen system has been provided for turbine governing system and MIV.

Low-pressure (LP) compressed air system shall generally be rated at 7.0 kg / cm² to meet requirements such as inflatable rubber seal of shaft glands, operation of pneumatic tools, cleaning, generator braking and jacking, boosting pressure in the fire protection hydro-pneumatic tank, pneumatic detection line for the operation of deluge valve provided for the generator transformer, etc...

The station compressed air system supplies air to the generator brakes, to the governor (if required) as well as station service and distribution stations. The system shall comprise of the following:

Two (2)	Three-Stage Reciprocating Compressor units complete with motors, starter control panel, interconnected piping, valves, safety devices, gauges, indicating instruments, suction filter, air dryer etc...
One (1)	High Pressure Air receiver of suitable size complete with pressure switches, safety relief valves, isolating valves, moisture trap, indicating instruments etc...
One (1)	Low Pressure Air receiver of suitable size for Generator Brakes and complete with pressure switches, safety relief valves, isolating valves, indicating instruments etc...
One (1)	Set of piping, fittings, valves, tapping points suitable for quick coupling, etc... for entire powerhouse area for feeding governor system etc... as per requirement.
One (1)	Set of special tools and devices for assembly and dismantling of compressor units.
One (1)	Provision of necessary contacts and / or ports for integration with plant

SCADA system.

One (1) Set of spares for 5 years of normal operation.

Any other items, not specified above, but are required for satisfactory operation of compressed air system shall also be included in the Bidder's / Contractor's scope.

This system is generally not required mini and micro hydro sets up to approximately 1000 kW rating. For small and medium size power stations, compressed air system is required for Governor O.P.U., Generator Braking and service air and consists of as specified above.

The totality of the required compressed air flow is provided by one compressor while the second compressor is used as standby. The compressors shall be noise free. The system shall have a nominal pressure of 7 to 10 bars and shall be sized to meet the service air requirements for:

- For generator braking system
- For governor oil pressure units, if required
- Operation of pneumatic tools during maintenance
- Service air for cleaning and miscellaneous use
- For air lines of fire protection system
- For Bus ducts pressurization as required etc...

Adequate number of tapping points shall be provided in the machine floors, erection bay, transformer bay, outdoor switch-yard etc...

Starting and stopping of the compressors are controlled by pressure switches. If the minimum air pressure required is not maintained in the air receiver, the standby compressor shall start automatically. The control system shall provide for the following:

- Selector switch for manual / automatic operation
- Selector switch for main / standby compressor
- On / Off push buttons and indicators for compressor units
- High and low pressure alarm

The air receiver of adequate capacity shall be designed and constructed in accordance with ASME pressure vessels code. The Air receiver shall be provided with:

- One hermetically sealed manhole
- One safety valve

- Pressure gauges, pressure switches etc...
- Necessary relays for operation of compressors.

1.3.13.7.4.1 General Design and Constructional Requirements

Compressed Air System shall be common for all the units. Two reciprocating multistage compressors driven by electric motors shall be provided to feed compressed air in the air receiver. One of the compressors shall work as main and other as standby. Their operation shall be made automatic with the help of pressure switches. Compressed air after passing through air dryers shall be fed to one high-pressure air receiver. One low-pressure air receiver shall be provided for generator brakes. Compressed air from high-pressure air receiver shall be tapped and fed to low-pressure air receiver through one pressure reducer.

Pressure rating of each compressor shall match maximum pressure requirement of oil pressure unit and generator brakes. The supplier shall check air requirement of the system and provide higher capacity, if required keeping compressor duty cycle in view. **Design calculation regarding compressor capacity and strength calculation of air receivers shall be submitted for approval of the KSEBL.**

The compressors will be driven by 3 phase, 415 VAC completely enclosed, fan cooled, squirrel cage induction motors with class F insulation through belt drive.

Compressor and motor shall be mounted on a common base plate, which shall be installed on floor with the help of foundation bolts.

Indian Standard IS 2825 shall be followed for design, manufacture and testing the air receivers.

The motor starter panel housing contactors, switch fuse units and meters etc... shall be mounted on the wall near the compressors and wired complete with leads labelled.

The connections to each motor shall be arranged so that either compressor may be removed for repair or replacement without interfering with the continuous operation of the other.

System design shall be subject to approval of the KSEBL.

1.3.13.7.4.2 Shop Tests

The shop tests on compressed air system shall include:

1. Dielectrics and insulation tests on all electric motors.
2. Routine operational tests including starting current, output torque Vs current

characteristics, noise, vibrations on electric motors as per Indian Standard or International standard.

3. Operational tests and tests for verification of Performance Characteristics of compressors as per Indian Standard / International standard. Compressors will be tested with their respective motors.
4. Hydrostatic pressure tests on air receivers at 1.5 times the rated pressure.
5. Hydrostatic and leakage tests on all valves at 1.5 times the rated pressure.
6. Operational tests on pressure reducer

1.3.13.7.4.3 Field Tests

Following tests will be carried out at site after installation:

1. Dielectrics and insulation tests on all electric motors.
2. Operational tests on compressors for minimum 8 hrs continuous operation to establish trouble free operation without abnormal vibrations and noise.
3. Operational tests on control panels and instruments.

1.3.13.7.5 Oil Handling System

The insulating oil required in the generator transformers for the hydro station shall conform to relevant IS. The type of turbine oil used as a working fluid in speed regulation system and as a lubricant and a coolant for thrust and guide bearings shall be as per the recommendations of the equipment manufacturer.

The oil handling system for each grade of oil shall incorporate two tanks (one for pure oil and another for used oil), associated piping and control equipment.

The oil handling facilities shall be located within the powerhouse or in an isolated building outdoors. To convey the oil to the turbines, generators and transformers, suitable oil pipes shall be laid within the powerhouse. Portable type pumps and purifiers and standard oil drums shall be used for small hydroelectric stations.

Generally, the system shall comprise of the following:

- One (1) Indoor station centrifuge type governor/ lubricating oil purifier of suitable capacity to purify the complete oil of one unit in less than 24 hours, complete with motorized pumps, electric heaters, thermostatic control, instruments etc...

Two (2)	Oil storage tanks of adequate capacity of one unit and 25% extra complete with manhole with hermetically sealed cover, oil inlet and outlet pipe connections, connection for oil purification and drying equipment, drain connections, level gauges, etc...
Two (2)	Online electrostatic oil filters with LVDH for each unit's governor oil system.
One (1)	Mobile insulating oil treatment plant complete with feeding pump, oil heater, thermostatic control, filtering compartment, vacuum pump, dehydrating compartment, discharge pump, control panel, piping, fittings etc... for treatment of transformer oil within a reasonable time.
One (1)	Mobile transfer pump for filling the clean oil in drums for transfer to units. Mobile tanks for carrying oil shall also be supplied.
One (1)	Set of special tools, devices etc... for assembly and dismantling of various components of oil handling system.
One (1)	Set of spares for normal operation for 5 years.

Any other items not specified above, but are necessary for satisfactory operation of the plant.

Suitable ICTP switches, connected to the main LT panel with ample sized cables, shall be provided in the transformer bay, generator floor and turbine floor in suitable locations to connect the oil purifying equipment.

An oil handling area with the purification plants for lubricating oil will be set up near the portal of the access tunnel. Oil purification will be carried out in this area before transporting it into the powerhouse for filling in the equipment's.

Any item of work not specifically mentioned in the specifications but which are usual and / or necessary for the satisfactory operation of the Fire Fighting System and Oil Handling System supplied shall be deemed to be provided by the Contractor and included in the quoted Price. All work shall be complete in all details whether such details are mentioned in the specifications or not.

Any ratings, if mentioned, are indicative only and are a minimum for giving a base line. The Bidder should ensure that the ratings of the various equipment are sufficient to take care of the design requirements of the equipment offered for the concerned project. Any increase in rating during detailed engineering stage will not entitle the Successful Bidder / Contractor for any extra charges. The Contractor should submit for approval the calculations for

arriving at the ratings of the various equipment.

Lubrication Oil Purifying System

The lubrication oil purifying system suitable to purify bearing oil, governor oil and inlet valve oils shall consist of one mobile purifying plants complete in all respects the oil hoses shall be of sufficient length and size to connect lubrication oil purifying plant to various equipment / components / systems.

The lubrication oil purifying plant shall be mounted on a trolley and shall be furnished with power cable of sufficient length. The system shall have its control panel mounted on the same trolley having purifying plant. Pressure gauges, push-buttons for starting and stopping and a volume meter with manual zero reset shall be located on the control panel with necessary protection system.

The lubricating oil purifier shall be centrifuge type required for the purification of lubricating oil. The capacity of the purifier shall be 5000 (Five Thousand) litres / hr. The lubricating oil may contain free and dissolved moisture of the order of 1000 to 2000 PPM initially which needs to be reduced in the range of 50 PPM, in not more than 2 passes after purification by purifier. Besides moisture, the oil may contain suspended impurities such as cotton waste, welding slag and spatters, metallic chips, small sand particles, iron fillings, pebbles, dust and pipe scales. The offered equipment shall not be damaged by the flow of oil containing these impurities. The oil may also contain grease and kerosene, which shall also be required to be removed. The size of suspended particles in the purified oil leaving the purifier shall not be bigger than 1 microns.

The lube oil filtration unit shall be a portable one and shall consist of combination of low vacuum dehydration (LVDH) and Electrostatic cleaners (ELC) using an online moisture sensor with all required accessories like vacuum pump of suitable rating, Balancing tank of suitable capacity, Vacuum chamber of sufficient capacity etc... The moisture removal efficiency shall be up to 500PPM, removal of particle up to 1 micron and shall have overload protection.

Pipes, Fitting and Hoses

All pipes shall be seamless steel tubes. Fittings shall be forged or compression type steel fittings with cutting ring seal. Hoses shall be steel-armoured, oil resistant and of suitable lengths. The hoses shall be provided with leakage-proof, quick-connect couplings. The hoses shall be able to withstand the required pressure and temperature of oil during the filtration process.

1.3.13.7.6 Fire Fighting System

The fire fighting system shall consist of:

1. Portable fire extinguisher system for the power house and switch yard as per guide lines of TAC, of Govt. of India.
2. Automatic fire detectors as per approved drawings and bill of materials.
3. Necessary cabling and wiring for fire detection system including associated accessories, consumables etc...
4. Other items not specified but required to complete the system in all respects to make it functional.
5. Spares.

1.3.13.7.6.1 Fire Fighting System for the Powerhouse

Fire fighting arrangements at the generator floor, control room, switchgear room etc... of the power house shall be provided. The equipment / system shall comprise fire / heat / smoke detectors, portable fire extinguishers and fire buckets as per the IS / relevant standards.

Comprehensive fire detection, alarm and protection system shall be provided for the Station in conformity with relevant IS. In addition, all buildings shall conform to National Building Code. Fire protection system shall be designed as per the guidelines of Tariff Advisory Committee (TAC) established under Insurance Act 1938 and / or NFPA.

Automatic fire detection and alarm system shall be intelligent and addressable type and shall be provided to facilitate detection of fire at the incipient stage and give warning to the fire fighting staff.

Major equipment to be used for fire detection and protection system shall be in accordance with Indian Standards or UL (Underwriters Laboratories, USA) or FM (Factory Mutuals, USA).

Dedicated fire-water storage and pumping facilities shall be provided for the fire fighting system as per TAC guidelines. Main fire-water pumps shall be electrically driven and standby pumps shall be diesel engine driven.

Hydrant system, complying with TAC guidelines, shall be provided at various locations to cover the entire Station. The fire protection system as well as hydrant system shall be designed complying with the guidelines of Tariff Advisory Committee (TAC) or NFPA as applicable.

All major and minor fire risks in the Station shall be protected against fire by suitable automatic fire protection systems. Following systems shall be generally adopted for various fire risks:

- a) Automatic high velocity water spray system, complying with TAC guidelines, shall be provided for the following areas:
 - Transformers of rating 10 MVA and above or oil filled transformers with oil capacity of more than 2000 litres shall be provided with automatic high velocity water spray system as per relevant IS. Alternatively, these transformers may be provided with Nitrogen injection based fire protection system. The transformers of 220kV or higher voltage may preferably be provided with Nitrogen injection based fire protection system in addition to automatic high velocity water spray system.
 - Lube oil systems including storage tanks, purifier units, coolers, turbine oil canal pipelines.
 - Generator seal oil system tanks, coolers.
- b) All major and minor fire risks in the Station such as transformers, cable galleries / shafts, control rooms etc... shall be protected against the fire by suitable automatic fire protection systems. The state of the art automatic fire detection and alarm system shall be provided to facilitate detection of fire at the incipient stage and warning to fire fighting staff. Automatic medium velocity water spray system, complying with TAC guidelines, shall be provided for the following areas:
 - Cable galleries, cable vaults, cable spreader rooms, cable risers, cable shafts etc...
 - Fuel oil pumping stations.
 - DG set building.
- c) The provision shall be made for water sprinkler system for oil plant rooms, especially in an underground powerhouse. In addition, provision shall also be made for fire hose cabinets / hydrants inside the powerhouse as well as for the transformer area. The capacity of overhead / pressurised water tank shall be adequate to meet the fire water requirement for one generator transformer for 40 minutes, plus operation of one hydrant for 60 minutes. Two nos. of fire pumps, each capable of pumping water to fill the overhead / pressurised water tank in reasonable time shall be provided. The above-indicated figures are the minimum

requirement.

- d) Automatic foam system shall be provided for fuel oil storage tanks as per NFPA.
- e) Automatic inert gas flooding system, comprising of 2x100% inert gas cylinder batteries and conforming to NFPA, shall be provided for Unit control rooms, control equipment rooms and area above false ceiling of these rooms, if specifically required in Part-2 of this specification.
- f) Portable and / or mobile fire extinguishers as per TAC guidelines shall be provided for each room/area of power station in addition to fixed fire protection system to extinguish fire in its early phase to prevent its spread.
- g) Passive fire protection measures such as fire barriers for cable galleries and shafts etc..., fire retardant coatings, fire resistant penetration sealing for all openings in floors, ceilings, walls etc..., fire proof doors etc... shall be provided to prevent spreading and for containment of fire.
- h) Fire fighting training to the staff of the station shall also be provided.

The arrangements of fire protection in Power House and its switch-yard have been divided under the following three groups:

- a) Fire protection scheme for Generators.
- b) Fire protection for generator transformers located in outdoor switch-yard.
- c) Fire protection of the area and equipment in power house not covered under above two groups.

The details of the equipment and method of fire fighting scheme for above referred equipment / area shall be designed, manufactured, installed and commissioned generally as per the following scheme.

1.3.13.7.6.2 Fire Protection Scheme for Generators

Either water based or CO₂ type of fire suppression system shall be provided. A water-based system shall be adopted in underground power stations because release of CO₂ gas in an underground installation shall be hazardous.

For CO₂ type of fire suppression system, an automatic CO₂ fire protection system, common for all the generators, comprising of two banks of connected CO₂ cylinders (ie. One as main and other as reserve) and ring headers, piping, discharge nozzles, thermostat, temperature detectors etc..., shall be supplied. Each bank shall consist of CO₂ cylinder both for initial as

well for delayed discharge and complete with pipes and valves. Both the initial discharge and delayed discharge shall commence discharging at once, the initial discharge within 2 minutes while the extended discharge shall maintain the concentration of about 25% for 30 minutes. Extended discharge shall be maintained by restriction of diameter of pipes and nozzles. Provision for manual release of CO₂ to individual machines from control room shall be provided.

A fire alarm panel with required number of heat, smoke sensors etc... shall be provided as per standards. The fire protection system shall be provided with valves, control unit nozzles etc... Conduit boxes and necessary wiring to a suitable junction box shall also be provided in the hot-air stream on the inlet side of the coolers and above the stator winding, to mount the fire detectors.

The temperature detectors shall be of the rate of the rise of temperature type. Automatic control shall be arranged to discharge CO₂ into the generator in the event of operation of temperature detector or of the differential relay of the generator (if provided). The system shall be complete with manual operation arrangement to release CO₂ and with all necessary pipes, fittings, directional valves, etc...

For water based fire suppression system, the fire extinguishing equipment for the generators shall generally be of water sprinkler system. In the event of fire occurring inside the generator, the water sprinkler system would be automatically initiated, by one or more of the special detectors provided in the generator air circuit. The system may also be operated, if required, by manual push button operation to be located at very conveniently approachable place.

1.3.13.7.6.3 Fire Protection of other Areas

The remaining areas of the powerhouse shall be provided with following fire fighting arrangements.

i. Fire detectors

The following locations of equipment shall be provided with fire / heat / smoke detectors. These detectors shall be installed directly above the equipment / most suitable locations.

- Generator Floor
- Control Room
- LT and 11 kV switchgear area

- Any other location deemed necessary.

These fire / smoke detectors shall initiate alarm and indication in the Fire Alarm Panel to be installed in the control room to identify the location of smoke / fire to enable corrective actions. The central alarm & annunciation panel shall also have a connection from the detectors.

ii. Portable Fire Extinguishers

Portable Fire Extinguishers of various types of fire extinguishers of requisite capacity shall be located at appropriate locations in the powerhouse as follows:

Type of Extinguisher	Quantity	Location
Trolley mounted CO ₂ type	2 Nos each	On Generator floor and 11kV switch yard.
CO ₂ type	6 Nos	Control room, switch-gear room
Foam type	4 Nos	Near OPU, Stores etc...
Dry Chemical type	6 Nos each	Control room and switch-gear room.
Inert gas clean agent system	5 Nos	General Electrical Installations, HT / LT switch-gear etc...

iii. Fire Buckets and Hydrants

Two sets of fire buckets, each set comprising 6 buckets filled with sand, shall be provided on covered steel stand at various places in 11 kV switch yard area.

Fire buckets filled with sand shall be provided on covered steel stand in switch-yard, unloading bay and machine hall. Water pipe line shall be laid in machine hall and fire hydrant hosepipes shall be provided at two different locations. The specification IS : 3844-2005 shall be adhered to for these works.

The Hydrant system shall consist of steel pipes water distribution system kept charged by a Over head water storage tank of adequate capacity. The overhead tank shall be filled by pumps. The water distribution system shall extend through powerhouse. The water system shall also supply water to hose stations for providing general protection through the powerhouse and outdoor switch-yard area.

Sufficient number of Portable extinguishers of adequate capacity will be located at each hose station at various elevations in the powerhouse, transformer area and switch-yard; various types of portable extinguishers shall be selected depending on

specific requirements.

Hand held portable extinguishers should be located at various points in the powerhouse for operation in case of emergency.

One set of special tools, devices, instruments etc... required for the system shall also be supplied.

The details of fire fighting system proposed by the contractor shall be submitted along with the offer. KSEBL's approval for the system shall be obtained prior to delivery of the items.

1.3.13.7.7 Air Conditioning and Ventilation System

A ventilation and air-conditioning system shall be provided as per the requirements specified in Part-2, to achieve proper working conditions inside the power house complex, to serve the purposes such as prevention of temperature stratification, removal of contaminated air, removal of waste heat from equipment as well as provide fresh air necessary for human comfort with regard to temperature, humidity, and oxygen content, and to extract / force out smoke and other toxic gases during fire.

Suitable system for circulation of natural air and exhaust shall be provided as a minimum requirement. Cooling of air, wherever required, may be provided by evaporating, water cooled cooling tubes or chiller units.

A choice of installation out of 3 different types of installations i.e. split type, package type or centralized air conditioning plants shall be made on the basis of the required tonnage and suitability of the installation at that particular location.

The air conditioning system shall provide conditioned air in powerhouse control room, communication room, conference hall etc... The system shall be designed to maintain a temperature of 24°C at suitable humidity of 50 ±5% in all air-conditioned areas.

Each split air conditioners shall be complete with compressor, condenser, air handling unit, cooling coil, humidification package, filters and vibration isolation pads, control and instruments etc... The evaporator unit shall be horizontally / vertically / floor mounted type as required and constructed of galvanized steel sheet of thickness not less than 18 gauge. It shall be suitable for indoor installation and shall have provision for draining out condensate water. The fan shall be of centrifugal type made of heavy gauge aluminium designed for low noise operation. The cooling coil section shall consist of copper tubes with aluminium fins to provide efficient heat transfer between tubes and fins. Air filters for the

blower suction shall be of synthetic washable type provided. Coil filters shall not be acceptable.

The condensing unit shall be supplied in weatherproof heavy gauge enclosure suitable for outdoor installation. Each unit shall comprise of 2 or 3 independent hermetically / semi-hermetically sealed compressor units together with associated air cooled condensers, refrigerant tubing and electrical system so that if one compressor unit is down, the other compressors can remain in service. The condenser tubes shall be of copper having extended aluminium fins. The compressor shall be easily accessible during running of the unit.

Redundancy of the Air conditioners shall be 2x100% or 3x50%. All the equipment of air conditioning system shall be designed for continuous duty. For fans, compressors and blowers continuous Motor rating (at 50°C ambient) shall be at least ten percent (10%) above the maximum load demand of the fan, compressors, blower at the design duty point.

All GI sheets under air conditioning system shall be hot dip galvanized or spray galvanized unless otherwise specified and minimum zinc deposition shall conform to class 275 of IS: 277.

In the Control room, false ceiling shall be provided 3m above the finished floor level and shall be of non luminous (opaque) type fire resistant material. Glass areas exposed to sun shall be provided with Venetian blinds of light colour.

Sufficient numbers of ventilating fans shall be provided in all other areas for proper ventilation.

There shall be forced air ventilation to generator floor, turbine floor, spherical valve area, service bay, Cable vault, switchgear room etc... Mechanical type ventilation system using supply air fans, exhaust air fans or roof exhausters as applicable shall be provided for the above purpose. Ventilation of the turbine pit with suitable exhaust system for removing welding fumes during maintenance shall be provided.

Sufficient number of exhaust fans of suitable capacity shall be provided in the battery room, toilets etc... for their ventilation. Gravity louver dampers shall be provided for all exhaust air fans.

The number of air changes per hour in evaporative/ mechanically ventilated areas shall be as follows:

<u>Sl. No.</u>	<u>Area</u>	<u>Air changes</u>
1.	General areas except toilets and pantries	15
2.	Various switch-gear / MCC rooms, pump rooms, toilets, pantries etc...	20
3.	Battery rooms etc... where gaseous fumes are generated	30

In the areas producing lot of heat, the temperature limitation shall be the criteria for ventilation system design. In this case the inside dry bulb temperature shall be maximum 3°C above the summer design ambient dry bulb temperature during summer.

The criterion, which gives higher number of air changes / higher quantity of air in either of the conditions as mentioned above, shall be the basis for selecting the required airflow for that area.

All ventilation systems shall be designed for continuous duty and shall operate on 100% fresh air basis. For fans and blowers continuous motor rating (at 50°C ambient) shall be at least ten percent (10%) above the maximum load demand of the Fan / blower at the design duty point.

All mechanically ventilated areas shall be positively ventilated by means of supply air fans, generally in combination with exhaust fan / roof extractors. Wherever exhaust fan / roof extractors are not provided, such as MCC / switchgear rooms, the pressurized condition shall be maintained with gravity operated back draft dampers. However, as exception, hazardous areas and fumes / odor generating areas such as toilets shall be negatively ventilated by means of exhaust air fans / roof exhausters and inlet louvers.

Supply air fan catering for electrical switchgear / MCC rooms shall be provided with pre-filters and fine filters, while supply air fans for other areas shall be provided with pre-filter only.

Supply air fans, exhaust air fans and roof ventilators / extractors of each area shall be provided with their local starter panel.

All accessories such as rain protection exhaust hood, transformation piece, vibration isolators, Galvanized bird screen etc... as required shall be provided for the ventilators / extractors.

The operations of the air-conditioning and ventilation systems shall be interlocked with the fire alarm system.

The sizing calculations for all the equipment shall be furnished by the bidder and shall be subject to approval of the KSEBL.

Following shall also form part of the scope of supply as a minimum:

One (1) set of spares for all the above requirements for normal operation of 5 years.

One (1) set of special tools, devices, test devices, etc... for assembly, installation, testing commissioning and dismantling etc...

Any item of work not specifically mentioned in the specifications but which are usual and / or necessary for the satisfactory operation of the equipment / system shall be deemed to be provided by the Contractor and included in the quoted Price. All work shall be complete in all details whether such details are mentioned in the specifications or not.

Any ratings, if mentioned, are indicative only and are a minimum for giving a base line. The Bidder should ensure that the ratings of the various equipment are sufficient to take care of the design requirements of the equipment offered for the concerned project. Any increase in rating during detailed engineering stage will not entitle the Successful Bidder / Contractor for any extra charges. The Contractor should submit for approval the calculations for arriving at the ratings of the various equipment.

1.3.13.7.7.1 Tests

The Contractor shall conduct shop tests on dates agreed with the KSEBL and make arrangements for the KSEBL's representative to witness the tests.

All testing envisaged in IS / IEC shall be carried out. The Contractor shall make all arrangements, equipment, material and consumables to the tests and prove compliance of the equipment with the standards at shop and at site.

The test reports shall be got approved by the KSEBL before despatch of any item.

1.3.13.7.8 Water Level Measuring & Transmitting Device

1.3.13.7.8.1 Scope of Supply

Water level measuring & transmitting device for intake and tail-race channel shall be provided if required as per Part-2 and shall comprise of the following:

- Level transducer with transmitting device for intake with complete mounting arrangement.
- Level transducer with transmitting device for tail race with complete mounting

arrangement.

- Water level signals receiving and processing device with mounting arrangement.
- Interconnecting cables between sensors, transmitters and control unit.

1.3.13.7.8.2 General Design and Constructional Requirements

For monitoring water level upstream of intake gates, one set of suitable electronic level sensor (strain gauge or capacitance type) and transmitter unit shall be provided for transmitting the water level signal to controlling unit mounted in control & metering panels in control room. One set of identical level sensor and transmitter unit shall be provided for water level in tail-race. The signals from both the units shall be analogue signals in the form of 4 to 20 mA. These signals shall be processed in centralized control unit. Necessary power supply to sensors and transmitting units shall be provided from control unit.

Output signals for fore-bay level, tailrace level and their difference shall be provided from the control unit for further utilization in Governor electronic cubicle and SCADA. Digital indicators shall be provided in the control unit for indicating fore-bay level, tail-race level and their difference i.e. gross head. The device should be of reliable make.

The level sensors shall be mounted inside a pipe in such a way that oscillations in water level are damped out and pipe do not get clogged by floating materials or silt etc... complete with mounting accessories.

Level sensors should be hermetically sealed and it should be possible to take out and calibrate them easily.

1.3.13.7.8.3 Tests

The Contractor shall conduct shop tests on dates agreed with the KSEBL and make arrangements for the KSEBL's representative to witness the tests.

All testing envisaged in IS / IEC shall be carried out. The Contractor shall make all arrangements, equipment, material and consumables to the tests and prove compliance of the equipment with the standards at shop and at site.

The test reports shall be got approved by the KSEBL before despatch of any item.

1.3.13.7.9 Spares

The following spares for 5 years operation and maintenance of the equipment shall be supplied:

1. Fire Fighting System

- Detector of each type 2 Nos

2. **Oil handling system**

- Connecting hose with couplings of each type and size 1 set.
- Seals and gaskets of each type 1 set.

Note: A set is defined as the total number required for one unit.

1.3.14 Site Installation, Field Testing and Tests on Completion

1.3.14.1 Introduction

The scope of these specifications is to stipulate the basic general guidelines to the Bidder / Contractor regarding the pre-commissioning testing, commissioning and performance testing of turbines, generators and associated equipment in the powerhouse, compliance to the latest published edition (prior to the date of closing of tender) of the international standards and recommendations specified throughout the specifications for the testing of the complete equipment and other general requirements as per **Section 1.1**, which are required for verifying the performance of the plant / equipment being provided under the scope of this tender / contract.

Any item of tests not specifically mentioned in the specifications but which are usual and / or necessary for verifying the satisfactory operation of the equipment / system shall be deemed to be provided by the Contractor and included in the quoted Price. Testing of the equipment / plant shall be complete in all details whether such details are mentioned in the specifications or not.

1.3.14.2 Reference Standards and Codes

The testing procedure, measurement and methods shall be in accordance with the latest revision of applicable IS / IEC or equivalent standards.

The Contractor shall adhere to sound design and construction practices with regard to codes and material specifications in order to warrant operational safety and ease of maintenance of plants as well as simplicity of control and stability in plant operation.

- IEC test Code 41 - International Code for Field Acceptance Tests on Hydraulic Turbines
- IEC Publication No. 308 - International Code of Tests of Speed Governing System for Hydraulic Turbines
- IEC Test code 545 - Commissioning Guide for Hydraulic Turbines
- IEEE 472 (1974) - Testing of Electronic Circuits of Governor
- ASME performance test code 29 for governor acceptance test
- IS 5456 - Testing of air compressors

- IEC 62006 – 2010 - Hydraulic Machines – Acceptance test of Small Hydroelectric Installations.
- IEC 60545 - Guide for Commissioning and Maintenance of Hydraulic Turbines.

1.3.14.3 *Reference Sections*

Section 1.1	-	General Technical Requirements
Section 1.2	-	Main Inlet Valves
Section 1.3.1	-	Turbines
Section 1.3.2	-	Governors
Section 1.3.3	-	Generators
Section 1.3.4	-	Excitation System
Section 1.3.5	-	Control and Monitoring
Section 1.3.6	-	Protection
Part - 2	-	Specific Requirements for the Project

1.3.14.4 *Submittals and Approvals*

The Contractor shall seek the prior approval of the KSEBL for the following through timely submittals.

- Graphs or curves showing performance characteristics
- Test reports / data
- List of suppliers / manufacturers of testing equipment
- A complete list giving details of testing equipment and auxiliaries
- Operation and Maintenance manual of supplied testing equipment.
- Copy of Valid calibration certificate of testing and measuring / recording equipment.
- Methodology of testing
- Test procedure during erection
- Site Acceptance Test procedure
- Pre-Commissioning and Commissioning Test Procedure.

1.3.14.5 *Deliverable Documents*

All the detailed test schedule, test protocols and test reports shall be submitted for approval of the KSEBL.

All testing and measuring / recording equipment used shall have valid calibration certificates and the same shall be submitted to the KSEBL. The details of calibrations shall be included in the test report along with copy of the calibration certificate.

1.3.14.6 *KSEBL's other Requirements*

Other technical requirements shall be as given in Part-2 “**Specific Requirements for the Project**” of this specification.

All equipment shall be finally tested and commissioned by the manufacturer's Commissioning engineer to the satisfaction of KSEBL's Engineer. The field tests shall demonstrate that all guarantees for equipment have been met in accordance with the specifications and that all equipment has been properly installed and correctly adjusted and is suitable for commercial operation.

Before testing of equipment at site, the contractor shall ensure that he has obtained approval of all work test certificates, along with the previously submitted detailed testing and commissioning procedure / plan from the KSEBL / Engineer-in-Charge. All punch points associated with the erection of the concerned equipment should also be cleared before starting of the testing and commissioning procedure.

The tests shall include those specified and any others necessary to demonstrate compliance with these specifications. Any other tests which are considered necessary by the manufacturer of the equipment have to be conducted at site. Special tools and tackles required, if any, for the pre-commissioning / Commissioning / Field Efficiency / Acceptance / Index tests shall be arranged by the Bidder / Contractor and also shall be clearly indicated in the offer. The cost including charges towards various testing shall be clearly and separately indicated in the offer and no extra compensation shall be admitted at a later stage for non-consideration of the charges for the above.

The contractor shall prepare the detailed test and commissioning procedures and submit to the KSEBL for approval. He should furnish a comprehensive and coordinated schedule of start up and commissioning which chronologically detailed field activities. Time duration after completion of field tests of various electrical and mechanical systems should not

exceed 10 to 15 days for small hydro installation.

All testing and measuring / recording equipment used shall have valid calibration certificates and the same shall be submitted to the KSEBL.

All tests shall be carried out by the contractor. All electrical / mechanical adjustments and tests, all load and commissioning tests, and all work of a similar nature which could affect the operation of the KSEBL's electrical system shall be carried out at times specified by the KSEBL, irrespective of the day or hour.

The arrangements for these tests including testing device shall be within scope of the contractor's work. All instruments / equipment and apparatus required for the tests shall be supplied by the contractor and calibrated to the satisfaction of the KSEBL. During the commissioning at site, each and every gauge and instrument shall be tested using suitable means to demonstrate their proper functioning and to confirm factory calibration and contact settings.

Hydraulic pressure test at 150 percent of the maximum dynamic head including water hammer experienced under worst conditions shall be conducted on the assembled and welded distributor / spiral casing and inlet valves to check and rectify any defects. The test ring, bulkhead and pressure generation pump required for carrying out pressure test shall be arranged by the contractor at his own expense. Hydraulic pressure tests, leakage tests and operational tests, where applicable, shall also be performed on other components such as turbine components, pressure tanks, governors, sump tanks, pumps, motors, grease equipment, valves, piping system etc...

1.3.14.7 *Start-up & Commissioning Activities*

The process of start-up and commissioning of hydro electric plant has following stages:

- Field Tests
- Start up Tests
 - Dry condition tests
 - (Pre-start up, pre-commissioning tests)
 - Watered up condition tests
- Commissioning Tests
- Testing of Control System
- Commercial Operation

- Technical Review of Commissioning of the Hydro-power Station

1.3.14.7.1 Field Tests

At this stage all systems and subsystems are individually tested.

Test at this stage shall include, but not limited to, the following:

- All critical unit clearances and dimensions are checked.
- Alignment of unit shaft system.
- Calibration and adjustment of all temperature sensing devices, pressure switches, flow switches, transducers is done.
- Continuity of all cabling and their connection as per cable schedules are checked.
- Operation of all control system in both energized and de-energized state is checked.
- Hydrostatic tests of all pressurized fluid system.
- AC / DC high potential tests.
- Bench test of protective relaying.
- Check out also include all field testing that can be performed before the turbine begins to operate.

All tests carried out must be properly documented for each system and subsystem and signed by tests engineers of manufacturer / Contractor and KSEBL. This documentation helps the KSEBL to identify potential problem in specific equipment before start-up and take remedial measure in advance.

1.3.14.7.2 Start-up Tests

Before starting of machine, start up tests of generating units, all other systems and subsystems should have been done during field tests. These tests are divided in two categories.

- Pre-commissioning tests (Dry Condition).
- Commissioning tests (Watered up condition).
 - No load tests.
 - Load tests or performance tests.

1.3.14.7.2.1 Pre-commissioning Tests

These tests are conducted before charging the water conductor system of the unit.

These checks can be carried out in parallel with field testing.

Some typical tests are as follows:

- Hydrostatic tests of generator coolers, bearing coolers and piping.
- Insulation resistance & dielectric test of generator.
- Functional checks and adjustment of generator speed switches and pressure switches.
- Functional checks of brakes, needle valves, nozzle jet, and excitation system.
- The entire unit must be thoroughly inspected before charging with water for tools, other objects which might have been inadvertently left in the unit.
- Check penstock man hole draft tube manholes are properly closed and tightened.
- Check working of all hydro-mechanical gates & valves etc...
- Check main & auxiliary transformers and their cooling arrangement.
- Check switch-yard & switch-yard equipment.
- Check all unit auxiliaries & station auxiliaries for their proper functioning.

1.3.14.7.2.2 Commissioning / Watered-up Tests

- Unit is charged with water, leakages from penstock and DT main holes, coolers, shaft seals are checked, remedial action, if found necessary, are to be taken.
- Check penstock pressure, DT pressure, cooling water pressure and availability of water at proper pressure in each cooler.
- Ensure working of flow meters.
- Then machine is rotated for the first time at slow-speed, ensure for any abnormal sounds or interference in machines, take immediate remedial action, if necessary.
- This is a critical stage as for the first time all equipment components are operating as an integral system at rated head and flow condition.
- The first unit rotation is done at slow speed then machine is run at 25, 50, 75 and final 100% speed.
- Following test at this stage are done:
 - On line field test of generators such as telephone interference factor, wave form

deviation etc...

- Shaft run out.
- Bearing temperatures stabilization (this is called bearing run also).
- Reliability of start, stop, synchronizing unit is also to be confirmed.
- All protective devices, lock out relays and emergency stop system are checked at low load to ensure that they are functional.
- All these tests are divided in two categories:
 - i. No load tests: These test conform the operation of the generator and powerhouse auxiliaries equipment under no load conditions. Typically these are follows:
 - Phase rotation check
 - No load saturation test
 - Short circuit saturation test
 - Operational tests, check thermal relays, speed switches, RTDs, flow switches.
 - Excitation system checks.
 - Point to point continuity test to verify the components are connected properly.
 - Insulation resistance tests to check the condition of cable insulation.
 - Functional test of each component and the interconnected system of components in both auto and manual mode.
 - Test of the software and hardware associated with the computer control system.
 - ii. Load Test: These test conform the operation of generator under load condition. Typically these are follows:
 - Heat run test to determine maximum temperature rise.
 - Load rejection tests.
 - Brake operational time to safely stop the machine.
 - Measurement of excitation field current at generator rated output.
 - Measurement of cooling water flow rates for the bearings.
 - Unit capacity test.

The load rejection test is performed at 25, 50, 75, 100% and 110% rated load which confirm the unit can be safely stopped under any operating condition. During these tests pressure rise in penstocks and speed rise of the machine are measured to confirm that both of these parameters are within design limit. Any abnormal noise, alarm, high temperature and any unusual or unexpected condition must be thoroughly investigated.

1.3.14.8 *Typical Erection Requirements and Testing Details*

1.3.14.8.1 Erection and Testing of Turbines

The successful Bidder / Contractor shall prepare an erection procedure and check points at every stage so as to set elevation and centre-line as also form of different components of turbine to be installed at site. The procedure should contain full cross referencing to approved turbine drawings and to location of measurement points and should become a part of maintenance manual. Erection tolerances should follow Indian and International practices or standards.

The procedure should give limit for location of embedded parts which need to be verified and monitored before pouring of concrete.

The procedure should also specify measurement records to be made during installation and setting of components for example relative location, clearances, elevation, rotational checks etc... It should cover requirements of connected generators also.

The tests on the turbine / generator units shall include all applicable tests listed in Chapter-II of the IEC Publication No.545, IEC Publication No. 41 and those called for in the individual sections here before. In addition to the tests listed in the above publications, the following tests shall be conducted on each turbine units.

A) Tests during Erection

For Francis Turbine:

- i. 100% radiographic testing of all welded seams of DT liner spiral case and inlet pipe.
- ii. Pressure testing of spiral casing measurements of clearances of labyrinth seals, guide bearing pads.
- iii. Measurement of guide vane gaps.

For Kaplan / Propeller Turbines:

- i. 100% radiographic testing of all welded seams of DT liner spiral case and inlet pipe.

- ii. Pressure testing of spiral casing.
- iii. Measurements of clearances of runner & runner chamber guide bearing pads.
- iv. Measurement of guide vane gaps.
- v. Pressure testing of runner assembly in erection bay.

For Pelton Turbine:

- i. 100% radiographic testing of all welded seams of inlet pipe, manifold branch pipe and other welded components of machine.
- ii. Pressure testing of manifold / branch pipe.
- iii. Measurement of clearances between guide pads & bearing journals of all guide bearings.
- iv. Checking alignment of generator and turbine shaft and setting of bearings.
- v. Checking of splitter ridge and notch radius tolerance during rotation of runner. The axial tolerance on splitter ridge and radial tolerance on bottom of notch in no case should exceed $\pm 0.3\%$ of PCD.

B) Pre-Commissioning Tests

The pre-commissioning tests on all units shall include but not limited to the following:

For Francis Turbines:

Once erection is complete following tests are required to be carried out:

- i. Relation between servomotor stroke and guide vane opening.
- ii. Determination of GV opening at no load.
- iii. Rotational checks for establishing alignment of shaft.
- iv. GV opening / closing time by dry stroking.
- v. Operation of unit at no load – check run out of rotating parts, behaviour of various bearings, setting over speed trip device.
- vi. Operation of unit at part loads and full load – check run out of rotating parts, behaviour of various bearings, check vibration pulsation and noise.
- vii. Output and guide vane opening relationship.
- viii. Load rejection tests at 50%, 75%, 100% and 110% of rated load.
- ix. Check proper operation of all turbine auxiliaries.
- x. Tests for meeting performance guarantee.

For Kaplan / Propeller Turbines:

- i. Relation between servomotor stroke and guide vane opening.
- ii. Determination of GV opening and blade opening at no load.
- iii. Rotational checks for establishing alignment of shaft.
- iv. GV opening / closing time by dry stroking:
 - a) Runner blade opening and closing time by dry stroking.
 - b) Relation between guide vane opening and runner blade opening.
- v. Operation of unit at no load – check run out of rotating parts, behaviour of various bearings, setting over speed trip device.
- vi. Operation of unit at part loads and full load – check run out of rotating parts behaviour of various bearings, check vibration, pulsation and noise.
- vii. Output and guide vane opening and runner blade opening relationship.
- viii. Load rejection tests at 50%, 75%, 100% and 110% load.
- ix. Check proper operation of all turbine auxiliaries.
- x. Tests for meeting performance guarantee.

For Pelton Turbines:

- i. Check water or oil tightness of all bearing sumps, cooling coils and piping.
- ii. The operating time of servomotors shall be adjusted.
- iii. The components of various servomotor locking mechanisms shall be checked for proper operation and adjustment.
- iv. All equipment, protective relays, sensors and instruments shall be checked and adjusted.
- v. Operation of nozzle / deflector correlation in dry state shall be checked and adjusted.
- vi. Determination of nozzle opening for starting and no load run.
- vii. Check for leaks.
- viii. The bearing heat exchangers and cooling coils shall be tested to a pressure of 150 per cent of the rated working pressure for a period of 30 minutes using water.
- ix. Pressure drops across heat exchangers and guide bearing coolers shall be recorded at normal rated water flow.
- x. Check dynamic balancing of machine.

- xi. Manual rotation of the unit.
- xii. Measurement of clearance between shaft and guide bearing.
- xiii. De-energized mechanical run, checking mechanical balance, alignment of generator and turbine shafts, bearings etc... Vibration levels shall be checked.
- xiv. Operation of unit at no load – check run out of rotating parts, behaviour of various bearings, setting over speed trip device.
- xv. Operation of unit at agreed, part loads and full load – check run out of rotating parts, behaviour of various bearings, check vibration pulsation and noise and ensure these are within limits.
- xvi. Over speed tests to allow checking and adjusting of protective relays.
- xvii. Load rejection test at various agreed part loads & full load – check speed rise, pressure rise and ascertain these are within limit.
- xviii. Check proper operation of all turbine auxiliaries.
- xix. Perform all tests for meeting performance guarantees.

C) Commissioning Tests

The following Commissioning Tests are required on all units:

1. Mechanical running tests from no load to full load, checking temperature and flows of cooling water, stability and vibration.
2. Shafts run-outs measured at guide bearings, coupling and generator guide bearing for every 10 percent of nozzle opening between speed no load and 100 per cent load.
3. Checking temperature and temperature stabilization of bearings, for each 10% increase in load between no load and full load.
4. Load pickup tests at loads selected by the KSEBL.
5. Load rejection tests in five stages between 20% and 100% of full load, recording voltage, pressure and speed rise.
6. Heat run at rated load, power factor and voltage.
7. Cooling water and air temperature measurements.
8. Shaft voltage tests.
9. Calculation, recording and confirmation of maximum temperature rise of the various parts at maximum continuous output rating.

The turbine, after continuous operation for 72 hours, shall be free from any problems of leakages, over-heating, vibration, failure, damage etc... and the machine will be taken over by the KSEBL only thereafter.

D) Field Efficiency / Acceptance Tests

Each turbine shall be tested at site for establishing fulfilment of guarantees in respect of turbine output and efficiencies including weighted average efficiency. The tests shall be carried out as per IEC 41 for field acceptance tests of hydraulic turbines.

These tests shall be carried out by the Contractor through an MNRE approved agency. If required, the KSEBL may carry-out the tests through an independent agency. In such a case, the contractor shall recommend the method of flow measurement, field acceptance tests etc... and shall provide all necessary efficiency testing equipment and other provisions (such as pickups, embedded connections etc...) for the efficiency tests at no additional cost to the KSEBL.

E) Index Tests

The index tests will be performed on the unit in order to confirm the shape of the efficiency curve to confirm that the guaranteed output is met, and to calibrate the flow meter. A tolerance of ± 0.5 percent shall be allowed for measuring inaccuracies of the index test curve when superimposed over the curve intersecting guaranteed efficiency points.

The index tests shall be performed in accordance with IEC field tests code including the latest revision of the chapter on index tests.

1.3.14.8.2 Testing of Governor

The tests on the governor system shall include all applicable tests listed in IEC publication No.308, IEEE 472 and ASME Performance test code 29. In addition to the tests listed in the above publication, the following tests shall be conducted on each governor.

A) Pre-Commissioning Tests

The pre-commissioning tests on the governors shall include:

1. Verification and adjustment of the complete governor hydraulic system including oil and air tightness of the related components. Purging of all air pockets.
2. Adjustment of operating times in dry state (adjustment of the orifices).
3. Verification of proper operation of the restoring devices.
4. Check operation and setting control range of speed setting devices.

5. Simulated governor stability tests.

B) Commissioning Tests

The following Commissioning Tests are required on all governors:

1. Adjustment of all controls and instrumentation.
2. Adjustment of the governor parameters to obtain stable operation under all operating conditions including speed no load operation.
3. Adjustment of needle injector operating time.
4. Verification and adjustment of the governor stability performance with respect to the specified requirements and also with respect to the maximum frequency variation.
5. During adjusting and commissioning tests, the contractor shall graphically record the behaviour of the regulated installation following perturbations of loads or settings. A copy of the results of every test carried out, including the data relevant to the tests shall be given to the KSEBL.

1.3.14.8.3 Testing of Generator

The tests on generating units shall include all applicable tests listed in IEC Publication No.34, IEEE Test code 115 and those called for in individual sections here before. In addition, the following tests shall be carried out on each generator:

1. Balancing of rotor.
2. Measurement of air gap length.
3. Mechanical run to check mechanical balance, bearing temperature, automatic braking etc...
4. Machine dry out with heating by short circuiting of stator.
5. Insulation resistance test after mechanical run and measurement of PI values.
6. HV dielectric tests on stator and rotor after insulation resistance test.
7. Rotor and stator winding resistance measurement.
8. Short circuit saturation curve.
9. Open circuit saturation curve.
10. Phase balance test.
11. Brush bedding and brush arcing tests.
12. Heat run at rated load, rated power factor and rated voltage.

13. Over speed tests.
14. Load pick up tests at selected loads from no load to full load.
15. Load rejection tests at 110%, 100%, 75%, 50% and 25% rated output and measurement of speed rise and pressure rise.
16. Shaft voltage test.
17. Time-RPM retardation curve, without excitation on the generator, from synchronous speed to standstill.
18. Split phase current balance test. This measurement shall include measurement of half phase unbalance current at balanced no load stator voltage and over a range of load conditions.
19. Neutral voltage measurement and recording for purpose of stator earth fault relay setting.
20. Record thrust bearing and upper bracket deflection at dead load and operating loads.
21. Hydrostatic pressure testing on each bearing cooler.

1.3.14.8.4 Testing of Excitation System

The tests on excitation system shall include the following:

1. Performance check of all auxiliary, stabilizing, limiting and protective circuits after adjustment to the correct settings.
2. Voltage-build up tests on auto control.
3. Steady state accuracy of voltage control, from no load to full load.
4. Minimum excitation limiter test.
5. Maximum excitation limiter test.
6. Load rejection test to determine maximum voltage rise under AVR control. The load rejection tests shall be conducted at:
 - 0 MW at rated MVAR;
 - 50% of maximum continuous rated output at rated power factor;
 - 100% of maximum continuous rated output at rated power factor.

7. With the maximum excitation setting and the generator operating at various loads just within the limit, the stability margin shall be demonstrated by the response to a 5% step injection to the voltage regulator. The sense of the step injection shall be to attempt to reduce the excitation.
8. Tests to determine the field current under the following conditions:
 - Rated kVA, rated power factor and 110% voltage
 - 110% rated kVA, rated power factor and 110% voltage
9. Dielectric test for rectifier transformer
10. Demonstration of changeover from automatic to manual control and vice versa.

1.3.14.8.5 Testing of Control, Protection and Instrumentation

The objectives of the commissioning work are to successfully energize the Plant at full voltage and connection to the system. The tests on control, protection and instrumentation include:

1. Test and commission the generator transformer relay panels, the generator relay panels, the local control panels and any other panels provided as part of the turbine generator units, at all locations where the systems are installed.
2. The testing shall include testing of the interface to the associated communication systems, adjacent protective systems and in particular the CT's, VT's and circuit breakers.
3. The testing shall include all indicating meters, relays, control, protection and alarm equipment and similar functions associated with the plant.
4. Calibration of all instrumentation, protective relays and control devices, including interfacing to the future supervisory control system.
5. Verification of secondary current and potential magnitude and phase angles under normal load condition on the units.
6. Checking of all wiring and insulation resistance tests as per standards.
7. CT and VT cable resistance (burden) shall be measured, and all reading in the test records shall be noted.
8. Secondary injection tests shall be performed on each relay and each panel to prove the integrity of the instrument transformer secondary wiring through the various

meters, relays and control devices.

9. The magnetization characteristics of all CT's shall be checked at a minimum of five points to identify the CT's and to confirm that the CT class is suitable for its intended duty and operation. All VT's shall be checked for polarity, phasing and, where practicable, for secondary output.
10. Primary current injection shall be made using injection methods suitable for each particular installation to confirm that the connection, phasing, ratio and polarity tests which were carried out on an individual basis on the various power transformers, instrument transformers, relays, meters and other components are correct as a total system.
11. The internal relay and / or external fault and event recorders and other systems shall be checked for recording or printing operation as appropriate. The recording operation shall be checked from each event record by initiating device operation. Stored data shall be accessed, downloaded and recorded as appropriate to the systems supplied. All alarm outputs shall be similarly checked.
12. The correctness of all DC polarities, the minimum operating levels of DC relays and the correct functioning of DC relay schemes, selection and control switching, indication and alarms, and data gathering systems shall be tested using negative and positive logic methods.
13. On load tests shall be made to confirm functional system performance and as a final design check.
14. Both operation (in zone) and stability (through fault) checks shall be made during on load tests.
15. A final on load secondary current and voltage check shall be made after the protective gear has been placed in service to ensure that all connections and test links have been replaced and test leads removed and confirm the integrity of the CT and VT circuits.
16. Carry out and record on approved test sheets functional tests on all modules, subsystems and systems both in-station, inter-station and inter-system in accordance with pre-approved test programs and test methods.
17. All ancillary electrical equipment shall be tested per relevant equipment standards and shall include:

- Functional check of switchgear including circuit breakers, motor drives and position indicators;
- Check of interlocking and automatic changeover schemes;
- Vector group and phasing tests;
- Rotational tests on all motors;
- Megger testing of all secondary wiring;
- Complete check of all cabling system including insulation and continuity tests.

1.3.14.8.6 Testing of Inlet Valves

The tests on main inlet valves shall include the following:

1. Verification and air purging of the hydraulic system.
2. Checking and adjustment of various safety and locking mechanisms for proper operation.
3. Operation of the valve through several opening and closing strokes under dry conditions. Adjustment of opening times.
4. Leakage tests.
5. Valve flow closure test in five stages between 10% and 100% of full flow. Resulting pressure rises shall be noted. The closing time shall be verified and adjusted if necessary.

1.3.14.8.7 Reliability Tests

The reliability test shall be performed on all three power generating units that are renovated to satisfy the KSEBL that all components are in satisfactory operating condition.

The reliability test shall commence when all other tests on completion applicable to that unit, including auxiliaries, have been satisfactorily completed. The reliability test shall be conducted for a continuous period of 15 calendar days measured from the commencement or recommencement of the reliability test to satisfactory completion.

During the reliability test, the unit shall be operated by the KSEBL and the contractor shall provide at his own expense a full time representative approved by the KSEBL to direct the KSEBL's engineers in the operation and running of the plant.

The contractor may make minor adjustments to the unit provided that such adjustments do not in any way interfere with, limit or prevent the use of the unit by the KSEBL or result in reducing the output or efficiency of the equipment.

Should any failure or interruption occur due to any defect for which the contractor is responsible, such defect shall be made good by the contractor and the reliability test shall recommence, without any charge to the KSEBL.

1.3.14.8.8 Test Reports / Records

The Contractor shall submit all the test reports for KSEBL's approval. If the test result of any equipment is not acceptable to KSEBL, the Contractor shall re-test the equipment after making necessary corrections / modifications, or replacement of the equipment or its parts at his expense. Finally, all the tests and certificates are to be signed by the KSEBL's Engineer.

1.3.14.8.9 Commercial Operation

The unit is operated at rated output for a specified number of days. If no major problems occur during contractually required period of operation at rated out-put, the unit is taken over by owner for commercial operation as detailed out elsewhere.

The unit index test and efficiency tests are also performed during commission phase.

1.3.14.9 Technical Review of Commissioning Activities

1.3.14.9.1 Items to Review before Unit Start-up & Commissioning

i. Combined electrical / mechanical review task:

- Review factory & field test certificates for all major pieces of equipment.
 - Turbine.
 - Governor.
 - Speed increaser (if any).
 - Draft tube gates, Intake gates, spillway gates, inlet valves.
 - Generators.
 - Main power transformers.
 - Generator switch gears (medium voltage).
 - Low voltage switch gears.

- Unit or plant control switch boards.
- Confirm that manufactures have provided detailed written installation instructions for all major pieces of equipment, including detailed dimensional record sheets.
- Review all detailed dimensional record sheets in conjunction with a visual inspection of all major pieces of equipment.

ii. Mechanical review task

- Verify that hydrostatic tests have been performed on all pressurized fluids systems.
- Review operational check out sheets for each mechanical system, including calibration sheets for all level switches, flow switches, pressure switches etc...
- Review unit alignment check out sheets.
- Review bearing setting, centering, gaps check out sheets.
- Review generator air gap check out sheets.
- Review functionality check out sheets for brakes, cooling system, oil pressure unit system, gland seal's repair seals, top cover drainage system, greasing system etc...

iii. Electrical review tasks

- Review system ground resistance test certificate and ensure adequate ground connection as per relevant ISS.
- Review surge protection of powerhouse / switch-yard.
- Confirm that phasing check has been performed across generator circuit breaker.
- Review the station battery / battery charger arrangement and operational check out sheet.
- Verify that all relays are bench tested and that the settings are as per design and that CT shorting screws have been removed.

1.3.14.9.2 Items to Review / Inspected during Unit Start-up & Commissioning

i. Mechanical review

- Observe first mechanical rotation of unit.
- Observe and review results of bearing temperature run.
- Observe and review results of unit load rejection tests.
- Observe turbine index test, verify that results are consistent with manufacturers promised performance.
- Verify unit alignment and balance.
- Monitor for excessive vibration and GB run out.

ii. Electrical Review

- Observe unit manual starts, stops and synchronizations.
- Observe unit automatic starts, stops and synchronization.
- Observe one manually initiated emergency stop sequence.
- Observe unit stops by activation of each lock out relay.

iii. Review of PLC used for unit control

- Identify manufacturer's recommended chassis and logic ground points and see whether they are to be connected collectively or grounded separately. If connected collectively confirm how common mode noise is prevented from entering the PLC.
- Verify the grounded resistance value for chassis and logic grounds are consistent with the manufacturer's recommendation.
- Ensure that surge protection are provided on all inputs to the I/O racks that will be susceptible to voltage transients including all cables routed to devices located outside the powerhouse.
- Ensure that the AC power for PLC is reliable and free of voltage transients and are from an inverter fed by DC station batteries.
- Confirm that the final PLC software coding has been well documented and that the document is available for future plant maintenance and trouble shooting.

Finally it should be ensured that written installation instructions which include detailed dimension records sheets have been provided by manufacturer. These sheets are used to record important installation information e.g. the installed generator air gap, installed turbine

clearances, installed turbine, generator speed increaser shaft alignment. The completed dimensional record sheets should be compared with manufacturer's tolerance requirement to confirm proper installation of the equipment. They will also be used during future unit maintenance outages.

1.3.14.10 Testing and Measuring Instruments

The following testing and measuring instruments shall be supplied with the plant:

1. Meggar (Range 250/500/1000/2500/5000/10000V)	-	1 No.
2. Digital Earth megger (Range 0.01 to 2000 ohm)	-	1 No.
3. Multi-meter – True RMS (Digital)	-	2 Nos.
4. Tong tester – AC/DC, 0-1000A, 0-600V range	-	1 No.
5. BDV kit	-	1 No.
6. Millivolt – Milliampere source (0–20 mA / 0–30V) with probe and clamps	-	1 No.
7. Thermal imaging camera – Infra red type	-	1 No.
8. Dimmerstat, 15 A, 3 Phase	-	1 No.
9. Dimmerstat, 5 A, Single phase	-	1 No.
10. Power quality analyser – Fluke 435 or equivalent	-	1 No.
11. CT analyser – Omicron VE000657 / Megger MRCT or equipment	-	1 No.
12. Hand held vibration monitor – SPM make model BIB 15 or equivalent-	-	1 No.
13. High voltage test kit (0-40kV)	-	1 No.
14. SF6 gas leakage detector	-	1 No.
15. Transformer oil filtration plant	-	1 No.
16. Dial gauges with magnetic base	-	4 No.
17. Portable Partial discharge analyser	-	1 No.
18. Spirit level	-	1 No.
19. Dry type RTD calibrator	-	1 No.
20. 4-20 mA / 0-30 V Calibrator	-	1 No.
21. Temperature Calibrator suitable for all scanners	-	1 No.
22. Pressure gauge calibrator with digital test gauge with adaptors	-	1 No.

1.4 Power Transformers & Switch-yard Equipment

1.4.1 Power Evacuation Arrangement

1.4.1.1 Introduction

This section covers the KSEBL's requirements for the arrangements to be provided for evacuating power from the powerhouse switch-yard.

1.4.1.2 Reference Sections

Section 1.1	-	General Technical Requirements.
Section 1.3.6	-	Protection.
Section 1.4.2	-	Power Transformers.
Section 1.4.3	-	Switch-yard Equipment.
Section 1.4.4	-	Switch-yard Control, Protection and Instrumentation.
Section 1.4.5	-	Switch-yard Installation and Tests on Completion.
Part - 2	-	Specific Requirements for the Project.

1.4.1.3 General

The power generated from the powerhouse will be connected to the Kerala Grid. The Kerala grid is interconnected with the Southern Grid through various 400kV and 220kV transmission lines. The main transmission system within the state comprises of lines at 400kV, 220kV, 110kV and 66kV and a sub-transmission / distribution system at 33kV and 11kV.

The power generated from the generating units of powerhouse at voltage levels of 11 / 6.6 / 3.3 kV will be stepped up suitably to any one of the transmission / sub-transmission voltage levels of 220 / 110 / 66 / 33kV using power transformers, and brought to the substation adjacent to the powerhouse through multi-circuit / Single circuit lines. The requirements and details of arrangements to be made for evacuating power are given in **Part-2** of this specification (**Specific requirement of the Project**). The exact length of line, number of spans required and the positioning and arrangement of towers etc... shall be finalized by the contractor in consultation with the KSEBL's engineers. Prior approval of the KSEBL shall be obtained for the proposals and design.

If Power evacuation arrangements up to the nearby substation are included in the scope of

supply, as per Part-2 of this specification, then all materials and works connected with construction of the switch-yard, erection of towers, stringing of the lines and associated works shall be provided by the Contractor as per this contract and the price shall be included in the bid.

Any item of work not specifically mentioned in the specifications but which are usual and / or necessary for the satisfactory operation of the equipment / system shall be deemed to be provided by the Contractor and included in the quoted Price. All work shall be complete in all details whether such details are mentioned in the specifications or not.

Before delivery of equipment / materials to site, the contractor shall submit all work test certificates for approval and obtain despatch clearance from the KSEBL / Engineer-in-Charge.

1.4.2 Power Transformers

1.4.2.1 Introduction

The scope of these specifications is to stipulate the basic general guidelines to the Tenderer / Contractor for the design, manufacture, testing at manufacturer works, standard and quality of workmanship, general finish of plant, compliance to the latest published edition (prior to the date of closing of tender) of the international standards and recommendations specified throughout the specifications, supply, insurance, delivery and storing at site, erection, site testing, commissioning, performance and reliability confirmation, warranty confirmation of the complete equipment and other general requirements as per Section 1.1, which are required for the plant / equipment being provided under the scope of this tender / contract.

Any item of work not specifically mentioned in the specifications but which are usual and / or necessary for the satisfactory operation of the equipment / system shall be deemed to be provided by the Contractor and included in the quoted Price. All work shall be complete in all details whether such details are mentioned in the specifications or not.

This section covers the KSEBL's requirements for the Power Transformers (**Generator Step-Up Transformer & Station Auxiliary Transformer**) in the powerhouse switch-yard.

1.4.2.2 Reference Standards and codes

The Equipment shall be designed, manufactured, tested, installed and commissioned in accordance with the latest revision of applicable IS / IEC or equivalent standards.

The Contractor shall adhere to sound design and construction practices with regard to codes and material specifications in order to warrant operational safety and ease of maintenance of plants as well as simplicity of control and stability in plant operation.

- IS 1866 - Code of practice for maintenance of insulating oil.
- IS 2026 - Power transformers.
- ANSI C57.12 - Distribution, power and regulating transformer and reactors other than current limiting reactors.
- IEC 60076 (Parts 1, 2, 4 and 5) - Power transformers.
- IS 1271 - Thermal evaluation and classification of electrical insulation.
- IS 335 - New insulating oils.
- IEC 60298 - Insulation oil for transformer.
- IS 2099 - High voltage porcelain bushings.
- IS 12063 - Classification of Degrees of Protection Provided by Enclosures of Electrical Equipment.
- IS 2071 - Method of high voltage testing.
- IS 2705 - Current transformers.
- IS 3347 - Dimensions for porcelain transformer bushings.
- IS 3637 - Gas operated relays.
- IS 3639 - Fittings and accessories for power transformer.
- IEC 60185 - Transformer neutral CT.
- IS 6600 - Guide for loading of oil immersed transformers.
- IS 9434 - Guide for sampling and analysis of free and dissolved gas in oil filled

Atmosphere.

- IS 10028 - Code of practice for selection, installation and maintenance of transformer.
- IS 5 - Colours for ready mixed points.
- IS 5561 - Electric power connectors.
- IS 354 - Method of sampling and test for resins for paints.
- IEC 137 - Insulated bushings for alternating voltages above 1000V.
- CBIP Publication No. 317 - Manual of Transformer.

1.4.2.3 Reference Sections

- Section 1.1 - General Technical Requirements
- Section 1.3.6 - Protection.
- Section 1.3.7 - Bus Ducts, LAVT & NGR.
- Section 1.3.14 - Site Installation, Field Testing & Tests on Completion.
- Section 1.4.3 - Switch-yard equipment
- Section 1.4.4 - Switch-yard Control, Protection & Instrumentation.
- Section 1.4.5 - Switch-yard Installation and Tests on Completion.
- Part - 2 - Specific Requirements for the Project.

1.4.2.4 Submittals and Approvals

The Contractor shall seek the prior approval of the KSEBL for the following through timely submittals.

- Design calculations.
- Detailed outline General Arrangement drawing showing plan, front elevation, side elevation with all fittings and accessories, Weight / Quantity of oil, Roller, rail gauge sketch etc...
- Assembly drawings and weights of main component parts.

- Shipping drawings showing dimensions and weights of each package.
- Schematic diagram showing the flow of oil in the cooling system as well as each limb and winding. Longitudinal and cross sectional views showing the duct sizes, cooling pipes etc... for the transformer drawn to scale shall be furnished.
- Schematic / Circuit Drawings of all auxiliary equipment, cooler controls etc..., Rating Plate, Connection Drawings and specifications.
- Large scale drawings of high and low tension windings of the transformers showing the nature and arrangement of insulation and terminal connections.
- Detailed drawing of bushing, showing plan & elevation, terminal details, mounting details, make and type, number, incorporating electrical characteristics, description of various parts, total creepage / protected creepage distance, weight of oil, total weight of bushing, dimensions, short time rating etc...
- Roller Stopper arrangement drawing.
- Foundation plan of the transformer including auxiliary equipment.
- Graphs showing performance.
- Description, literature and data on transformer construction, winding, bushing, heat exchanger, tap changing gear etc...
- The Contractor shall purchase equipment from reputed vendors only and the name of vendors shall be submitted for KSEBL's approval.
- Material certificates and test reports.
- Erection methodology.

Before delivery of equipment to site, the contractor shall submit all work test certificates / reports for approval and obtain despatch clearance from the KSEBL's representative.

1.4.2.5 Deliverable Documents

- Layout drawings of the Switch-yard showing the detailed arrangement of Power Transformers and Auxiliary systems, clearly indicating dimensions and all important elevations.
- General outline drawings showing dimensions, quantity of insulating oil, spacing of wheels in either direction of motion, location of centre of gravity, net weight and shipping weights of transformers, tap change gear / regulating transformer,

marshalling box and location of coolers, supporting structure for coolers etc...

- Assembly drawings of HV and LV bushings.
- Control and wiring diagrams and drawings.
- Drawings showing typical sectional views of the windings with details of insulation cooling circuit, method of coil bracing and core construction.
- Drawings showing construction and mounting details of marshalling boxes.
- Drawings showing wheel loading and centre of gravity of transformer.
- Drawings giving details of nameplate, terminal markings and connection diagram.
- Sectional view showing disposition of various fittings.
- General arrangements of foundation and structure.
- Full details of construction of bushings and other relevant data.
- Technical literature on tap changer, cooling system, relays, motors, and general constructional features of winding temperature indicator, Buchholz relay, oil temperature indicator etc...
- A schedule showing the requirement of set of spare gaskets.
- Type test certificates for transformers, bushings etc...
- Quality assurance plan adopted for the manufacture of the transformers.
- Erection methodology.
- Routine Test report / Data.
- A complete list giving details of equipment and auxiliaries.
- Operation and maintenance manual covering full details of operation, maintenance and troubleshooting procedure.

1.4.2.6 Scope of Work

Detailed scope of work is given in Part-2 “**Specific Requirements for the Project**” of this specification. Any item of work not specifically mentioned in the specifications but which are usual and / or necessary for the satisfactory operation of the equipment supplied shall be deemed to be provided by the Contractor and included in the quoted Price. All work shall be complete in all details whether such details are mentioned in the specifications or not.

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or necessary for the satisfactory operation of the equipment supplied shall be deemed to be provided by the Contractor and included in the quoted Price. All work shall be complete in all details whether such details are mentioned in the specifications or not.

1.4.2.7 KSEBL's Other Requirements

1.4.2.7.1 Ratings and Data

Other technical requirements shall be as given in Part-2 “**Specific Requirements for the Project**” of this specification. Any ratings, if mentioned, are indicative only and are a minimum for giving a base line. The Bidder should ensure that the ratings of the various equipment are sufficient to take care of the design requirements of the equipment offered for the concerned project. Any increase in rating during detailed engineering stage will not entitle the Successful Bidder / Contractor for any extra charges. The Contractor should submit for approval the calculations for arriving at the ratings of the various equipment.

The tentative layouts of the powerhouse are given in drawings appended to the specifications. All equipment shall be neatly arranged and shall be readily and easily accessible for operation and maintenance.

The Bidder should ensure that the ratings of the various equipment are sufficient to take care of the design requirements of the equipment offered for the concerned project. Any increase in rating during detailed engineering stage will not entitle the Successful Bidder / Contractor for any extra charges. The Contractor should submit for approval the calculations for arriving at the ratings of the various equipment.

The generator transformers shall comply with the requirements of the latest versions of the relevant IS / IEC standards. Provision of “Off-circuit” tap changer shall be made for generator-transformers of conventional generating units. On load tap changer may be considered for pumped storage schemes having reversible units. The range of operation for the tap changer shall be governed by the power system requirements. The transformers shall have off- load tap changers, complete with all necessary auxiliary equipment, insulating oil for first filling and oil cooling systems. Complete set of transformer neutral interconnection bus with support insulators and neutral CT, matching with the phase CT's, shall be provided.

Transformer shall be capable of operating under the natural cooled condition up to the specified load. The forced cooling equipment shall come into operation by preset contacts of winding temperature indicator and the transformer shall then operate as a forced cooled

unit as ONAF. Cooling shall be so designed that during total failure of power supply to cooling fans the transformer shall be able to operate at full load for at least ten (10) minutes without the measured winding hot spot temperature exceeding 140°C . Also stopping of one or two cooling fans should not have any effect on the cooling system. The generator transformers shall be provided with two complete independent sets of cooling equipment each with 50% capacity. One spare fan shall be provided for each cooler bank. Transformers fitted with two coolers each capable of dissipating 50 percent of the heat at continuous maximum rating shall be capable of operating for 20 minutes in the event of failure of blowers associated with one cooler, without the measured winding hot spot temperature exceeding 140°C at continuous maximum rating.

The Transformers shall be designed to ensure satisfactory operation under such sudden variations of load, frequency and voltage as may be met-with under system working conditions and capable of withstanding, without injury, the mechanical and thermal stresses resulting from external shorts circuits. Generator Transformer shall be suitable for continuous operation at rated MVA on any tap with voltage variation in accordance with relevant IS / IEC standards.

All materials used in the manufacture of the transformers shall conform to Codes and Standards as above.

Design of all outdoor apparatus, including bushing insulators with their mountings, shall ensure that no pockets be formed wherein collection of water can take place.

The Transformers shall be provided with Oil and Winding temperature indicating meters. The Transformers shall have adequate protective system including the usual protective relays such as Buchholz relay, Winding temperature high alarm, trip etc... and provision for Automatic start / stop of cooling fans.

Surge arrester shall be provided on the high voltage side of each transformer. The surge arrester characteristics, their numbers and exact locations shall be decided based on the insulation co-ordination studies.

Insulation levels for the transformer windings and bushings shall comply with the requirements indicated in the following Table.

Rated voltage	Rated power freq. withstand voltage (kVrms)	Rated switching impulse withstand voltage (kVp)	Rated lightning impulse withstand voltage (kVp)
800kV	830	1550	2100

Rated voltage	Rated power freq. withstand voltage (kVrms)	Rated switching impulse withstand voltage (kVp)	Rated lightning impulse withstand voltage (kVp)
420kV	630	1050	1425
245kV	460	-	1050
145kV	275	-	650
72.5kV	140	-	325
52kV	95	-	250
36kV	70	-	170
24kV	50	-	125
17.5kV	38	-	95
12kV	28	-	75

Firewalls shall be provided wherever required as per the guidelines of BIS.

The generator transformers having three phase rating of 120MVA and above shall be provided with on line dissolved / evolved gas analyser system.

Short circuit withstand test shall be conducted on one of each type and rating of generator - transformers to validate the design and quality unless such test has been conducted within last five years on a transformer of same design. In case there is a change in design before five years, the new transformer design shall be validated by carrying out short circuit withstand test.

1.4.2.7.2 Electrical Characteristics and Performance

a) Type of Transformers and Operating Conditions

The transformers shall be oil-immersed, core type and shall be suitable for outdoor installation. They shall be provided with conservator vessels. Transformer shall be capable of operating under the natural cooled condition (ONAN) up to the specified load. ONAF cooling shall be also provided.

The MVA capacity of the transformer shall be chosen equivalent to the maximum MVA capacity of the generator (maximum continuous output of 110 percent of the rated output at rated power factor) for an ambient temperature of 50°C.

b) Frequency

The transformers shall be suitable for continuous operation with a frequency variation of 3% from the normal value of 50 Hz, without exceeding the specified temperature rise. During occasions when full load is thrown off from the units momentarily, the frequency may go up by 30%.

c) Continuous Maximum Ratings and Overloads

The transformers shall be capable of operation continuously, in accordance with IEC loading or its equivalent guide, at their continuous maximum rating and at any ratio. Bi-directional flow of power is required in very rare occasions.

The transformers shall operate without exceeding temperature rises, winding gradients and hot spot at any particular tapping at the rated kVA provided the voltage does not vary by more than $\pm 10\%$ of the voltage corresponding to the tapping. The Transformers shall be capable of delivering rated current at a voltage equal to 105% of the rated voltage.

Continuous operation at rated MVA on any tap with voltage variation of $\pm 10\%$ corresponding to the voltage of the tap and in accordance with IS: 6600 shall be possible. All the transformers shall operate at full load for at least ten minutes without exceeding the calculated winding hot spot temperature of 140°C in the event of complete failure of power supply to the cooling equipment.

d) Duty under Fault Conditions

The transformers shall be capable of withstanding, without damage, any external short-circuit between phases as mentioned in IS 2026 or equivalent standards.

The transformer and all its accessories including CT's etc... shall be designed to withstand without any injury, the thermal and mechanical effects of any external short circuit to earth and of short circuits at the terminals of any winding for a period of 3 seconds. The short circuit level of the HV and LV system to which the subject transformer will be connected is 50kA ($I_{\text{sym.rms}}$, 3-phase fault on 400kV) 40kA ($I_{\text{sym.rms}}$, 3-phase fault on 220kV), 31.5kA ($I_{\text{sym.rms}}$, 3-phase fault on 110kV and 66kV) & 25 kA ($I_{\text{sym.rms}}$, 3-phase fault on 33, 22 and 11 kV).

Transformer shall be capable of withstanding thermal and mechanical stresses caused by symmetrical or asymmetrical faults on any winding.

The transformers shall, under exceptional circumstances due to sudden disconnection of load, be capable of operating at a voltage approximately 25%

above normal rated voltages for a period not exceeding one minute and 40% above normal for a period of 5 seconds.

e) Losses

The Contractor shall indicate whether the figures given for guaranteed losses in the schedule of guaranteed technical particulars are with or without tolerances. If tolerances are applicable, the limits for the same should be indicated. In the absence of any indication to this effect, the figures for no-load and load losses (excluding auxiliary losses) will be increased by 10% as provided in the Indian Standards.

Changes in the figures assigned for transformer losses will not be permitted after opening of the bids and bid evaluation will be carried out on the basis of information made available at the time of bid opening.

The no-load loss in kilowatts at rated voltage and rated frequency and the total losses in kilowatts at rated output, rated voltage and rated frequency shall be guaranteed under penalty for each transformer. For the purpose of penalty computations, the test figures of the no-load and the total losses will be compared with the corresponding guaranteed figures.

The penalties shall be separately evaluated from (i) the excess of the test figures of the no-load loss in kilowatts over the corresponding guaranteed value, and (ii) the excess of the difference between the test values of the total losses and the no-load loss in kilowatts over the difference of the corresponding guaranteed value. No tolerance shall be permitted over the test figures of the losses.

The penalties shall be calculated at the rate of 0.5% of the Contract price of the transformer per kilowatt for the excess of no-load loss, and at the rate of 0.5% of the Contract price of the transformer per kilowatt for the excess of the difference in the total and no-load losses for the transformers. For fraction of kilowatt, the penalties shall be applied pro-rata.

For the purpose of comparison of tenders, the quoted prices shall be equalized for the transformer losses at the rate of 0.5% of the Contract price of the transformer per kilowatt of no-load losses and at the rate of 0.5% of the Contract price of the transformer per kilowatt of the difference between total losses and no-load losses on the basis of the guaranteed loss figures for the transformers. No tolerance will be allowed for this purpose.

The Contractor should note that the values assigned for the capitalisation of losses

are based on the present worth and therefore, capitalisation of investment will not be made separately.

f) Regulation and Impedance

The Contractor shall indicate the guaranteed impedance and tolerance thereof. The impedance voltage at principal tap and rated kVA shall be stated in the bid and tolerance shall be in accordance with IS 2026 or its equivalent.

g) Vibration and Noise

Every care shall be taken to ensure that the design and manufacture of the transformers and auxiliary plant shall be such as to reduce noise and vibration to the level of that obtained in good modern practice.

Vibration level at rated voltage and frequency shall not be more than 200 microns peak to peak. Average vibration shall not exceed 60 microns peak to peak. Tank stresses shall not exceed 2.0 kg / mm² at any point on the tank.

The noise level at rated voltage and frequency shall be as per the NEMA Standard Publication TR-1.

h) Suppression of Harmonics

The transformers shall be designed with particular attention to the suppression of harmonic voltage, especially the third and fifth, so as to eliminate waveform distortion and from any possibility of frequency disturbances, inductive effects or of circulating currents between the neutral points at different transforming stations reaching such a magnitude as to cause interference with communication circuits. Percentage of harmonics at normal voltage and at maximum system voltage shall be stated in the tender.

1.4.2.8 Design and Construction

1.4.2.8.1 General

The materials and workmanship shall be of suitable commercial quality as have proven successful in the respective uses in similar services and under similar conditions.

Corresponding parts of all equipment and spares shall be of the same material, dimensions, workmanship and finish and shall be interchangeable.

1.4.2.8.2 Cores

The cores shall be constructed from high-grade, cold-rolled, non-aging, grain-oriented, low loss and high permeability Super grain oriented silicon steel laminations. All parts of the cores and winding shall be of robust design capable of withstanding any shocks to which they may be subjected to during lifting, transport, installation and service. Adequate provision shall be made to prevent movement of core and winding with respect to tank during these conditions.

Material to be used for the transformer core shall be made of **prime grade Imported Cold Rolled Grain Oriented (CRGO) laminations** and not from second grade steel laminations. Only those bidders who directly imported **CRGO** either from the manufacturer or through their accredited marketing organization of repute (and not through any agent) shall be considered. **In support of this requirement the bidder should submit an undertaking in the form of affidavit on Rs.200/- stamp paper, duly notarised, in the specified format.**

The laminations shall be annealed in a non-oxidizing atmosphere to relieve stresses and restore original magnetic properties of material after cutting and punching operation. The laminations shall be treated after cutting etc... to remove all burrs and checked during stage inspection. These shall be coated with baked enamel insulation coating. The insulation shall be inert to the action of hot transformer oil and be perfectly adhesive. Paper and varnish insulation shall not be accepted. Particulars of proposed insulation shall be stated in the tender.

The core shall be rigidly clamped and / or bolted to ensure adequate mechanical strength and to prevent vibrations during operation. The bolts used in the assembly of the core shall be suitably insulated and the clamping structure so constructed that the eddy currents will be minimum. The insulation of core to bolts and core to clamps plates shall be able to withstand a voltage of 2 kV RMS for one minute.

All steel sections used for supporting the core shall be thoroughly sand blasted after cutting, drilling and welding. When bell type tank construction is offered, suitable projecting guides shall be provided on core-assembly to facilitate removal of tank.

Each core lamination shall be insulated with a material that will not deteriorate due to pressure and hot oil.

The supporting framework of core shall be so designed as to avoid presence of pockets, which would prevent complete emptying of the tank through drain valve or cause trapping of air during oil filling.

The maximum flux density in any part of the core and yoke of transformers at rated MVA and frequency shall not exceed 1.9 Wb/m^2 at any tap position with $\pm 10\%$ voltage variation from voltage corresponding to the tap. Transformer shall also withstand following over fluxing conditions on combined voltage and frequency fluctuations:

- a) 110% for continuous rating.
- b) 125% for at least one minute.
- c) 140% for at least five seconds.

The over- fluxing characteristics up to 170% shall be furnished.

The bidder shall indicate the maximum flux density allowable continuously, as well as for time intervals of 1 minute and 5sec and the limit of flux density at which core material used by them saturates.

The design of magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthing clamping structure and the production of flux components at right angles to the plane of the lamination, which may cause local heating.

Number of steps in the limb and yoke shall be matching and dimensionally identical to minimize the effect of cross fluxing and for better mechanical strength.

The core shall be provided with lugs suitable for lifting complete core and coil assembly of transformer and be fixed in the tank so that its shifting will not occur when the transformer is moved or when a short circuit occurs.

Every care shall be exercised in selection treatment and handling of core steel to ensure that the laminations are flat and that finally assembled core is free from distortions.

1.4.2.8.3 Windings

The supplier shall ensure that windings of the transformers are made in dust proof environment. The conductors shall be of electrolytic grade copper. The transformers shall be designed to withstand the impulse and power frequency test at a voltage as specified in IS 2026 or its equivalent. The insulation of the coils shall be of high grade Kraft / Manila paper and shall be treated with suitable insulating varnish or equivalent compound to develop the full electrical strength of the windings. The voltage between adjacent coils shall be kept as low as consistent with the given design. The impulse test and power frequency test voltage shall be as per the relevant IS / Standards followed.

All permanent current carrying joints in the windings and leads shall be welded or brazed.

Preference shall be given to a winding with a continuous conductor. The stacks of windings shall receive adequate shrinkage treatment before final assembly. Adjustable devices shall be provided for taking up any possible shrinkage of coils in service.

The windings shall be arranged so as to ensure free circulation of oil and to reduce hot spots in the windings. The conductors shall be transposed at sufficient intervals in order to minimise eddy currents and equalise the distribution of current and temperature along the windings.

The windings and connections of the transformer shall be braced to withstand shocks, which may occur during transport, or due to switching, short-circuit and other transient conditions during service.

The insulation of transformer windings and connections shall be free from insulating compounds which are liable to soften, ooze out, shrink or collapse or be catalytic and chemically active in transformer oil during service. The insulation of the coils shall be treated suitably to develop full electrical strength of the windings and for this, hot oil vacuum impregnation process shall be used for improving the electrical and thermal properties of insulating paper. The insulating material to be used shall be of class "A" as specified in the latest relevant standards.

All materials used in the insulation and assembly of the windings shall be insoluble, non-catalytic and chemically inactive in the hot transformer oil and shall not soften or otherwise be adversely affected under the operating conditions.

Coil assembly and insulating spacers shall be so arranged as to ensure free circulation of oil and to reduce the hot spot of the winding.

The stacks of windings shall receive adequate shrinkage treatment before and after final assembly. Adjustable devices if necessary shall be provided for taking up possible shrinkage of coils if any, in service. The provision made in this respect shall be clearly brought out in the Bid.

The conductors shall be transposed at suitable intervals in order to minimize eddy current and to equalize the distribution of current and temperature along the windings.

The windings shall be so designed that all coil assembly of identical voltage rating shall be interchangeable and field repairs to the windings can be added without special equipment.

Fibre optic Sensors shall be embedded in each phase of the winding located where the Temperature is the highest for transformer provided with fibre optic temperature measuring systems.

All threaded connections shall be provided with locking facilities. All leads from the terminal board and bushings shall be rigidly supported to prevent injury from vibration.

The winding conductor shall be of Copper material.

The LV winding as well as HV winding of all the transformers shall be fully insulated.

The winding shall be designed to reduce to a minimum out-of balance force in the transformer at all voltage ratios.

1.4.2.8.4 Tanks

The transformer tank and cover shall be oil tight and fabricated from good commercial grade low carbon steel of adequate thickness. The weld procedure and performance shall be in line with IS: 2062. **The transformer tank with bushings including tap-changing compartments, radiators and coolers, shall be designed to take full vacuum. The transformer tank along with radiators and other accessories shall be tested for vacuum and pressure test as per CBIP recommendations.** The tank shall be designed and constructed for vacuum filling of oil and be capable of withstanding without leakage or distortion continuous internal gas pressure of 0.7 atmosphere with oil at operating level.

Tank shall be of welded construction and fabricated from tested quality low carbon steel of adequate thickness. The Transformer tanks shall be of the Bell type construction. The tanks of all transformers shall be complete with all accessories and shall be designed so as to allow the complete transformer with the tank and filled with oil, to be lifted by crane or jacks, transported by road, rail or water without overstraining any joints and without causing subsequent leakage of oil. The tank cover shall be bolted to the tank and the transformer design shall be such that the tank will not be split between the lower and upper cooler connection for un-tanking.

The Transformer Tank shall be provided with one pressure relief valve / device to operate at a pressure below the test pressure for the tank.

All seams and those joints not required to be opened at site shall be factory welded and wherever possible they shall be double welded. After completion of tank construction and before painting, dye penetration test shall be carried out on welded parts of jacking bosses, lifting lugs and all load bearing members. The requirement of post weld heat treatment for tank / stress relieving parts shall be based on recommendations of BS: 5500 table 4.4.3.1.

Tank stiffeners shall be provided for general rigidity and these shall be designed to prevent retention of water.

The tanks shall be designed to withstand:

- i. Mechanical shocks during transportation.
- ii. Vacuum filling of oil.
- iii. Continuous internal pressure of $35 \text{ kN} / \text{m}^2$ over normal hydrostatic Pressure of oil.
- iv. Short circuit forces.

Wherever possible the transformer tank and its accessories shall be designed without pockets wherein gas may collect. Where pockets cannot be avoided, pipes shall be provided to vent the gas into the main expansion pipes.

The base of each tank shall be so designed that it shall be possible to move the complete unit by skidding in any direction without injury when using plates or rails.

Tank shields shall be such that no magnetic fields shall exist outside the tank. They shall be of magnetically permeable material. If required impermeable shields shall be provided at the coil ends. Tank shield shall not resonate when excited at the natural frequency of the equipment.

Suitable guides shall be provided in the tank for positioning the core and coil assembly.

Each tank shall be provided with:

- i. Lifting lugs suitable for lifting the equipment complete with oil.
- ii. A minimum of four jacking pads in accessible position at 500 mm height to enable the transformer complete with oil, to be raised or lowered using hydraulic or screw jacks.
- iii. Suitable haulage holes shall be provided.

Lifting eyes or lugs shall be provided on all parts of the transformer requiring independent handling during assembly or dismantlement. In addition, the transformer tank shall be provided with lifting lugs and bosses properly secured to the sides of the tank for lifting the transformer by using hydraulic or screw jacks.

The tank cover shall be sloped to prevent retention of rain water and shall not distort when lifted.

The tank covers shall be fitted with pockets at the position of maximum oil temperature corresponding to MCR (Maximum Continuous Rating) for RTD Sensors and bulbs of oil and winding temperature indicators. It shall be possible to remove these sensors bulbs without lowering the oil in the tank.

Bushings, turrets, covers of inspection openings, thermometer pockets etc... shall be

designed to prevent ingress of water into or leakage of oil from the tank.

At least two adequately sized inspection openings, one at each end of the tank shall be provided for easy access to bushings and earth connections. The inspection covers shall not weigh more than 25 kg. The inspection covers shall be provided with two handles.

Man holes / inspection covers with welded flange and bolted covers shall be provided on the tank cover. The inspection covers shall be of sufficient size to afford easy access to the lower ends of bushings, terminals etc... Adequate space shall be provided between the cores and windings and the bottom of the tank for collection of any sediment.

Suitable no. of jacking bolts shall be provided on tank cover and inspection covers.

All bolted connections shall be fitted with weather proof, hot oil resistant gasket in between for complete oil tightness. If gasket is compressible, metallic stops shall be provided to prevent over-compression.

All bolts and nuts used in connection with tank and fittings shall be galvanized / Zinc plated & passivated. All Bolts & Nuts, Pins shall be locked in position with exception of those external to the transformer. If bolts and Nuts are placed so that they are inaccessible by means of ordinary spanners, suitable special spanners shall be provided by the supplier.

All seams, flanges, lifting lugs, braces and permanent parts attached to the tank shall be welded. The tank shall be reinforced by stiffeners of structural steel for general rigidity. The tank cover shall be bolted to the tank.

A manhole with bolted cover shall be provided on the tank cover to inspect main parts of the transformer and other strategic locations.

All bolted connections to the tank shall be fitted with suitable oil tight gaskets, which shall give satisfactory service under the operating conditions. Suitable guides shall be provided for positioning the various parts during assembly or dismantling.

The tank and the inspection covers shall have suitable lifting arrangement.

The transformer tank shall be equipped with all necessary valves and accessories. The transformer tank and its accessories shall be designed without pockets where gas may collect. Where pockets cannot be avoided, pipes shall be provided to vent the gas off.

1.4.2.8.5 Undercarriage

The transformer tank shall be supported on strong structural steel base equipped with forged steel or cast steel single flanged wheels suitable for moving the complete

transformer completely filled with oil. Flanged wheels shall be provided suitable for use on a 1435mm gauge track along longer axis as well as along shorter axis. Wheels shall be provided with suitable bearings, which shall be rust and corrosion resistant. Fittings for lubrication shall also be provided.

Under carriage shall be provided with jacking pads. It shall be possible to change the direction of the wheel through 90 degree when the transformer is lifted on jacks to permit movement of the transformer along its longitudinal or transverse axis on standard gauge (preferably broad gauge) tracks in both the longitudinal and transverse directions. Suitable locking arrangement along with foundation bolts shall be provided for wheels to prevent accidental movement of transformer.

All wheels shall be detachable and shall be made of cast iron or steel as required. gauge track and shall be so placed that pinch bar can be used to move the transformer.

Pulling eyes shall be provided to facilitate haulage of the transformer. These shall be suitably braced in the vertical direction so that bending does not occur when the pull has a vertical component.

Rails are included in the scope of supply of Bidder. The technical details of the rails including size and material characteristics shall be submitted by the Bidder.

1.4.2.8.6 Anti-Earthquake Clamping Device

To prevent transformer movement during earthquake, clamping device shall be provided for fixing transformer to the foundation. The Bidder shall supply necessary bolts for embedding in the concrete foundation. The arrangements shall be such that the transformer can be fixed to or unfastened from these bolts as desired. The fixing of the transformers to the foundations shall be designed to withstand seismic events to the extent that a static coefficient of 0.3g, applied in the direction of least resistance to that loading will not cause the transformer or clamping devices as well as bolts to be over stressed.

1.4.2.8.7 Conservator Vessels, Oil Gauges & Breathers

A conservator, air cell type, complete with sump, filling hole and drain valves shall be provided in such a position as not to obstruct the electrical connections to the transformers, having a capacity between highest and lowest visible levels to meet the requirements of expansion of the total cold oil volume in the transformer and cooling equipment from the minimum ambient temperature to 100°C. Conservator shall be with volumetric capacity at least 7.5 percent of a total volume of oil in the main tank of the transformer. A pressure

relief valve shall be provided with sufficient size for rapid release of any pressure that may be generated within the tank, which will result in damage to the equipment.

The conservator tank shall be bolted into position so that it can be removed for cleaning purposes. The conservator shall be fitted with magnetic oil level gauge with electrically insulated contact for low oil level alarm.

Conservator shall be provided in such a position as not to obstruct the electrical connections to the transformer.

Separate conservator tank / compartment in the main conservator shall be provided for OLTC.

A magnetic type oil gauge shall be provided and it shall be mounted at a convenient height to be read from ground level. The oil level at 30°C shall be marked on the gauge. Taps or valves shall not be fitted to the oil gauges. A contact from oil level gauge shall be provided to initiate alarms against low oil level. Prismatic oil level gauge shall also be provided.

Each conservator vessel shall normally be fitted with a dehydrating filter breather in which silica gel is used as dehydrating agent and designed such that:

- (a) The passage of air is through a dust filter and the silica gel.
- (b) The external atmosphere is not in contact with the silica gel for which an oil seal may be provided.
- (c) The moisture absorption indicated by a change in colour of the tinted crystals can be easily observed from a distance.
- (d) Breather is mounted not more than 1400 mm above rail top level.
- (e) Minimum quantity of silica gel will be 1 kg for every 3500 litres of oil in the tank.

The power transformer shall have constant oil pressure system with a floating rubber bellow in the conservator tank, which is connected to the external air through breather so that the transformer oil should not have any contact with air.

The Bidder shall provide diaphragm type oil sealing system (Balloon technology) in the conservator. The requirements of this system are given below:

- a) In this system, contact of the oil with atmosphere shall be prohibited by using a flexible or nitride rubber reinforced with nylon cloth air cell.
- b) Diaphragm used shall be suitable for continuous operation at a temperature of 100°C, to which transformer oil is likely to rise.
- c) The connection of the air cell to the top of the conservator shall be by an air proof

seal permitting entrance of air into the cell only.

- d) The Diaphragm of the conservator shall withstand the vacuum during installation and maintenance. Otherwise provision shall be made to isolate the conservator from main tank during vacuum by providing vacuum sealing valve in the pipe connecting main tank with the conservator.

A shut off valve shall be provided at the conservator to cut off oil supply to the transformer.

Air bag type conservator shall be provided i.e., oil in conservator shall be separated from atmosphere by rubber bellow in the air balloon system. The conservator vessel shall be fitted with breathers in which silica gel is the dehydrating agent. The moisture absorption shall be visible from distance by a change in colour of tinted crystals.

1.4.2.8.8 Pressure Relief Valves

Adequate number of spring loaded pressure relief Valves shall be provided at suitable locations. These shall be of sufficient size for rapid release of any pressure that may be generated in the tank and which may result in damage to the equipment.

The device shall operate at a static pressure, which is less than the hydraulic test pressure of transformer tank. It shall be mounted directly on the tank. One set of electrically insulated contacts shall be provided for alarm and tripping at the recommended settings.

1.4.2.8.9 Joints and Gaskets

All gaskets used for making oil joints shall be of proven material such as granulated cork bonded with synthetic rubber gaskets. All bolted connections to the tank shall be fitted with suitable oil tight gaskets, which shall give satisfactory service under all operating conditions.

1.4.2.8.10 Cooling Equipment

The generator transformers shall be provided with two complete independent sets of cooling equipment each with 50% capacity. One spare fan shall be provided for each cooler bank section.

The cooling equipment shall be so designed and installed that undue noise and vibration under running conditions are avoided. The cooling equipment shall be capable of dissipating the full load losses of the transformer.

Two auxiliary power supplies, 415V, three phase, 4 wire shall be drawn from two separate

switch-gears for the cooler control cabinet. Cooler control equipment shall be divided in two halves, each having one power supply incomer with bus section between two halves.

Control equipment for Fan motors shall be mounted in a marshalling cabinet adjacent to the transformer and shall include the necessary contactors with automatic control and Annunciator equipment and provision for manual control.

The switching in or out of the cooling equipment shall be controlled by winding temperature and there shall be provisions for automatic switching in or out at predetermined temperature levels which should be capable of adjustment and setting at will.

Radiators shall be designed to withstand the pressure conditions specified for the tank (the radiators shall be designed and constructed for vacuum filling of oil and be capable of withstanding without leakage or distortion continuous internal gas pressure of 0.7 atmosphere with oil at operating level) and shall be designed so as to be accessible for cleaning and painting to prevent accumulation of water on the outer surfaces.

Radiators shall be detachable type, mounted on the tank and provided with:

- Top and bottom shut-off valves (at each point of connection to the tank) and blanking plates.
- Bottom drain plug, top filling plug and air release plug at the top.
- Lifting lugs.

Valves and connections shall have following features:

- Sluice type valves with hand wheels.
- Clear indication of open and closed positions.
- Provided with blanking plates and screwed plugs.

1.4.2.8.11 Voltage Control

The transformer shall be provided with an off-circuit tap changing switch having local manual control for varying its effective ratio of transformation when the transformer is de-energised. The Tap changer switch shall have following features:

- i. Designed for sustained over current of not less than 150% of rated current of the winding.
- ii. It shall not occupy any intermediate position between clearly marked tap positions.
- iii. It shall be capable of repeated operation and withstanding S.C. Forces.

- iv. It shall have integral handle with pad-locking facility at every tap position.
- v. The tap charger shall have tap position indicator.

The HV winding shall have taps at 105%, 102.5%, 100%, 97.5%, and 95%.

1.4.2.8.12 Bushing Insulators and Terminals

The electrical characteristics of the bushings shall be in accordance with IS 3347 and IS 2099 or their equivalent. Dimensions and requirements of condenser bushings shall be in accordance with IS 12676, 1989. The LV bushing of transformer shall be of the solid porcelain type suitable for connection to bus bars in isolated phase bus ducts. The HV bushing of the transformers shall be oil filled condenser type (66kV and above) or porcelain type depending upon the voltage (for 33kV and less). The grounded parts of the bushing shall be at a minimum height of 2.6 Mts. above ground. No arcing horns shall be provided on any bushing. Bushings of identical voltage rating shall be interchangeable. All bushings shall be equipped with suitable terminals of approved type and size and all external current carrying contact surfaces shall be silver plated, adequately. The insulation class of the high voltage neutral bushing shall be properly coordinated with the insulation class of the neutral of the high voltage winding. The bushings shall have high factors of safety against leakage to ground and shall be so located as to provide adequate electrical clearances between bushings and between the bushings and grounded parts. All bushings shall have puncture strength greater than the dry flashover value.

Porcelain used in bushing manufacture shall be homogeneous, free from laminations, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture. Glazing of porcelain / bushing shall be of uniform brown colour and free from blisters, and burrs.

Special precaution shall be taken to eliminate moisture from paper insulation during manufacture, assembly, transport and erection.

Condenser type bushings shall be provided with:

- i. Oil level gauge.
- ii. Oil filling plug and drain valve if not hermetically sealed.
- iii. Tap for capacitance / tan delta measurement.

The terminal marking and their physical position shall be in accordance with IS 2026 unless specified otherwise.

When bushings have an under-oil end of re-entrant form, the pull – through lead shall be

fitted with a gas bubble deflector.

Suitable neutral CT with the same ratio of main CT's shall be provided for REF protection.

Where turret type current transformers are specified, the bushings shall be removable without disturbing the current transformers. Bushing turrets shall be provided with vent pipes which shall be connected to route any gas collection through the Buchholz relay.

1.4.2.8.13 Terminal Connectors

The LV and HV bushings shall be provided with suitable terminal connections. The LV side connections of the transformer shall be electrically and mechanically suitable for receiving the bus duct. The terminal connections for HV side bushing shall be suitable for connection to ACSR conductor used in the project.

1.4.2.8.14 Temperature Indicating Devices and Alarm

A dial type thermometer shall be provided to indicate the top oil temperature with a dial range of oil 0-120°C. A dial type winding temperature indicator responsive to the combination of top oil temperature and winding circuit, and calibrated to follow the hot spot temperature of the winding shall be provided with a dial range of 0-120°C. The tripping contacts of the winding temperature indicators shall be adjustable to close between 60°C and 120°C and alarm contacts to close between 50°C and 100°C and both shall reopen when the temperature has fallen by about 10°C. Another adjustable contact shall also be provided to start the air forcing fans.

The above indicating devices and alarms shall be provided inside suitable terminal boxes with all wiring brought to terminal strips. The terminal box shall be provided with cable terminations, space heaters with thermostat controls etc...

Temperature measurement of Oil and windings for transformers above 50 MVA shall be done using Fibre optic sensors meeting the following criteria:

- a) System shall be of proven technology. The temperature sensing tip along with the fibre optic cable shall be of an already type tested design. Details of the relevant tests conducted shall be submitted along with the offer. The probes shall be directly installed in each phase / winding of power transformer to measure the winding hot spot and at the top (inside) of the transformer to measure top oil temperature. There shall be minimum eight probes inside the transformer, out of which four are to be connected to the monitoring system and remaining four are to be kept as standby probes, to be connected to the monitoring unit in case of failure of corresponding

probe.

- b) Six (6) probes shall be installed, two nos. in each phase / winding, at the hottest spots of each of the phase winding. The locations of the probes shall be proposed by the Manufacturer by identifying the hot spots with necessary supporting calculations/ documents and shall be finalized by agreement of the Purchaser. Remaining two (2) probes shall be at the top (inside) of the transformer for measuring top oil temperature.
- c) Probes shall be able to be completely immersed in hot transformer oil; they shall withstand exposure to hot Kerosene vapour during the transformer insulation drying process (VPD). The probes shall meet the requirement to eliminate the possibility of partial discharge in high electrical stress areas in the transformer.
- d) Temperature range of the system should be -30°C to $+200^{\circ}\text{C}$ & accuracy of $\pm 2^{\circ}\text{C}$ with no recalibration required. The probes shall not get damaged / affected during filtration of the transformer.
- e) Probes shall be all silica, Teflon jacketed fibre with perforations/slits in the outer jacket to allow complete oil filling. The fibre with Teflon jacket shall be strong enough to withstand the severe conditions prevailing inside an EHV transformer.
- f) System should include analog outputs for each of the four (minimum) measurement channels. Temperature resolution of the analog outputs shall be $\pm 0.1^{\circ}\text{C}$ and the system shall offer user programmable temperature alarm outputs with 6 relays, alarm lamps (LEDs) and controller system status indicators. All inputs and outputs of the system shall meet the requirements of surge test as per IEEE C37.90.1-1989 in which a 3000V surge is applied to all the inputs and outputs without permanent damage to the instrument. The microprocessor based unit shall be of an already type tested design and details of type tests conducted shall be submitted with the offer.
- g) The system shall be capable of retaining temperature data of a minimum of 90 days at one (1) reading / minute and should retain max temperature of each channel until reset.
- h) The transformer manufacturer should submit data showing that the probes are located in the hottest point of the winding, while submitting drawings for approval.
- i) The Fibre optic cables are to be brought out of the main tank through tank wall penetrator feed-through plate. The feed-through plate shall be welded / bolted on to the Tank such that no oil leakage / moisture ingress will occur. The external fibre

optic extension cable shall then be run to main control cabinet, routed inside suitable conduits with large bend radius.

- j) The controller shall be housed in cooler control cubicle or in a separate enclosure having degree of protection IP 56.
- k) Temperature Rise Test Measurements shall be made with the FO Thermometers. The equipment shall be operational during temperature rise tests and be demonstrated during these tests. During probe verification, the hottest probes for each phase shall be identified, and temperature data for all probes recorded and reported in the test report.

1.4.2.8.15 Insulating Oil

The insulating oil for the transformers shall be of EHV grade, generally conforming to IS:335. The quantity of oil required for the first filling of the transformer with 10% extra shall be supplied and its full specification shall be stated in the bid.

- Sufficient insulating oil of NAPTHENIC Type (Made from NAPTHENICCRUDE) conforming to BS: 148 / IEC: 296 Class-I / IV shall be supplied for first filling of each transformer.
- An extra quantity of transformer oil equal to 10% of the total quantity of oil shall also be supplied.
- If the transformer is to be supplied gas filled, particular attention shall be paid to deliver the oil at site free from moisture and of uniform quality through out in non-returnable epoxy coated steel drums.
- The quantity of oil for first filling of each transformer shall be stated in tender along with manufacturer of the oil to be supplied.
- Use of inhibitors in oil shall not be resorted to.

1.4.2.8.16 Gas and Oil Actuated Relay

The GSU transformer shall be fitted with gas and oil actuated relay having alarm and trip contacts, which close following oil surge or low oil level conditions.

The gas and oil actuated relay shall be provided with a test cock to take flexible pipe connection for checking the operation of the relay and sampling of accumulated gases.

To allow gas to be collected at ground level, a pipe shall be connected to the gas release cock of the gas and oil actuated relay and brought down to a point approximately 1.25 m

above ground level, where it shall be terminated by a cock.

1.4.2.8.17 Internal Earthing Arrangement

i. Earthing Of Core Clamping Structure

The top & bottom main core clamping structures shall be connected to the tank body by copper straps.

ii. Earthing of Magnetic Circuit

The magnetic circuit shall be earthed to the clamping structure at one point only, through a link placed in an accessible position beneath an inspection opening in the tank cover. The connection to the link shall be on the same side of the core as the main earth connection.

Where oil ducts or insulating barriers parallel to the plane of the lamination divide the magnetic circuit into two or more electrically separate parts, the ducts of barrage shall be bridged by tinned copper strip bridging pieces to maintain electrical continuity and the magnetic circuit shall not be regarded as being of sectional construction.

iii. Earthing Terminals

Two (2) earthing pads (each complete with two (2) Nos. tapped holes, M 10 bolts, plain and spring washers) suitable for connecting 75 x 10 mm grounding flat shall be provided each at position close to the two (2) diagonally opposite bottom corners of tank.

Two earthing terminals suitable for connection to 50 x 6 mm galvanised steel flat shall also be provided on cooler, marshalling box and any other equipment mounted separately.

Two earthing terminals capable of carrying the short circuit current of the transformer for four seconds shall be provided.

iv. Earthing of Coil Clamping Rings

Where coil-clamping rings are of metal at earth potential, each ring shall be connected to the adjacent core clamping structure on the same side of transformer as the main earth connections.

1.4.2.8.18 Marshalling Kiosk

Made of Sheet steel of minimum 3mm thickness, vermin proof, well ventilated and weather proof marshalling box with water-tight hinged and padlocked door of a suitable construction shall be provided for the transformer ancillary apparatus. The box shall have sloping roof and the interior and exterior painting shall be in accordance with the specification. Padlock along with duplicate keys shall be supplied for marshalling box. The degree of protection shall be IP-55.

Wiring up to marshalling box shall be with PVC / SWA, PVC copper cable 660 / 1100 volts grade IS certified / marked.

The marshalling box shall accommodate the following equipment:

- i. Temperature indicators.
- ii. Terminal board and glands for incoming and out going cables.
- iii. Illumination lamps and 5A, 240 V, 3 pin socket with switch.

The temperature indicators shall be so mounted that the dials are not more than 1600 mm from the ground level and the door(s) of the compartment(s) shall be provided with glass window of adequate size to prevent internal condensation. An approved type of metal clad heater with thermostat and switch control shall be provided. The ventilation louvers, suitably padded with felt, shall also be provided.

All outgoing connections from the transformer viz.: Buchholz relay, temperature indicators, level indicators, etc... shall be wired to marshalling kiosk.

All incoming cables shall enter the kiosk from the bottom and the gland plate shall not be less than 450 mm from the base of the box. The gland plate and associated compartments shall be sealed in suitable manner to prevent the ingress of moisture from the cable trench.

1.4.2.8.19 Control Connection, Instrument Wiring & Terminal Boards

All controls, alarms, indicating and relaying devices provided with the transformer shall be wired up to the terminal block inside the marshalling box.

All wiring connections, terminal boards, fuses and lines shall be suitable for tropical atmosphere. Any wiring liable to be in contact with oil shall have oil resisting insulation. There shall be no possibility of oil entering connection boxes used for cables and wiring. When 400 / 415 volts connections are taken through junction boxes of marshalling boxes, they shall be adequately screened and 400 / 415 volts danger notice must be affixed to the

outside of junction boxes or marshalling boxes. All wiring shall be with stranded copper of 1100 volts grade and 4.00 sq. mm for CT leads and not less than 2.5 Sq.mm for other connections. All wiring cables shall be ISI- marked / certified and in accordance with the relevant ISS. Not more than two wires shall be connected to one terminal. At least 20 % spare terminals shall be provided. Each terminal shall be suitable for connecting two 2.5mm² standard copper conductors from each side.

All wires on panels and all multi-core cables shall have ferrules bearing same number at both ends. Same ferrule numbers shall not be used on wires in different circuits, on the same panels. Ferrules shall be of white insulating material and be provided with glossy finish to prevent adhesion of dirt. They shall be clearly and durably marked in black and shall not be affected by dampness or oil. Wiring shall, in general be accommodated on sides of the box and wires for each circuit shall be separately grouped.

Back of panel wiring shall be arranged so that access to the connecting stems of relays and other apparatus is not impeded. All the cables and capillary types of OTI and WTI etc... are to be wired properly on cable trays with the help of suitable cleats up to the marshalling box.

The cable trays shall be kept minimum 100 mm away from the tank body to avoid excessive heating of cables / wires.

Wires shall not be joined or tied between terminal points. Wherever possible, all circuits in which the voltage exceeds 125 volts shall be kept physically separated from the remaining wiring.

The function of each circuit shall be marked on the associated terminal boards. Where apparatus is mounted on panels, all metal cases shall be separately earthed by means of copper wire. No live metal part shall be exposed at the back of terminals boards.

All MCB's / fuses shall be labelled. All devices and terminal blocks within the marshalling box shall be clearly identified by symbols corresponding to those used on applicable schematic or wiring diagrams.

All wiring diagrams for control panels shall preferably be drawn as viewed from the back. The overall design of wiring shall be such that various wires and ends of the same wire can be traced easily and there is convenience to access the terminations and ferrule number shall be readable with convenience.

1.4.2.8.20 Bushings and Termination Arrangement Generator Step-Up (GSU) Transformer

The HV & neutral winding shall terminate on suitable porcelain bushings provided on the tank and LV winding shall be provided with suitable terminal connections. HV bushings shall be connected to conductors / cables used in the project. The connections from LV cable box shall be taken through XLPE cables of sufficient size per phase. Neutral bushing type current transformers for REF shall be provided on the neutral bushing.

Station Auxiliary Transformer

The HV & LV winding of station auxiliary transformer shall terminate on cable boxes and neutral star point shall be brought out through a suitable bushing on the tank. The connection from HV cable box shall be taken through XLPE cables and connections from LV cable box shall be taken through PVC cables.

Common to Generator and Auxiliary Transformers

The Electrical characteristics of bushings shall be in accordance with relevant IEC standards / IS:3347 / IS:2099. Any stress shield shall be considered as an integral part of bushing assembly.

Bushing current transformers shall be independently supported to ensure secure removal of bushings without disturbing the current transformer secondary terminals and connection.

1.4.2.8.21 Transformer Cooling System

The transformers shall be oil-immersed with ONAN cooling system complete with radiators, shut off valves, air release plugs, filter valves etc... Radiators shall have bolted flanged connections and pipe extensions to permit withdrawal of transformer tank without disturbing the radiators. Flexible joints shall be provided in the interconnecting pipes to facilitate erection and dismantling and reduce transfer of vibrations from tank to radiator. Blanking plates for each group of radiators shall be supplied.

1.4.2.8.22 Neutral Bushing Current Transformers

The bushing current transformers on neutral bushing shall comply with the requirements of latest issue of IS:2705. The reports of all type and routine tests as stipulated in the Indian Standards shall be furnished for approval to the Purchaser.

All technical particulars of bushing current transformers as called for in bidding schedule shall be furnished.

All secondary leads, including tapping shall be brought out to a weather proof outlet box near the bushing. The Contractor shall carry out conduit wiring from this outlet box up to the

transformer marshalling box or control cabinet.

1.4.2.8.23 Cable Box and Cable Box Bushing

Cable boxes shall be suitable for operating outdoor and suitable for vertical arrangements of cables ascending to the box from below. Cable boxes for the transformers shall be with the disconnecting chambers so that the transformers with accessories can be removed for servicing for repair without disconnecting the cable connections.

Boxes shall be suitable for aluminium conductor, XLPE / PVC cables as specified.

Compression glands and lugs shall be provided suitable for PVC cables.

The design and construction of the cable box shall be such as not to permit the entry of moisture into the box. Supports for cable boxes shall be provided by the Contractor. Suitable draining plug shall be provided with each cable box.

1.4.2.8.24 Piping, Valves and Flanges

The necessary piping, fittings and all types of valves shall be provided for connecting each transformer to the radiators. The oil piping shall be with machined flanged joints. Drain valves / plugs shall be provided in order that each section of the pipe work can be drained independently.

1.4.2.8.25 Cleaning and Painting

Surface preparation for tank, pipes etc...: - All surface of transformer tank, pipes etc... shall be thoroughly blast cleaned with sand or shot or grit in accordance with ISO 8501 Part-I to a minimum standard of SA 21 / 2 to make the surface free from visible oil, grease & dirt, mill scale, rust, paint coatings and foreign matter. Machined areas and threaded components etc... are to be covered during blasting to prevent damage. The first coat of primer paint should be applied not later than 3-4 hours after preparation of surface to avoid oxidation.

Surface preparation for radiator: - All internal and external surfaces of radiator shall be thoroughly cleaned either by chemical cleaning or by blast with sand or shot or grit in accordance with ISO 8501 Part-I to make surface free from visible oil, grease & dirt, mill scale, rust, paint coatings and foreign matter. Suitable chemical should be used for chemical cleaning, if required. The air that is used for blasting should be dry and free from oil. The first coat of primer paint should be applied not later than 3-4 hours after preparation of surface to avoid oxidation.

Painting – External & Internal surfaces: - Painting shall be carried out in closed dust free area. The external surface shall be coated with suitable layers of paint and to form an impermeable layer so that air and water cannot reach the substrate. The paint selected shall be stable in outdoor conditions such as rain, sunlight, pollution etc... Paint used for primer, under coat and top or finish coat should be from the same manufacturer and compatible to each other. In case in a rare event, Paint used for primer, under coat and top or finish coat are not from the same manufacturer the compatibility test of the paint from different sources shall be carried out. Painting shall be applied as per the recommendation of the paint manufacturer. The number of coat shall be such that the minimum dry film thickness (DFT) specified is achieved. The DFT of painted surface shall be checked with a measuring gauge to ensure specified DFT.

Before shipment, all steelwork not under oil shall be painted with a primary coat of anti-corrosive paint of durable nature and suitable for two coats of suitable paints as per manufacturer's standard practice to be applied at site after erection. The interior surfaces shall be painted according to the best standard practice. Complete painting scheme for the transformer is tabulated below:

	Tank, Pipes etc... (External surfaces)	Tank (Internal Surface)	Radiator (External Surface)	Radiator & Pipes (Internal)
Surface Preparation	Blast cleaning Sa 2 1/2	Blast cleaning Sa 2 1/2	Chemical blast / Blast cleaning Sa 2 1/2	Chemical cleaning if required
Primer coat	Epoxy based Zinc primer (30-40 microns)	Hot oil resistant, non corrosive varnish or paint or epoxy.	Epoxy based Zinc primer (30-40 microns)	Hot oil proof, low viscosity varnish, flushing with transformer oil.
Intermediate under coat	Epoxy HB MIO (30-40 microns)		Epoxy based Zinc primer (30-40 microns)	
Finish coat	Aliphatic poly urethane (min 50 microns)		PU paint (min.50 microns)	
Total DTF	Minimum 155 microns	Minimum 30 microns	Minimum 110 microns	
Colour shade	697 shade as per IS 5 or as specified in Part-2 of this specification	Glossy white for paint	Matching shade of tank / different shade aesthetically matching to tank	

Surface preparation for Control cabinets/ Marshalling Boxes: - Surface preparation for all transformer Control cabinets / marshalling Boxes shall be carried out conforming to following Indian standard in dust free area.

1. IS 3618 - Degreasing by solvent piping: phosphate treatment for iron & steel for protection against corrosion.
2. IS 6605 - code of practice for phosphating of iron & steel.

Chemicals: Suitable chemicals should be used and concentration of chemicals / weight of phosphate coating should be checked regularly as per recommendation of chemical manufacturer and applicable.

Inspection: Surface of application of paint should be dry free from oil, dirt, acid and loose adhering power and reasonably smooth in finish without uncovered areas, rusty surfaces and roughness.

Painting of control cabinets / marshalling boxes: - Enamel paints shall be used with total paint thickness as minimum 80microns.

Except for nuts, bolts and washers, which may have to be removed for maintenance purpose, all external surfaces shall receive a minimum of three coats of paint.

Nuts, bolts and washers which may have to be removed for maintenance purposes shall receive minimum of one coat of paint after erection.

All interior surfaces of mechanism chambers and marshalling boxes except those which have received anti-corrosion treatment shall receive three coats of paint applied to the thoroughly cleaned metal surface. The final coat is of a light coloured anti-condensation mixture.

Any damage to paint work, incurred during transport and erection shall be made good by the contractor by thoroughly cleaning the damaged portion and applying the full number of coats of paint that had been applied before the damage was caused.

1.4.2.8.26 Fittings and Accessories

The transformer shall be provided with the following fittings and accessories:

- One dial type indicating thermometer for oil of robust pattern mounted on the side of the transformer at convenient height to read the temperature of the hottest part of oil. Generator Transformers shall be fitted with adjustable alarm and trip contacts. The oil temperature indicator shall be provided with anti-vibration mounting.

- Two dial type winding hot spot, temperature indicators, one for each winding (H.V. and L.V. windings) of the transformer shall be provided. These shall be of the indicating type, responsive to the combination of top oil temperature and winding current, calibrated to follow the hottest spot temperature of the transformer winding. The winding temperature detectors in generator transformer shall operate a remote alarm in the event of hottest spot temperature reaching a predetermined value. The winding temperature indicator shall be provided with anti-vibration mounting.
- Pocket on tank cover for thermometer.
- One no. plain oil gauge with low and high level alarm contacts shall be provided.
- Gas and oil actuated relay (Buchholz Relay) with alarm and trip contacts.
- Silicagel breather.
- Pressure relief device.
- Two earthing terminals along with bolt and spring washers.
- Marshalling box for housing control equipment and terminal connections.
- Complete wiring up to the marshalling box with PVC copper cables of 650 / 1000 V grade. Wiring shall be brought through designated steel conduit pipe properly clamped on the tank.
- Inspection cover.
- Oil valves in the main tank.
- Drain valve with padlocking arrangement.
- Two sampling valves one at the top and other at the bottom.
- Diagram and rating plate.
- Jacking pads for jacking the transformer for changing direction of rotation of bidirectional wheels.
- Lifting lugs for lifting the complete transformer assembly filled with oil.
- Lifting eyes or lugs on all parts of the transformer requiring independent handling during assembly and dismantling.
- Bi-directional flange rollers with locking and bolting device.

- Anti earthquake clamping devices.
- Neutral Bushing CT.
- Under carriage.
- A set of four jacks for jacking the transformer.
- Indicating, alarm, relay equipment shall have contacts suitable for operation with 110V DC supply.

1.4.2.8.27 Packing and Transportation

The packing may be in accordance with the supplier's standard practice but he should give full particulars of packing for the approval of the KSEBL. Special arrangement should be made to facilitate handling and to protect and projecting connections from damage in transit. The maximum weight of a single package should not preferably be more than 40 tons and maximum size of package should not be more than 4m x 4m x 2.4m (h x l x b). The transformer shall be shipped filled with oil / with inert gas (whichever way desired by the Supplier and approved by the board, depending on the size etc...). Nitrogen filled with sufficient number of impact recorders with necessary arrangement to maintain nitrogen pressure during transit and storage.

All parts shall be adequately marked to facilitate field erection. Boxes and crates shall be marked with the contract number and shall have a packing list enclosed showing the parts contained therein. As the equipment is liable to be stored in the open, packing shall be suitable for outdoor storage under humid atmospheric conditions.

1.4.2.9 Losses, Guarantees, Bid Evaluation and Penalty

For the GSU transformer, the Contractor shall indicate whether the figures given for guaranteed losses in the schedule of guaranteed technical particulars are with or without tolerances. If tolerances are applicable, the limits for the same should be indicated. In the absence of any indication to this effect, the figures for no-load and load losses (excluding auxiliary losses) will be increased by 10% as provided in the Indian Standards. Changes in the figures assigned for transformer losses will not be permitted after opening of the bids and bid evaluation will be carried out on the basis of information made available at the time of bid opening.

The no-load loss in kilowatts at rated voltage and rated frequency and the total losses in kilowatts at rated output, rated voltage and rated frequency shall be guaranteed under

penalty for each transformer. For the purpose of penalty computations, the test figures of the no-load and the total losses will be compared with the corresponding guaranteed figures.

The penalties shall be separately evaluated from (i) the excess of the test figures of the no-load loss in kilowatts over the corresponding guaranteed value, and (ii) the excess of the difference between the test values of the total losses and the no-load loss in kilowatts over the difference of the corresponding guaranteed value. No tolerance shall be permitted over the test figures of the losses.

The penalties shall be calculated at the rate of 0.5% of the Contract price of the transformer per kilowatt for the excess of no-load loss, and at the rate of 0.5% of the Contract price of the transformer per kilowatt for the excess of the difference in the total and no-load losses for the transformers. For fraction of kilowatt, the penalties shall be applied pro-rata.

For the purpose of comparison of tenders, the quoted prices shall be equalized for the transformer losses at the rate of 0.5% of the Contract price of the transformer per kilowatt of no-load losses and at the rate of 0.5% of the Contract price of the transformer per kilowatt of the difference between total losses and no-load losses on the basis of the guaranteed loss figures for the transformers. No tolerance will be allowed for this purpose.

1.4.2.10 *Short-circuit Withstand Capability*

The GSU transformer shall be designed and constructed to withstand without damage the thermal and dynamic effects on external short circuits for 5 seconds under conditions specified IS:2026 (Part I) – 1977. This capability shall be demonstrated by short circuit test or type test report.

The transformers shall also be designed for operation at unbalanced loading conditions.

Transformers shall be free of partial discharges over the range of operating voltages.

1.4.2.11 *Tests*

Tests shall be carried out to evaluate the performance of the material and appliance generally as per the provisions of IS 2026 or its equivalent in the presence of KSEBL's personnel. Contractor shall raise the inspection call at least four weeks in advance along with intimation of the test date and venue. Further prior to issue of the call, the Contractor shall submit to the KSEBL a detailed Inspection Test Plan / procedure for approval.

Following test sequence shall be followed while taking up testing of transformers:

- Ratio, Polarity and Phase displacement.
- Resistance measurement.
- No-Load test.
- Sound Level test (if specified).
- Load Loss and Impedance measurement.
- Zero Sequence impedance test (for three phase transformers).
- Dielectric tests:
 - Switching Impulse test.
 - Lightning Impulse test (line terminals).
 - Lightning Impulse test (Neutral terminal).
 - Separate source AC withstand test (Applied voltage test).
 - Short-duration induced AC withstand voltage test including partial discharge measurement.
 - Long-duration induced AC withstand voltage test including partial discharge measurement.

The completely assembled transformer should be subjected to the following tests as per the above sequence and in accordance with IS 2026 or its equivalent standard.

1.4.2.11.1 Type Tests

1. Full-wave lightning impulse test
2. Temperature rise test

1.4.2.11.2 Routine Tests

1. Measurement of winding resistance.
2. Measurement of voltage ratio and check of voltage vector relationship.
3. Measurement of impedance voltage / short circuit impedance and load loss.
4. Measurement of no-load loss and current.
5. Measurement of insulation resistance.
6. Dielectric tests.
7. Separate-source power frequency voltage withstand test
8. Induced over-voltage withstand test.

9. Oil leakage test for tanks.
10. Vacuum test for tanks.
11. Pressure test on tanks.
12. Efficiency tests.

1.4.2.11.3 Special Tests

1. Measurement of zero sequence impedance.
2. Measurement of acoustic noise level.
3. Measurement of power taken by oil pumps / cooling fans.
4. Measurement of harmonics at no-load current.
5. Short circuit test.
6. Capacitance test to determine the capacitance between windings to earth.
7. Sweep Frequency Response Analysis (SFRA) Test shall be carried out on 220kV transformers at factory. The values / data shall be furnished to the KSEBL for future reference.

The transformer manufacturer shall provide all documents for proving the capability of the transformer to withstand the effects of dynamic short circuit as per the procedure elaborated in IS 2020 (part-5). However, if the said documents are inconclusive or are not sufficient to prove the short circuit capability, KSEBL may opt for physical conduct of short circuit test at the quoted rates.

1.4.2.11.4 Tests at Site

The following pre-commissioning tests shall be carried out (including as per Section 1.4.5 - Switch-yard Installation and Tests on Completion of this specification).

1. Checking ratio and polarity. The ratio shall be checked on all taps and between all the windings and the results should tally with the Contractor's tests.
2. Resistance measurement of windings. Kelvin Bridge meter should be used for the measurement of resistance. Tapped winding resistance shall be measured at all tap positions.
3. Insulation resistance measurement. IR value between windings and between windings to earth shall be checked using a 5000 Volts meggar.
4. Measurement of PI value.
5. Magnetising current and iron loss test.

6. Test on tap changer. Operation of the tap changer shall be checked.
7. Sweep Frequency Response Analysis (SFRA) Test shall be carried out on 220kV transformers during pre-commissioning at site. The values / data shall be furnished to the KSEBL for future reference.

1.4.2.12 Fire Protection

The transformers shall be provided with Mulsifier type fire protection system with all its associated auxiliary equipment as detailed below:

The transformers of 10 MVA and higher rating or oil filled transformers with oil capacity of more than 2000 litres shall be provided with automatic high velocity water spray system as per relevant IS or Nitrogen injection based fire protection system. The transformers of 220kV or higher voltage may preferably be provided with Nitrogen injection based fire protection system in addition to automatic high velocity water spray system.

Portable and mobile fire extinguishers shall be provided near the transformer bays to extinguish a fire in the initial stage to prevent its spread.

1.4.2.13 Tools

A full set of tools, spanners, jacks, special tools etc...,for assembling and dismantling the transformer, with a rack for holding them shall be supplied. All spanners shall be single ended and case hardened. Detailed list of these items shall be furnished in the tender. Following tools shall be supplied as a minimum:

1. Spanner set from 6mm to 32mm size	- 1 set
2. Heavy duty cutting pliers	- 1
3. Nose pliers	- 1
4. Circlip pliers	- 1
5. Hydraulic jacks of suitable capacity for lifting transformers	- 4 No.
6. Screw drivers (various sizes)	- 4 No.
7. Star screw driver (various sizes)	- 2 No.
8. Monkey pliers(various sizes)	- 2 No.
9. Adjustable spanners(various sizes)	- 2 No.
10. Tommy bars and any other special tools	- 2 No.

All the tools except jack must be supplied in a tool box.

1.4.2.14 Instruction Manuals

The Contractor shall be required to supply 6 (six) sets of instruction manuals per transformer, each properly bound in hard cover. Each set shall consist of the following:

- All the approved drawings.
- Erection, Operation & Maintenance manual for transformer and pamphlets for all spare parts e.g. OIL, WTI, Off-Load Tap-changer, Buchholz relay, Silica-gel breather / Pressure relief valve etc...
- Instructions for dehydration, if any.
- Precautions prior to vacuum application, if any.
- Any other information / data / documents / instructions considered necessary by the manufacturer for efficient functioning of the transformer.

1.4.2.15 Spares

The requirement of spares for each transformer shall be as follows:

1. Radiator Fan	-	2 No.
2. HV Bushing	-	1 No.
3. LV Bushing	-	1 No.
4. Neutral bushing	-	1 No.
5. Gaskets	-	1 Set
6. Oil gauge (for use in conservator)	-	1 No.
7. Recommended spares parts for off-load tap changer	-	1 Set
8. Relief diaphragm	-	2 Set
9. Buchholz relay	-	1 No.
10. Winding Temperature Indicator	-	1 No.
11. Oil Temperature Indicator	-	1 No.
12. Control Contactor for Cooler Control	-	1 No.

The Contractor shall also quote for any other item of optional spares recommended for 5 years of satisfactory and trouble free operation and maintenance of the equipment as per Clause 1.1.32 of this specification.

The KSEBL will decide on these optional spares to be ordered on the basis of the list.

1.4.3 Switch-yard Equipment

1.4.3.1 Introduction

This section covers the KSEBL's requirements for the Equipment in the powerhouse switch-yard. The scope of these specifications is to stipulate the basic general guidelines to the Bidder / Contractor for the design, manufacture, testing at manufacturer works, standard and quality of workmanship, general finish of equipment, compliance to the latest published edition (prior to the date of closing of tender) of the international standards and recommendations specified throughout the specifications, supply, insurance, delivery and storing at site, erection, site testing, commissioning, performance and reliability confirmation, warranty confirmation of the complete equipment, spares for 5 years operation of the equipment, special tools and testing devices as described and detailed in the specifications and in the annexed schedule of requirements and other general requirements as per **Section 1.1**, which are required for the plant / equipment being provided under the scope of this tender / contract.

The scope of supply shall include all parts, accessories, spares etc... which are essential for construction, operation and maintenance of the supplied equipment even though these are not individually or specifically stated or enumerated. Corresponding components of all the equipment and associated systems and the spares shall be of the same material, dimensions and finish and shall be interchangeable.

Any ratings, if mentioned, are indicative only and are a minimum for giving a base line. The Bidder should ensure that the ratings of the various equipment are sufficient to take care of the design requirements of the equipment offered for the concerned project. Any increase in rating during detailed engineering stage will not entitle the Successful Bidder / Contractor for any extra charges. The Contractor should submit for approval the calculations for arriving at the ratings of the various equipment.

1.4.3.2 Reference Standards and Codes

The Equipment shall be designed, manufactured, tested, installed and commissioned in accordance with the latest revision of applicable IS / IEC or equivalent standards.

The Contractor shall adhere to sound design and construction practices with regard to codes and material specifications in order to warrant operational safety and ease of maintenance of plants as well as simplicity of control and stability in plant operation.

- IEC 62271-100 & 60056 - Circuit breakers
- IS 13118 - Circuit breakers
- IEC 62271-102 - Alternating Current Dis-connectors with Earthing Switch.
- IEC 60376 - Sulphur hexa-fluoride gas
- IEC 60694 - Common clauses for high voltage switch-gear and control gear.
- IS 3070 - Lightning arrestor for AC systems
- IEC 60099-1 - Lightning arrestors
- IEC IC 37 - Metal oxide surge arrestors without gaps.
- IS 9921 - Isolators and earth switches.
- IEC 60129 - Isolators and earth switches.
- IS 2544 - Porcelain post insulators.
- IS 802 - Galvanised steel structure.
- IS 5547 - Capacitor voltage transformers.
- IEC 60044-2 & 5 - Voltage transformer.
- IEC 60044-1 - Current transformer.
- IS 335 - New insulating oils.
- IS 3156 - Voltage transformer.
- IS 2705 - Current transformer.
- IS 5621 - Hollow insulators for use in electrical equipment.
- IS 375 - Specification for marking and arrangement for switchgear, bus-bar main connection & Auxiliary wirings.
- IS 5578 & 11353 - Making and arrangement for switchgear bus-bar main connections and auxiliary wiring.
- IS 398 - Aluminium conductor for overhead transmission purposes (ACSR / ACC).
- IS 2121 - Conductor and earth wire accessories for overhead

power lines.

- IS 4826 - Hot-dip galvanizing coatings on round steel wires.
- IS 5082 - Wrought aluminium and aluminium alloy bars, rods, tubes and section of electric purpose.
- IS 8130 - Conductor for insulated electric cable & flexible cords.
- IS 6005 - Code of practice for phosphating iron and steel
- IS 2026 - Specification for Power Transformer
- IS 2062 - Specification of structural steel for fabrication
- IS 1367 - Technical Supply Conditions for Threaded Steel Fasteners.
- IS 2629 - Recommended Practice for Hot-Dip Galvanizing of Iron and Steel.
- IS 5556 - Serrated Lock Washers – Specification.
- IS 875 - Code of Practice for Design Loads (other than Earthquake) for Buildings and Structures.
- IS 5613 - Code of Practice for Design, Installation and Maintenance of Overhead Power Lines.
- IS 1818 / 9921 - AC Isolators and earthing switch for above 1000V
- IS 2805 - Dimensions for Ball Grips
- IS 7311 / 7285 - Specification for Seamless Steel Cylinders for Permanent and High Pressure Liquefiable Gases.

1.4.3.3 Reference Sections

- Section 1.1 - General Technical Requirements.
- Section 1.3.14 - Site Installation, Field Testing & Tests on Completion.
- Section 1.4.1 - Power Evacuation Arrangement.
- Section 1.4.2 - Power Transformers.
- Section 1.4.4 - Switch-yard Control, Protection & Instrumentation.
- Section 1.4.5 - Switch-yard Installation and Tests on Completion.
- Part - 2 - Specific Requirements for the Project.

1.4.3.4 Submittals and Approvals

The Contractor shall seek the prior approval of the KSEBL for the following through timely submittals.

- Following information and data for design of foundations from the supplier of the circuit breaker shall be furnished:
 - Dead weight per pole for complete circuit breaker.
 - Static bending moments above the feet of each pole and for complete circuit breaker.
 - Static shear force at the foot of each pole and for complete circuit breaker.
 - Maximum height of the steel supporting structure.
 - Maximum diameter of the pole.
 - Maximum horizontal force acting at upper terminal of each pole due to impact of closing / opening of the circuit breaker.
 - Max. impact loading in terms of equivalent static load both compression and upward due to opening / closing of the breakers. It shall be clearly stated whether these forces shall act simultaneously or at different timing.
 - No. of steel supporting columns provided for mounting the equipment

The above data should represent static reactions for the worst windage or operation conditions.

- Design calculations for CT and PT sizing, Earthing system, Lightning protection system etc...
- General Arrangement Drawings, Circuit diagrams and specifications.
- Cross sectional drawings.
- Lighting layout Drawings.
- Detailed Bill of Material indicating Make, Type, rating and Function.
- The Contractor shall purchase equipment from reputed vendors only and the name of vendors shall be submitted for KSEBL's approval.
- Inspection & Test Protocol (ITP) of equipment.
- Method Statement for Erection, Testing & Commissioning.

Before delivery of equipment to site, the contractor shall submit all work test certificates / reports for approval and obtain despatch clearance from the KSEBL's representative.

1.4.3.5 Deliverable Documents

- General outline drawings showing dimensional front side elevation and plan of the circuit breakers, isolators, surge arrestors, instrument transformers etc...
- Sectional views showing the general constructional features of the circuit breakers, isolators, surge arrestors, instrument transformers etc... including operating mechanism and arcing chambers and contacts of circuit breakers.
- Assembly and sub assembly drawings of the breakers, arcing chambers, contacts, operating mechanism etc...
- Wiring diagrams showing the local and remote control scheme of the breaker including alarms, indicating devices, instruments, space heaters etc...
- Following information and data for design of foundations from the supplier of the circuit breaker shall be furnished:
 - Dead weight per pole for complete circuit breaker.
 - Static bending moments above the feet of each pole and for complete circuit breaker.
 - Static shear force at the foot of each pole and for complete circuit breaker.
 - Maximum height of the steel supporting structure.
 - Maximum diameter of the pole.
 - Maximum horizontal force acting at upper terminal of each pole due to impact of closing / opening of the circuit breaker.
 - Max. impact loading in terms of equivalent static load both compression and upward due to opening / closing of the breakers. It shall be clearly stated whether these forces shall act simultaneously or at different timing.
 - No. of steel supporting columns provided for mounting the equipment.

The above data should represent static reactions for the worst windage or operation conditions.

- Descriptive literature for all the equipment.
- Type test reports of all the equipment.

- Quality assurance plan adopted for the manufacture of the equipment.
- Erection, testing and commissioning methodology.
- Routine Test report / Data.
- A complete list giving details of equipment and auxiliaries.
- Operation and maintenance manual covering full details of repair procedure.

The extent of the documentation to be furnished shall be to the satisfaction of the KSEBL.

1.4.3.6 Scope of Work

Detailed scope of work and technical details are given in Part-2 “**Specific Requirements for the Project**” of this specification. All foundation bolts and supporting structures / beams as required shall be included in the scope of supply.

The Bidder should ensure that the ratings of the various equipment are sufficient to take care of the design requirements of the equipment offered for the concerned project. Any increase in rating during detailed engineering stage will not entitle the Successful Bidder / Contractor for any extra charges. The Contractor should submit for approval the calculations for arriving at the ratings of the various equipment.

Any item of work not specifically mentioned in the specifications but which are usual and / or necessary for the satisfactory operation of the equipment supplied shall be deemed to be provided by the Contractor and included in the quoted Price. All work shall be complete in all details whether such details are mentioned in the specifications or not.

Before delivery of equipment to site, the contractor shall submit all work test certificates for approval and obtain despatch clearance from the KSEBL / Engineer-in-Charge. The equipment shall be dispatched only when all the required type and routine tests have been carried out and test reports have been approved by the KSEBL.

1.4.3.6.1 Circuit Breakers

For rated voltage of 66kV and above, the circuit breakers shall be of Sulphur Hexa-fluoride (SF_6) type, suitable for outdoor operation under the climatic conditions specified, without any protection from sun and rain. For rated voltage of 33kV, the Circuit breakers can be either SF_6 or Vacuum and for rated voltages up to and including 11kV the circuit breaker shall be Vacuum type, suitable for either indoor or outdoor applications as given in Part-2 “**Specific Requirements for the Project**”.

The different characteristics of the breakers such as recovery voltage and power factor, small inductive breaking capacity, re-striking voltage, breaking capacity of short line fault, long line switching etc... shall be designed as per the requirements of IS:13118 or IEC 60056.

The contractor shall provide all the fittings, accessories and auxiliaries as per requirements of the equipment and shall include Terminal Connectors suitable for XLPE Cable. Circuit breaker shall be suitable for remote control from the control room.

The circuit breaker shall be of modular construction with all components manufactured to assure maximum inter-changeability of standard basic elements. Circuit breakers whether of self supporting type or on raised steel structure should ensure minimum sectional clearance.

All parts of the breaker unit shall be mechanically designed to withstand all electrical, mechanical and other stresses, which may be experienced in the operation of the unit including those under short circuit conditions.

The breaker shall comprise of three identical single pole units, complete in all respects with all piping, fittings and wiring.

The circuit breaker shall be reasonably quiet in operation.

Necessary connecting materials such as clamps, bolts, nuts, washers etc... and fixing bolts for mounting the equipment on the supporting structures wherever required should be provided from the circuit breaker supplier.

For SF₆ Circuit breakers the design and construction of the plant valves, couplings, connections etc... shall be such that leakage of any SF₆ gas shall be a minimum. Similarly, valves, couplings and pipe work shall be so arranged that accidental loss of gas to the atmosphere shall be a minimum.

1.4.3.6.1.1 Duty Requirements

The circuit breaker shall be totally re-strike free under all duty conditions and shall be capable of performing their duties without opening resistor.

The circuit breaker shall meet the duty requirements for any type of fault or fault location, for line charging and dropping when used on an effectively grounded system with transmission lines of any lengths up to 200 km, depending up on the rated voltage and perform make and break operations as per the stipulated duty cycles satisfactorily.

The circuit breaker shall be capable of carrying the rated R.M.S value of the current

continuously at site conditions and at rated frequency without any deterioration, and the temperature rise of various parts shall not exceed the values specified as per IS:13118.

The circuit breaker shall be capable of rapid and smooth interruption of current completely suppressing all undesirable phenomena under all the conditions such as severe and persistent short circuit, interruption of steady and transient magnetising current of transformers, small inductive currents, fault current under phase opposition condition etc...

The circuit breaker with rated voltages of 220kV and above shall be suitable for three phase and single-phase auto re-closing operation. 110kV Circuit breakers shall be capable of above if specified in **Part-2** of this specification.

The breaker shall satisfactorily withstand the high stress imposed on them during fault clearing, load rejection and re-energisation of lines with trapped charges.

The circuit breaker shall be capable of interrupting rated power with recovery voltage equal to the rated maximum line to line service voltage at rated frequency and at a power factor not exceeding 0.15.

The breaker shall be capable of satisfactory operation even under conditions of phase opposition that may arise due to faulty synchronising. The maximum power, which the breaker can satisfactorily interrupt under phase opposition, shall be stated in the offer.

The breakers with rated voltage of 110kV and above having single pole operation shall be capable of pole discrepancy tripping when a close or trip command is given and one or two poles differ from the others.

The SF₆ breakers shall be provided with suitable interlock against closing when the SF₆ gas pressure is below the minimum required. The breakers shall be provided with suitable alarm facility to initiate warning against loss of SF₆ gas pressure. The alarm should be capable of providing signals to enable one tripping operation of the breaker when the SF₆ gas pressure is decreasing due to leaks etc...

The breakers with rated voltages of 110kV and above shall be supplied with two independent trip coils per pole and shall be suitably wired to carry independent trip commands from control panels, including trip circuit monitoring (both pre-close and post close) of each trip coil independently.

All the duty requirements shall be proved with the support of adequate test reports to be furnished along with the bid.

1.4.3.6.1.2 Constructional Features

The features and constructional details of circuit breakers shall be in accordance with the requirements stated hereunder.

All making and breaking contacts shall be sealed and free from atmospheric effects. For SF₆ Circuit Breakers the contacts shall be permanently under pressure of SF₆ gas. The gap between open contacts shall be such that it can withstand the rated dielectric stresses at zero gauge pressure of SF₆ gas due to its leakage.

It shall be clearly stated whether the main contacts are silver plated or not and the thickness of silver plating shall be stated if the same has been provided, Material of main & arcing contacts shall also be stated in the tender.

For SF₆ Breakers, it shall be clearly stated whether the contact travel is sufficient to withstand the rated voltage of the breaker in the event of leakage of SF₆ gas from the poles. In the event of leakage of extinguishing medium to a value which cannot withstand dielectric stresses specified in the open condition, it shall be clearly stated whether the contacts will remain in the open condition or self close.

Main contacts shall be the first to open and the last to close so that there will be little contact burning and wear. Arcing contacts shall be the first to close and the last to open and shall be easily accessible for inspection and replacement.

Main contacts shall have ample area and contact pressure for carrying the rated current and the short time rated current of the breaker without excessive temperature rise, which may cause pitting or welding.

Contacts shall be adjustable to allow for wear, easily replaceable and shall have a minimum of movable parts.

1.4.3.6.1.3 Temperature Rise

The maximum temperature and temperature rise attained by various parts of the circuit breaker when in service at site under continuous full load conditions and exposed continuously to the air and direct rays of the sun shall not exceed the permissible limits specified in IEC-62271 (latest edition) or relevant IS.

1.4.3.6.1.4 Recovery Voltage and Power Factor

Each circuit breaker shall be capable of interrupting without opening resistors rated power with recovery voltage corresponding to the rated maximum line to line service voltage at

rated frequency and at a power factor not exceeding 0.15. The breakers shall also be capable of interrupting faults currents of magnitude 2 to 10% of rated breaking current without causing any re-strike or non permissible over voltage in the system, critical current which gives the longest arc duration at lock out pressure of extinguishing medium and arc duration shall be indicated in the tender.

1.4.3.6.1.5 Asynchronous Operation

Each circuit breaker shall be capable of satisfactory operation even under conditions of phase opposition which may arise due to faulty synchronism as per IEC-62271 requirements. The maximum current which the circuit breaker can satisfactorily interrupt at twice the maximum phase to ground applied voltage under phase opposition conditions shall be stated in the tender.

1.4.3.6.1.6 Transformer Charging Current Breaking Capacity

The circuit breakers shall be capable of interrupting small inductive currents such as those occurring while switching off unloaded transformer banks and reactor / capacitor loaded transformers without giving rise to undue over voltage and without re-strikes. The minimum transformer charging current which can be interrupted by the breaker and corresponding over voltage value under such conditions shall be stated in the tender.

1.4.3.6.1.7 Re-striking Voltage

The circuit breakers offered shall be re-striking free. The rated transient recovery voltage (TRV) for terminal faults shall have specified values. Measures adopted for ensuring proper operation at high rate of rise of re-striking voltage (RR) and for limiting actual voltage across the circuit voltages breaker shall be described. The details of any device incorporated to limit or control the rate of rise of re-striking voltages across the circuit breaker contacts shall also be stated. The circuit breaker shall be capable of withstanding higher peak voltage and RR of TRV expected during clearance of short circuit immediately after the power transformers in the vicinity of centre of generation and at the end of long lines.

1.4.3.6.1.8 Overhead Line Charging Current Interrupting Capacity

Each circuit breaker shall be designed so as to interrupt without restricting the assigned line charging current as per IEC publication No. 62271 (latest edition), if any, corresponding assigned maximum over voltages both on the line and supply side of the circuit breaker

shall be clearly stated.

1.4.3.6.1.9 Breaking Capacity for Kilometric Faults

The interrupting capacity of the circuit breaker for kilometric faults under supply side and line side characteristics shall be as per IEC-60056. The details of test conducted from providing the capabilities of the breakers under kilometric fault conditions shall also be stated in the tender.

1.4.3.6.1.10 Insulating Supports and Housing

Porcelain used in the manufacture of insulator supports/housing shall be homogeneous, free from cavities and other flaws or imperfections that might affect the mechanical or dielectric quality. Glazing of the porcelain shall be of uniform brown colour free from blisters, burns and similar other defects. Porcelain supports / housing shall be designed to have ample insulation, mechanical strength and rigidity for the conditions under which these will be used.

The bushings shall be securely cemented with the pole base such that its failure from base due to shear is prevented. The insulators shall be designed to have ample insulation, mechanical strength and rigidity for satisfactory operation under the conditions indicated in this specification. All insulators / bushings of identical ratings shall be interchangeable. The puncture strength of insulators/bushings shall be greater than the dry flashover value. When operating at normal rated voltage, there shall be no electric discharge between the conductor and the porcelain parts. The insulators / bushings shall be entirely free from radio interference when operating at a voltage of 10% above rated voltage and shall also be free from external and internal corona. Total phase to earth creepage distance and that between top and bottom terminals shall not be less than the specified values.

1.4.3.6.1.11 Noise Level

The circuit breakers shall be reasonably quiet in operation. Noise level at the base of the breaker should be less than 140dB. Breakers shall be provided with sound muffles to reduce the noise level, if required. Bidders shall indicate the noise level of breaker at distance of 50, 100 and 150 m from itself.

1.4.3.6.1.12 Terminal Connectors and Connecting Terminals

Circuit breakers shall be provided with appropriate number of solder-less clamp type

Aluminium / Bimetallic connectors which shall be universal type suitable for horizontal as well as vertical take-off for single or multiple conductor as per actual requirement specified in **Part-2**. Short circuit rating and time as well as continuous current rating of the terminal connectors shall be the same as that of the circuit breaker offered. Suitable terminal earth connector for earthing connections shall be provided.

1.4.3.6.1.13 Grounding

Two grounding terminals shall also be provided on each equipment / apparatus for proper grounding connection with the station ground-mat.

1.4.3.6.1.14 Metal Parts

All ferrous parts of equipment shall be heavily hot dip galvanized. Bolts, nuts, screws, pins, washers etc... used in these equipment shall also be galvanized. The galvanizing should conform to IS-2629 latest edition.

All current carrying parts shall be of non-ferrous metal or alloys and shall be designed to limit sharp points, edges and sharp faces.

1.4.3.6.1.15 Sulphur Hexafluoride (SF₆) Gas

The SF₆ gas shall meet the requirements as per IEC 376 and be suitable in all respects for use in the switchgear under all operating conditions. The high-pressure cylinder in which the SF₆ gas is shipped and stored at site shall comply with requirements of the standards and regulations of IS 4379 and IS 7311.

SF₆ gas filling, evacuation and refilling equipment shall be supplied. This unit shall include a trolley with compressed SF₆ gas cylinder, gas regulator with manometer and necessary coupling for filling gas in the breaker. The gas evacuation and refilling equipment shall consist of evacuating pump with vacuum gauge suitable for evacuating the circuit breaker to the required degree of vacuum, in addition to the gas-filling unit.

1.4.3.6.1.16 Operating Mechanism

Circuit breaker shall be operated by pneumatic mechanism, spring charged mechanism or hydraulic mechanism. The mechanism shall be strong, positive, and quick in action and shall be removable without disturbing other parts of the circuit breaker. The operating mechanism shall be suitable for high speed re-closing. It shall be anti-pumping and trip-free. Working parts of the mechanism shall be of corrosion resisting material. Operating

mechanism shall normally be operated by remote electrical control. Provision shall be made for local electrical control. Provision for Local Mechanical operation along with necessary indications shall also be provided. Necessary alarms against failure of operating mechanism shall be provided for pneumatic or hydraulic mechanisms.

The control circuit shall be designed to operate on 110V DC. Closing coil shall operate correctly at all values of voltage between 85% and 110% of the rated voltage and tripping coil between 70% and 110% of the rated voltage.

Operating mechanism with all accessories shall be in a control cabinet. An outdoor weather proof central control cabinet with hinged doors for the three poles of the breaker shall be provided with the terminal boards, control power switch, relays and switches, door interlocking, operation counter, position indicator, pressure switches and gauges, manual controls for pneumatic / motor operated mechanism and other items for the proper operation and control of the breaker along with supply of tubing, cables from individual pole operating boxes to common control cabinet (for circuit breakers with single pole operation capability). Thermostatically controlled space heaters and lights for illuminating the cabinet may be provided. The operating mechanism shall be housed in cabinet with IP55 protection.

The doors, removable covers and panels shall be gasketed all around with rubber gaskets. Ventilating louvers, if provided, shall have screens and filters. The screens shall be made of either brass or GI wire mesh.

Cable entries to the cabinet shall be from the bottom. The bottom plates of the cabinet shall be fitted with removable gland plates for fixing the cable glands, the size of which shall suit the external cables to the panels. Cable glands shall be screened type, made of brass and shall be suitable for PVC armoured cables.

Design and construction of the SF₆ circuit breakers shall be such that there is minimum possibility of gas leakage and ingress of moisture.

1.4.3.6.1.17 Painting

All sheet steel work shall be phosphated in accordance with IS-6005 "Code of practice for phosphating iron and steel".

Oil, Grease, dirt and dust shall be thoroughly removed by emulsion clearing. Rust and scale shall be removed by picking with diluter acid followed by washing with running water, rinsing with slightly alkaline hot water and drying. After phosphating, thorough rinsing shall be carried out with clean water followed by final rinsing with dilute dichromate solution and

oven drying. The phosphate coating shall be sealed with application of two coats of ready mixed stoving type zinc chromate primer. The first coat may be "Lush dried" while the second coat shall be stoved. After application of the primer, two coats of finishing synthetic enamel paint shall be applied, each coat followed by stoving. The second finishing coat shall be applied, after inspection of 1st coat of painting.

The exterior paint colour shall be light grey, shade No.631 of IS-5. The interior colour shall be white. Each coat of primer and finishing paint shall be of a slightly different shade to enable inspection of the painting. A small quantity of finishing paint shall be supplied for minor touching up required at site after installation of the cabinet.

1.4.3.6.1.18 Rating Plates

Weather proof and corrosion proof rating plates showing year of manufacture and other values as per IS 13118 shall be provided on all circuit breakers.

1.4.3.6.1.19 Terminal Blocks and Wiring

The terminals shall be of the channel mounting type and shall comprise a system of individual terminals so that terminal blocks can be formed for easy and convenient cabling consistent with the high reliability required of the circuits. Terminal blocks shall be of 1100V grade and of current carrying capacity 10 Amps, one-piece moulded, complete with insulated barriers, stud type terminals suitable for wires up to 2.5 mm², spring washers, nuts, lock nuts and identification strips etc... Terminal block design shall include a white fibre marking strip with clear plastic, slip-on / clip-on terminal covers.

Marking on the terminal strips shall correspond to wire number on the wiring diagrams. Not more than 2 wires shall be connected to any terminal. Suitable supports shall be provided for the incoming cables. The terminal blocks shall be arranged to provide maximum accessibility to all conductor terminations.

All wiring terminations shall be with suitable tinned copper crimped lugs. All wiring shall be carried out with single core, stranded, tinned or annealed copper conductor with PVC insulation (FRLS type) and shall be flame, vermin and rodent proof. Segregation of AC and DC wiring shall be done. Numbering ferrules of appropriate size / colours shall be used for wiring. All circuits directly connected to the Trip circuit shall be provided with a Red marker with the label "TRIP" engraved in white colour.

Terminal Blocks accommodating terminations at voltages higher than 110V shall be partitioned off and the voltage clearly labelled. 415 / 240 V AC circuit terminals shall be

segregated from other terminals and shall be fitted with non-inflammable transparent plastic covers to prevent contact with any live parts. Warning labels with red lettering shall be mounted thereon in a conspicuous position. Segregation of different Voltage levels within the terminal blocks shall be achieved using barriers. Voltage levels shall be clearly identified by labels. Terminal Blocks associated with external sources of supply shall be fully shrouded and fitted with a danger-warning label. All connections shall be made at the front of the terminal board and no live metal shall be exposed at the back.

Sensitive control circuits shall be effectively shielded against extraneous signals and interference.

Wire colours shall comply with relevant standard, viz:

- Green / Yellow - connections to earth.
- Black - AC connections and connections in AC / DC circuits.
- Grey - Connections in DC circuits.

At least 20% spare terminals for all circuits shall be provided on each terminal block. There shall be minimum clearance of 250 mm between the first row of terminal blocks and the associated cable gland plate. Also, the clearance between two rows of terminal blocks shall be minimum 150mm.

1.4.3.6.1.20 Interlocks

Necessary interlocks to prevent closing or opening of the breaker (manual and remote) under low pressure, and devices for initiating alarm shall be provided. Provision shall also be made to enable electrical interlocking with the opening or closing of the isolator when the breaker is closed.

1.4.3.6.1.21 Tests

Each circuit breaker shall comply with the type tests and shall be subjected to the routine tests prescribed in IEC 62271. Report of all type tests as stipulated in IS / IEC and the line charging current, transformer charging current, interrupting tests etc... shall be furnished along with the bid.

Complete set of type test reports with necessary oscillograms, drawings pertaining to the offered circuit breakers shall be submitted with the tender. Tenders not accompanied by Type Test Reports as specified in IEC-60056, shall not be considered.

Routine tests shall be carried out on each breaker in the presence of KSEBL's

representative if so desired by the KSEBL. The equipment shall be dispatched to site only after obtaining approval of the KSEBL for the test reports.

Routine test certificates of associated equipment such as motors support insulators, hollow insulators, gas cylinders and SF₆ gas etc... as per relevant IS / IEC shall also be supplied for reference and records of the KSEBL.

1.4.3.6.1.21.1 Field Tests on Breakers

Each circuit breaker shall be liable to undergo field testing before its initial operation.

During the field testing, each circuit breaker must satisfactorily perform and satisfy the requirements of the specification. Special tests, if any, arranged by the KSEBL at site to prove any of the requirement of the breaker shall be carried out in the presence of supplier's Engineers who shall fully associate with the testing.

Details of the pre-commissioning tests to be carried out on the breakers at site shall be enclosed with the tender for reference and approval of the KSEBL.

Special tools and tackles required, if any, for the pre-commissioning tests shall also be clearly indicated in the tender.

All test reports for routine tests shall be submitted and got approved from the KSEBL before dispatch of the equipment.

1.4.3.6.1.21.2 Type Test

Following type tests (but not limited to) as applicable in accordance with IS 13118 and IEC:62271 are required to determine adequacy of the circuit breaker.

- i. Dielectric tests (1.2/50 micro second lightning impulse withstand) and one minute power frequency voltage with stand (dry & wet) test.
- ii. Radio interface voltage (RIV) tests for circuit breakers with rated voltage greater than 245kV.
- iii. Temperature rise tests.
- iv. Measurement of the resistance of the main circuit.
- v. Short-time withstand current and peak withstand current tests.
- vi. Mechanical and environmental tests.
- vii. Miscellaneous provisions for making and breaking tests.
- viii. Short circuit making and breaking tests.

- ix. Basic short circuit test duties.
- x. Critical current tests.
- xi. Single phase short making and breaking tests.
- xii. Capacitive current switching tests.
- xiii. Magnetizing and small inductive current switching tests.

1.4.3.6.1.21.3 Routine Tests

- i. Power frequency voltage withstand dry tests on the main circuit.
- ii. Voltage withstand tests on control and auxiliary circuits.
- iii. Measurement of the resistance of the main circuit.
- iv. Mechanical operating tests.
- v. Design and visual checks.

1.4.3.6.1.22 Instruction Plate and Markings

All name plates, instruction plates, wiring signs and any marking or word on the equipment and its parts and accessories should be in English language.

In order to facilitate sorting and erection at site, every part of the plant and equipment shall be suitably marked. These markings shall be in conformity with those given on the assembly drawings.

All name plates shall be riveted one. The main nameplate shall also be riveted inside the apparatus / switch cubicle. Contract No. & name of purchaser shall be mentioned on the name plate drawings.

1.4.3.6.2 Surge Arrestors

The Surge Arrestors should conform to the technical requirements as required and shall be suitable for the applicable system.

The arrestors shall be designed to have adequate thermal discharge capacity for severe switching surges, long duration surges and multiple strokes. The energy handling capability of the Arrestor offered, supported by calculations should be submitted with the offer and during detailed engineering stage.

The Lightning Arrestor should be fitted with pressure relief devices and arc diverting ports and should be tested as per the requirements of IEC specification for minimum prospective

symmetrical fault current.

The grading ring on each complete Arrestor for proper stress distribution should be provided if required for attaining all the relevant technical parameters.

The surge arrestors shall be of modern design consisting of hermetically sealed units incorporating non-linear resistors (metal oxide) stacked vertically.

The arrestors shall be suitable for mounting on outdoor structures. All metal parts shall be of non-rusting and non-corroding metal.

Each arrestor shall be provided with a nameplate of weatherproof material containing the marking required as per IEC 60099-1.

Each arrestor shall be provided with surge counter / leakage indicator.

Arrestors shall comply with the requirement of all type tests as per IEC recommendation of TC 37 WG-4.

1.4.3.6.3 Isolators

Isolators without Earthing blade shall be used for Bus Isolation and Isolators with Earthing blade for Line Isolation.

Other technical requirements shall be as given in Part-2 **“Specific Requirements for the Project”** of this specification.

The isolators and earth switches shall comply in all respects with IS 1818 / 9921 or IEC publication No.62271-102.

The isolator with earthing switch shall be triple pole, double break type, manually operated with blade movement in horizontal plane, suitable for outdoor installation. Earthing switch for the Isolator shall be mechanically interlocked with the main blade and shall be manually operated type.

It shall be possible to padlock the manual operating handle both in open and closed position of switches. Isolator shall be electrically interlocked with the main breaker that these can only be closed, if the circuit breaker is in open position. Similarly, it should be only possible to open the Isolator when the circuit breaker is in open position. The earthing connection for operating handle is included in the scope of supply which shall comprise of copper leads between the operating handle and station ground-mat. Six pairs of NC & NO auxiliary switches shall be provided in the mechanism box for interlocks and indications in the control room.

1.4.3.6.3.1 Constructional Features

Each isolating switch shall consist of three individual pole units, which shall be interchangeable. The isolators are required to be double break, three posts per phase, triple pole, single throw, gang operated, outdoor type rotating centre post, silver plated contacts, with horizontally operating blade (copper) and insulator posts arranged vertically.

The isolators (for Bus) / isolators with earth switches (for Line) with rated voltages of 110kV and above shall be motor operated (from Remote and Local) along with emergency manual operated mechanism. The manual operating mechanism shall be of robust construction conveniently located for operations and easily operable by a single person.

The frame of each isolator and earthing switch shall be provided with two reliable earthing terminals for connection to an earthing conductor having clamps of diameter of at least 12 mm suitable for withstanding earth fault conditions. The isolator and earthing switches are required to be used in electrically exposed installations and this should be taken into account while fixing the clearance between phase and earth. The Speed of operation during opening or closing shall ensure minimum arcing.

The isolators shall be provided with suitable terminal boxes of IP 55 protection with terminal strips, local controls, interlock facilities, heaters with thermostat controls, rubber gaskets etc... An auxiliary switch with suitable no of NO and NC contacts shall be provided in the Control Mechanism. In addition to the scheme requirement, 2 NO + 2 NC contacts shall be provided as spare for both Isolator and Earth Switch for KSEBL's use. Provision for padlocking the mechanisms in either the open or closed position shall be provided.

1.4.3.6.3.2 Isolator Insulation

Insulation to ground, insulation between open contacts and the insulation between phases of the completely assembled isolating switch should be capable of withstanding the dielectric test voltages specified as per IS: 2026. Insulation between open contacts of a pole should be at least be 15% more than the insulation between the live parts of a pole to ground so that if any flashover occurs when switch is open, it should be to the ground.

The post insulators, which should be of the multiple stack type, should consist of no. of stacks units per stack conforming to IS 2544 or other internationally recognised standards. The insulators selected should be suitable for use in the type of normally polluted atmosphere stated in **Part-2** and should be specifically suited to meet the particular requirements of ultimate torsional strength and cantilever loads which they will be called upon to resist during service at the rated voltages. The guaranteed data and particulars of

the insulators adopted for the equipment should be obtained from the supplier.

The porcelain shall be homogeneous and free from all cavities and flaws. Design of the insulators shall ensure ample insulation, mechanical strength and rigidity for satisfactory operation under site conditions. The design shall also ensure that the losses caused by capacitive currents or conduction through dielectric are minimum and that the leakage due to moist and dirty insulator surface is least.

All metal caps and supports shall be cemented to the porcelains whereas the blades and contact blocks shall be bolted to the metal parts of insulator thus making the replacement of damaged insulators easy. Polycone type insulators will be preferred.

1.4.3.6.3.3 Main Contacts

All isolators / isolators with earth switches shall have heavy-duty, self-aligning and high-pressure line type fixed contacts of modern design and made of hard drawn electrolytic copper. These contacts shall be liberally dimensioned so as to carry rated current continuously as well as to withstand safely the highest short circuit currents for the rated duration, that may be encountered during the service, without causing mechanical damage to any part or temperature rise which may damage the insulation. Contacts shall be well protected all round by a metal cover to provide not only electrostatic screening but also to prevent coarse dust from entering between the contacts.

The various parts should be accordingly finished to ensure inter-changeability of similar components. The switch blades forming the moving contacts should be made from tubular section of hard drawn electrolytic copper having suitable diameter and shell thickness. The surfaces of the contacts should be rendered smooth and silver plated. In nutshell the male and female contact assemblies should be of substantial construction, and design of their assemblies shall ensure:

- i. Electro-dynamic withstand ability during short-circuits without any risk of repulsion of contacts.
- ii. Thermal with-stand capability during short circuits.
- iii. Constant contact pressure even when the live parts of the insulator stacks are subject to tensile stresses due to linear expansion of connected bus bar or flexible conductors either because of temperature variations or strong winds.
- iv. Wiping action during closing and opening.
- v. Self alignment assuring closing of the switch without minute adjustments.

The earthing switches should be provided with three sets of suitable type of fixed contacts below the fixed contacts assemblies of the main switch on the incoming supply side and three sets of moving contacts having ganged operation. These contacts too should be fabricated out of electrolytic copper and dimensioned to withstand the rated currents.

1.4.3.6.3.4 Arcing Horns & Arcing Contacts

A set of adjustable arcing horns may be mounted on each insulator stack of the isolating switch.

Besides above mentioned adjustable arcing horns which are required for the purposes of insulation co-ordination, the isolators may be provided with make before and break after arcing contacts if considered necessary by the manufactures.

A graph showing impulse and power frequency spark over voltages for various gap settings of the arcing horns should be provided by the supplier.

1.4.3.6.3.5 Insulation Co-ordination

Insulation of the equipment and transmission lines should be properly co-ordinated both in respect of power frequency and impulse voltages. The gap setting of arcing horns on the isolator for achieving such coordination should be provided.

1.4.3.6.3.6 Isolators & Earth Switch Operation

The isolators and isolators with earth switches inclusive of their operating mechanism should be such that they cannot come out of their open or closed positions by gravity, wind pressure, vibrations, shocks etc... Isolators and earth switches shall be capable of resisting in closed position, the dynamic and thermal effects of maximum possible short circuit currents specified. The operating mechanism should be of robust construction, easy to operate by a single person and conveniently located for local operation in the switch-yard. The Isolator and corresponding Earth switch shall be interlocked for correct sequence of operation. The rating of the Earth switch shall be the same as that of the Isolator with respect to rated short time current and dynamic peak withstand current.

Earthing blade shall be operated by a separate mechanism on manual and motorized mode (local & remote) but interlocked so that it can be closed only when the main disconnecting switch is open and vice-versa.

Each isolating switch with a rated voltage of 110kV and above shall be remote controlled from the control room. Provisions shall also be made for local electrical control. Each

earthing switch shall be designed to withstand the electro-dynamic stress due to currents up to peak rated values as per IEC recommendation. The isolator shall be suitable for interrupting small inductive and capacitive currents such as those occurring while disconnecting lines at no load, bus bars or voltage transformers under energized condition.

1.4.3.6.3.7 Interlocks

For the purpose of making the operation of the isolator dependent upon the position of the associated circuit breaker or other equipment as may be required at site, a suitable electrical interlock should be provided on each isolator. The interlocks should be of robust design of some reputed make and contained in a weather proof and dust tight housing.

Besides the electrical interlocks, the earthing switches should be provided with mechanically operated interlock so as to ensure that:

- a) It should be possible to close the earthing switch only when the isolating switch is in the fully open position.
- b) It should be possible to close the isolating switch only when the earthing switch is in the fully open position.
- c) The earth switch should not open automatically while attempting to close the isolator.
- d) The operation of the earth switches should also be interlocked with the CVTs / CTs supplies from the transmission line i.e. it should be possible to close the earth switch only when the line is dead from the feeding end, and there is no supply from the secondaries of the line CVTs / CTs.
- e) The operation of earth / isolating switch should not take place when the corresponding isolator/earth switch is in operating stroke.

In addition to the above, the line and the bus isolators should fulfil the following requirements:

- a) The Isolators should close only when the circuit breaker of corresponding bay is open.
- b) The bus isolator of the bus coupler bay should close only when the bus coupler circuit breaker is open.
- c) The line isolator should close only when the corresponding circuit breaker and the earthing switch of the corresponding line are open.
- d) Electro-magnetic type interlocking should also be provided to avoid wrong local

operation of the isolator (manual or motor) when the corresponding circuit breaker is in closed position.

Isolators and earth switches should be so designed that the above noted requirements can be conveniently met.

1.4.3.6.3.8 Terminal Connectors

Sufficient number of high conductivity terminal connectors suitable for conductor type specified in **Part-2** of this specification shall be supplied.

Each isolator connected with outgoing lines should be provided with appropriate number of bimetallic, solder-less clamp type of connectors suitable for the transmission line conductor. Each terminal clamp should be suitable for both vertical & horizontal connection of station bus bars and jumpers. Each isolator should also be provided with appropriate number of grounding terminals and clamps for receiving grounding connections. The maximum length of the jumper that may be safely connected or any special instructions considered necessary to avoid undue loads on the post insulators should be provided.

1.4.3.6.3.9 Supporting Structures

All isolators and earthing switches should be mounted rigidly in an upright position on their own galvanised steel supporting structure and not on the line or bus-bar structures. The isolators and isolators with earth switches shall be suitable for being mounted on galvanised steel supporting structures. The galvanised steel structures shall in general conform to the latest issue of IS 802 or other equivalent standards. Sufficient sets of the supporting structures shall be supplied by the Manufacturer or Contractor.

1.4.3.6.3.10 Name Plates

Weather proof, corrosion proof rating plates, showing year of manufacture and other values required as per IS shall be provided on all isolators.

1.4.3.6.3.11 Temperature Rise

The maximum temperature attained by any part of the equipment in service at site under continuous overload capacity conditions and exposed continuously to the direct rays of sun should not exceed the permissible limit fixed by the applicable standard, when corrected for the difference between the ambient temperature at site and the ambient temperature specified by the standard.

1.4.3.6.3.12 Tests

Each isolators and earth switches shall strictly comply with the requirements of all type tests and shall be subjected to all routine tests stipulated in the relevant standards. Copies of the type tests already performed on similar type of isolators must be enclosed with the tender to judge the merits of the equipment offered by the Contractor.

1.4.3.6.4 Instrument Transformers

The instrument transformers shall be of outdoor type, single phase, 50 Hz, oil immersed or SF6 insulated and self cooled.

Other technical requirements shall be as given in Part-2 “**Specific Requirements for the Project**” of this specification.

1.4.3.6.4.1 General

The instrument transformers shall be of single phase, oil immersed or SF6 insulated and self cooled type, suitable for the services indicated, complete in all respects, and conforming to the modern practice of design and manufacture.

The core shall be of high-grade, non-ageing, electrical silicon steel laminations of low hysteresis loss and high permeability to ensure high accuracy at both normal and over-currents or voltages.

The instrument transformers shall be sealed to eliminate breathing and prevent air and moisture from entering the tank. The instrument transformers shall be provided with an oil level gauge, and a pressure-relieving device capable of releasing abnormal internal pressures. The temperature rise should be as specified in IS 2705 or IS 3156.

1.4.3.6.4.2 Performance Criteria

- i. The current transformer characteristics shall be such as to provide satisfactory performance of burdens ranging from 25% to 100% of rated burden over a range of 10% to 100% of rated current in case of metering CTs and up to the accuracy limit factor/knee point voltage in case of protection CTs.
- ii. For measuring CT's the instrument security factor (ISF) at all ratios shall be less than five (5).
- iii. The accuracy class of measuring CT's and CVT's shall be Class 0.2S and 0.2 respectively.

- iv. The temperature rise of current transformer winding when carrying rated current at rated frequency with rated output shall conform to the IS 2705 (Part 1) : 1992.
- v. The cores used for protection shall produce undistorted secondary current under transient conditions at all ratios, with specified CT parameters.

1.4.3.6.4.3 Temperature Rise

The maximum temperature attained by any part of the equipment in service at site under continuous overload capacity conditions and exposed continuously to the direct rays of sun should not exceed the permissible limit fixed by the applicable standard, when corrected for the difference between the ambient temperature at site and the ambient temperature specified by the standard.

1.4.3.6.4.4 Construction

Current transformers should be of robust design, tested quality and reliable in operation. Only pure high grade paper, wound evenly under controlled conditions and impregnated with mineral oil under high vacuum should be used for the main insulation. The assembly of each CT should be dried, filled with appropriate quality of insulating oil under high vacuum and hermetically sealed with or without inert gas to eliminate undesirable effect of moisture and oxygen on the internal insulation. No breathers and/or drying chemicals should be used in the design and construction of CTs.

Alternatively gas insulated Current Transformer using Sulphur Hexafluoride (SF_6) gas under modest pressure as an insulating medium and with Silicone composite Insulators may be provided. An additional rupture disc shall be provided in the tank, to release any high pressure developed during a failure. Further, provision for remote monitoring of gas pressure through the contacts of density meter installed in the Current Transformer unit shall be provided.

The shape of the external metal parts should ensure that rain water runs off and it does not accumulate. All external surfaces should be resistant to atmospheric corrosion either by the selection of suitable materials or by proper treatment such as hot dip galvanisation, etc... Likewise, the internal metal surfaces coming in contact with oil should be given proper treatment unless the material used itself is oil resistant. Bolts, nuts and washers to be used as fasteners should be heavily hot dip galvanised throughout. The galvanising should conform to IS: 2629-1966. All CTs / CVT's should have an oil level gauge marked with the maximum and minimum levels. Although no oil samples may be required to be taken for

neither analysis nor any filter connections made for reconditioning of oil at site but a filling plug at the top and a drain at the bottom of the lower tank should be provided on each CT for use during initial assembly or any subsequent repair.

The instrument transformers shall be mounted on oil filled bushings conforming to IS 2099 or SF₆ insulated Silicon Composite Insulators suitable for outdoor use and upright mounting on steel structures.

The bushings shall be provided with lifting arrangements, oil filling and drain plugs, oil sight glass etc... They shall ensure ample insulation, mechanical strength and rigidity for operation under site conditions.

The instrument transformers shall preferably be hermetically sealed units with in-built provision to dissipate any excessive pressure build up. In lieu, adequate pressure relief device shall be provided.

Terminal Connection box shall be hot dip galvanised. Polarity marks shall be indelibly marked on each instrument transformers and at the lead terminals at the associated terminal block.

All instrument transformers shall carry a name plate as per the relevant IS incorporating the year of manufacture also.

The instrument transformers should be with dead/live tank design. The instrument transformers should be of single phase oil immersed or SF₆ insulated, self cooled and suitable for services indicated, complete in all respects conforming to the latest edition of relevant standard specification. The cores should be of high grade, non-ageing silicon laminated steel of low hysteresis loss and high permeability to ensure high accuracy at both normal and fault currents. The CTs should be hermetically sealed with or without inert gas to eliminate breathing and prevent air and moisture from entering into the tank. To take care of volumetric variation of oil due to temperature changes-stainless steel bellows/Nitrogen should be provided for oil filled CT's. In case Nitrogen is used the supplier should ensure that gas is filled at suitable pressure to take care of the expansion & compression of nitrogen gas. The equipment should be provided with oil level gauge and pressure relieving device capable of releasing abnormal internal pressures. The secondary terminals should be brought out in a compartment on one side of the equipment for easy access. The secondary taps should be adequately reinforced to withstand normal handling without damage.

Equipment should be provided with power factor terminals for testing loss angle (Tan delta).

The equipment should also be provided with drain valve, sampling plug to check

deterioration of oil characteristics and replacement of oil at site. Means adopted for sealing the CTs hermetically and to absorb the variation in volume of oil due to temperature variation by way of provision of stainless steel volume adjustable bellows or other means should be clearly brought out in the tender. Rubber or PVC / synthetic bellows for the purpose should not be accepted. The secondary terminal of CTs should be provided with short circuiting arrangement.

1.4.3.6.4.5 Terminal Connectors

All current transformers and CVT's should be provided with appropriate number of solder-less clamp type primary connectors suitable for ACSR conductor as specified in **Part-2** and should be suitable for horizontal as well as vertical take off with single or multiple conductors as per actual requirement. Terminals shall be so mounted as to enable easy connection. Suitable terminal earth connectors for earthing connections shall also be supplied.

1.4.3.6.4.6 Type of Mounting

The current transformers and CVT's should be suitable for mounting on steel structures. The necessary flanges, bolts, nuts etc... for the base of CTs should be galvanized.

1.4.3.6.4.7 External Insulation

The external insulation should comprise of hollow porcelain, which will also serve as housing for the main insulation or other internal parts of the CTs and CVT's. Insulators should be of high grade and homogeneous porcelain made by the wet process. The porcelain should have hard glazing and should comply with the requirements of IS 5621 in all respects. Alternatively Silicone Composite insulators can also be provided.

The skirt forms should be carefully selected to achieve the necessary flashover distance and total / protected creepage distances as required.

1.4.3.6.4.8 Current Transformers

The ratings shall be as given in Part-2 of this specification.

The current transformers shall be of ring type with suitable construction at the bottom for bringing out secondary terminals in a weather-proof terminal box. The CTs shall preferably be suitable for horizontal transportation. Expansion chamber at the top of the porcelain insulator should be suitable for expansion of oil and provision of primary terminals.

1.4.3.6.4.8.1 Core and Windings

The current transformer core to be used for metering and instrumentation shall be of the accuracy class specified or appropriate class suitable for commercial and industrial metering. The saturation factor of this core shall be low enough not to cause any damage to measuring instruments in the event of maximum short circuit current.

Current transformer cores to be used for protective relaying purposes shall be of accuracy class specified or appropriate class suitable for distance protection, differential protection, over current protection and bus bar protection. The cores shall be designed for a minimum saturation factor of 10 for the highest setting.

All the cores may be continuous without any air gap. All the protection cores shall be formed out of high grade, cold rolled, grain-oriented silicon laminated steel, whereas the metering cores in which high accuracy at low amperes turns and low ISF are required, may be of Mu metal or such other ferromagnetic material. The core material shall have low hysteresis loss and high permeability. The area of cross-section of the cores as also the flux densities at rated primary current and rated burden shall be consistent with the required characteristics of the CTs. The cores shall be carefully annealed and bonded after they are wound to relieve the stress during winding.

The conducting material for the primary winding shall be of electrolytic high conductivity copper strips and sufficient area of cross section shall be provided to cater for the guaranteed short time as well as continuous thermal current ratings under site conditions.

The winding shall be of wound type or hair pin type.

The main insulation shall be paper and oil combination having high mechanical strength, superior electrical withstand properties and good ageing qualities to ensure long trouble free life for the CTs. Winding shall be designed to have high mechanical strength for safety against short circuit stresses.

The secondary winding shall be high conductivity copper wire of suitable cross-section.

The copper wires shall have enamel insulation and paper insulation may also be provided to enhance reliability. The secondary winding shall be uniformly distributed on the total circumference of the core. For obtaining different ratios, the secondary winding may be suitably tapped. The leads of the secondary taps shall be brought out to the terminal box. In addition to above the manufacturer shall meet the following requirements:

- i. The secondary winding shall be totally encased in metallic shielding providing a uniform equipotential surface for even electric field distribution.

- ii. The lowest part of the insulation assembly shall be properly secured to avoid any risk of damage due to transportation stresses.
- iii. The upper part of insulation assembly resting on primary bar shall be properly secured to avoid any damage during transportation due to relative movement between insulation assembly & top dome.
- iv. Nitrogen if used for hermetic sealing should not come in direct contact with oil.
- v. The secondary terminals shall be terminated to stud type non disconnecting terminal block inside the terminal box.

The secondary terminals shall be provided with facilities for grounding and short-circuiting arrangements. The secondary taps shall be adequately reinforced to withstand normal handling without damage. Provision for cable entry from bottom shall be made in the secondary terminal box.

Facilities shall be provided at terminal blocks in the marshalling box for star delta formation, short-circuiting and grounding of CT secondary terminals.

Polarity marks shall indelibly be marked on each current transformer and at the lead terminals at the associated terminal block.

Bushings / insulators shall conform to relevant clause of IS. The bushing / insulator for CT shall be one piece without any metallic flange joint. Bushings shall be provided with oil filling and drain plugs, oil sight glass etc... The bushing/insulator of current transformer shall have adequate cantilever strength.

1.4.3.6.4.8.2 Fittings and Accessories

Following fittings and accessories shall be provided as a minimum with each Current Transformer:

1. Primary terminals.
2. High frequency current surge divertors.
3. Terminal connectors for connections from line to the CT primary.
4. Oil level gauge.
5. Pressure relief device.
6. Expansion chamber or other suitable type of device for absorbing variations in the volume of oil due to change of temperature.
7. Weather proof secondary terminal box fitted with door and complete with terminals

and shorting links.

8. Lifting lugs.
9. Fixing lugs with bolts, nuts and washers for holding down the CTs on the supporting steel structures.
10. Rating and diagram plates.
11. First filling of oil.
12. Oil filling plug and drain valve.
13. Earthing terminals.

The name plate shall contain the information as per relevant Indian Standard and IEC. However it shall contain but not limited to following information:

- a) Manufacturer Name & country of origin.
- b) Year of Manufacturer.
- c) Serial Number & type.
- d) Rated primary & secondary currents.
- e) Rated frequency.
- f) Rated VA & Accuracy Class.
- g) Rated ALF / ISF.
- h) Knee point voltage.
- i) Highest system voltage.
- j) Rated insulation level.
- k) Rated short time thermal current.
- l) Rated dynamic current.

1.4.3.6.4.9 Capacitive Voltage Transformers (CVTs)

The ratings shall be as given in Part-2 of this specification.

Voltage transformers shall be capacitive with electromagnetic units and shall be suitable for carrier coupling. Two fuses with suitable rating shall be provided on each secondary and shall be located in the individual phase secondary terminal boxes.

Voltage transformers shall be suitable for HF coupling required for PLCC. Necessary arrangement for preventing the HF signal to flow to the metering circuit shall be provided

and details of the same shall be given.

The electromagnetic unit comprising compensating reactor, intermediate transformer and protective and damping devices should have a separate terminal box with all the secondary terminals brought out.

The damping device, which should be permanently connected to one of the secondary windings, should be capable of suppressing the ferro-resonance oscillations.

These transformers should be suitable for use on transmission line to pass through the carrier frequencies for communication and low voltage for protection and metering. The single phase CVTs should be of suitable ratio and suitable for outdoor installation on steel structures. The equipment should be supplied with terminal connectors suitable for vertical take off from line conductor and hot dip galvanized base fasteners. Other details should be in accordance with the specifications for potential transformers. The secondary terminals should be provided duly marked for above requirements.

The CVTs should be suitable for mounting on steel structures. All nuts, bolts, flanges and base should be hot dip galvanized. The terminal connectors should be such as to give intimate contact between conductor & terminal and offer protection against and effects of electrolytic and atmospheric corrosion and should also have sufficient mechanical strength. The connectors should conform IS 5556: 1970. The junction boxes should be suitable for terminating all the connections of the CVT secondary with other equipment of the power station. 400V grade terminal connectors of 15 Amp (continuous) current rating should be provided.

1.4.3.6.4.10 Marshalling Boxes

Suitable junction boxes / marshalling boxes shall be supplied along with each set of instrument transformers (one for three current transformers and one for three CVT's). The boxes shall be of adequate size to terminate all cables from instrument transformers and to control panels including provision for star connection of various secondary windings. The boxes for CVT's shall be provided with suitable three pole MCB's in VT secondary circuit. The boxes shall be of IP 55 protection with thermostatically controlled heaters.

Junction boxes (3 phase) shall be equipped with 5 Amps. 110 volts AC triple pole miniature circuit breakers, continuously rated with one set of normally closed and one set of normally open auxiliary contacts.

1.4.3.6.4.11 Tests

The current and voltage transformers shall conform to type tests and shall be subjected to routine tests as stipulated in IS 2705 (Part I, II, III & IV) or IEC 60044-1, and IS 3156 (Part I, II, III & IV) or IEC 60044-2 / IEC 60044-5 and respectively.

Each instrument transformer shall be subjected to routine tests as specified in Indian Standards or IEC in the presence of KSEBL's representatives, if so desired by the KSEBL. All test reports shall be submitted and got approved by the KSEBL before despatch of the equipment.

1.4.3.6.5 Support Structures

Steel structural work shall include:

- The preparation and supply of all necessary design calculations, material indents, arrangement drawings, shop details drawings, shops material lists, site bolt lists and dispatch documents for steel structures.
- Supply, fabrication, galvanizing, transportation, delivery and storage of all steel structures including site bolts, rivets, electrodes etc... complete in all respects.
- Erection including any staging or false work required for erection, handling, transport and rectification of damaged structures, fixing, bolting, welding, alignment, levelling, etc... of all steel structures, materials etc...
- Inspection of Structures.

Scope of supplies and erection shall cover complete steel structural works for gantries, lightning towers, lightning mast, equipment mounting structures, etc... along with all bolts nuts washers, foundation bolts etc... as may be required for installation and proper functioning of the out door switch yard and associated transmission line complete in all respect, according to the stipulations as indicated in this specification.

1.4.3.6.5.1 Instruction to Tenderer

The Tenderer shall ascertain himself, by visit to site, the actual site conditions, local factors etc... No claim due to any special site condition or ignorance of site condition shall be considered after the acceptance of his bid.

The successful tenderer shall arrange for procurement of steel, consumables etc... and also shall arrange for equipment, tools, tackles, instruments, galvanising etc... necessary for erection, complete in all respects as per approved drawings .and specification.

KSEBL's approval of all structural drawings will be given in respect of design parameters, general arrangement and rationality of structural arrangement only. Such approval from the KSEBL will not absolve the successful tenderer's responsibility for correctness and adequacy of the structural design.

The successful tenderer shall furnish the quality assurance plan for KSEBL's approval.

1.4.3.6.5.2 Technical Specification

1.4.3.6.5.2.1 Design Parameters

- Structures shall be designed with adequate strength to meet the requirements of the equipment specified loading conditions stipulated and site condition.
- Structures shall be of generally of lattice type construction, fabricated out of mild steel rolled section and plates.
- All site connections shall be with bolts only.

1.4.3.6.5.2.2 Codes and Standards

- Super imposed loads (except wind load) to be considered for design shall conform to IS: 802 - 1977 (Part – I).
- Wind loading shall conform IS: 875 (Part - 3) -1987 with following consideration.
 - a) Terrain Category = 1.
 - b) Class of Structure = A.
 - c) Probability Factor K1 = 1.0.
 - d) Topography factor K3 = 1.0.
- Design of steel structures shall conform to IS: 802 - 1977 (Part - 1) and IS: 5613 (Part-3)-1985.
- Galvanizing of steel structures shall conform to IS: 4759 – 1990.
- Bolts and fasteners shall conform to IS: 1367 (Part - 13) – 1978.
- Fabrication, galvanizing, inspection and packing shall be in accordance with IS: 802 (Part - 2) – 1978.
- Testing shall be in accordance with IS: 802 (Part - 3) – 1978.

Note: All works shall generally be executed in accordance with Indian standards and other

relevant standards mentioned therein.

1.4.3.6.5.2.3 Stability of Structures

The stability of the structures as a whole or any part of it shall be investigated and weight or anchorage provided so that the least restoring moment including anchorage shall not be less than the sum of 1.2 times the maximum overturning moment due to dead load, and 1.4 times the maximum turning moment due to imposed loads.

In cases where dead load provides the restoring moments only 0.9 times the dead load shall be considered. The restoring moments due to imposed loads shall be ignored.

1.4.3.6.5.2.4 Materials of Construction

Structural steel shall conform to IS: 2062 - (Grade -A) -1992.

1.4.3.6.5.3 Inspection

All steel structures shall be subject to inspection by KSEBL's representative.

1.4.3.6.5.4 Erection Testing & Commissioning

These shall conform to IS: 802 (Part - 3) -1978.

The support structures shall be sized to maintain the connections under the different working conditions besides the connections' own weight. Stresses caused by expansion and short circuit considered in the most unfavourable circumstances shall be considered for designing supports.

The support structures shall be manufactured using steel angle bars and hot dip galvanized after manufacture. The different elements shall be assembled on site by hot dip galvanized bolts supplied with the supports.

Earthing points shall be provided for connection to the main earthing system.

1.4.3.6.6 Bus Conductors & Line Conductors

1.4.3.6.6.1 General

The bus bar is used to receive the power generated by Hydro Project through generator transformer and also to evacuate the power through transmission network system.

The design and engineering are based on following parameters.

1.4.3.6.6.2 Type

The outdoor bus bars are either of the rigid type or the strain type. In the rigid type, pipes are used for bus-bars while for strain type AAC or ACSR conductors are used and also for making connections among the various equipment, wherever required. The bus-bars and the connections are supported on pedestal insulators.

1.4.3.6.6.3 Bus Bar Material

The materials in common use for bus bars and connections of the strain type are ACSR. The Kundha conductor is commonly used for Hydro Power Projects. The details shall be as given in **Part-2** of this specification.

In the case of rigid bus arrangement, aluminium pipes of Grade 63401 WP confirming to IS: 5082 may be used.

Since aluminium oxidise rapidly great care is necessary in making connections. In the case of long spans expansion joints should be provided to avoid strain on the supporting insulators due to thermal expansion or contraction of pipe.

The bus bar sizes should meet the electrical and mechanical requirements of the specific application for which they are chosen.

1.4.3.6.7 Cable Channels

- The cable channels shall have removable covers for the full width.
- Minimum working passage of 500 mm shall be provided between cable racks or between cable rack and wall.
- Shall have suitable drainage facility to avoid accumulation of seepage water.

1.4.3.7 Inspection & Testing

1.4.3.7.1 Inspection of Switch-yard Equipment

1.4.3.7.1.1 General

Inspection & testing of equipment covered under the Technical Specification shall be carried out by the KSEBL's representative at the manufacturers' works / premises prior to dispatch to ensure that their quality & workmanship are in conformity with the contract specifications and approved drawings.

1.4.3.7.1.2 Finalisation of Quality Assurance Plan (QAP)

Within four weeks of the award of contract the contractor shall furnish the Quality Assurance Plan as per standard Performa.

Inspection & testing of plant & equipment shall be undertaken by the KSEBL after finalisation & approval of QAP.

1.4.3.7.1.3 Responsibility for Inspection

Any inspection by the KSEBL does not relieve the responsibility of quality assurance and quality control functions, as expected of the contractor to be performed by him for supply of plant & equipment as part of the contractual obligations.

1.4.3.7.1.4 Extent of Inspection

Routine test as per IS or IEC or equivalent standards for 100% equipment.

Type test shall be carried out on each type of equipment for which the tenderer fails to produce Type Test Certificates carried on similar type of equipment within five years period.

1.4.3.7.1.5 Tests, Test Certificates & Documents

For each of the items being manufactured, following test certificates and Documents (as applicable for each of the equipment) in requisite copies shall be prepared and submitted to the Inspecting Engineer for scrutiny & records.

- Routine / type / calibration / acceptance / special test certificates for electrical items.
- Certificates from competent authority for the items coming under statutory regulations.

Should the result of tests not come within the margin specified, the tests shall if required be repeated at Contractor's cost without any liability to the KSEBL.

1.4.3.7.1.6 Method of giving Inspection Calls

Inspection calls shall be given by the contractor with ten days notice period. All calls shall accompany two sets of relevant test certificates and inspection report of the Contractor / sub-contractor after satisfactory completion of internal inspection and tests by them as per approved QAP. Inspection calls without enclosing relevant test certificates & internal inspection report shall not be entertained.

1.4.3.7.2 Site Testing of Switch-yard Equipment

Test of all equipment shall be conducted as per latest BIS.

The site tests and acceptance tests to be performed by contractor are detailed in **Section 1.4.5 Switch-yard Installation and Tests on Completion.**

The contractor shall be responsible for satisfactory working of complete integrated system and guaranteed performance.

1.4.3.8 Spares

The minimum requirement of spare parts shall be as follows:

Spares of Circuit Breaker

1. Fixed contacts (for SF ₆ CB)	-	1 set.
2. Moving contacts (for SF ₆ CB)	-	1 set.
3. Closing coil	-	1 set.
4. Tripping coil	-	1 set.
5. Pneumatic interlock switch	-	1 set.
6. Insulation column complete with interrupter, moving contact, fixed contact, operating rod etc... for one pole.	-	3 set.
7. Auxiliary contacts	-	1 set.
8. Compressor / spring charging motor	-	1 set.
9. Gas density monitor with alarm contact (for SF ₆ CB)	-	1 No.
10. SF ₆ detector (for SF ₆ CB's)	-	1 No.
11. Vacuum Bottle (for VCB)	-	1 No.
12. Terminal Connectors	-	1 set.

Spares of Isolators

1. Post insulators	-	1 set.
2. Switch blades	-	1 set.
3. Male and female contact assemblies	-	1 set.
4. Auxiliary contact assembly	-	1 set.
5. Limit switches	-	1 set.

6. Terminal Connectors - 1 set.

Any other spares recommended by the manufacturer as essential for the satisfactory and trouble free operation of the equipment as per Clause 1.1.32 of this specification.

The Contractor shall also quote for any other item of optional spares recommended for 5 years normal operation. The KSEBL will decide on these optional spares to be ordered on the basis of the list.

1.4.4 Switch-yard Control, Protection and Instrumentation

1.4.4.1 Introduction

This section covers the KSEBL's requirements for the protection, metering, indication, control equipment & other devices in the powerhouse switch-yard, as required by the specific design offered to complete the system in all respects as per Section-1.1 of this Specification.

The scope of these specifications is to stipulate the basic general guidelines to the Bidder / Contractor for the design, manufacture, testing at manufacturer works, standard and quality of workmanship, general finish of the equipment, compliance to the latest published edition (prior to the date of closing of tender) of the international standards and recommendations specified throughout the specifications, supply, insurance, delivery and storing at site, erection, site testing, commissioning, performance and reliability confirmation, warranty confirmation of the complete equipment and other general requirements as per **Section 1.1**, which are required for the systems / equipment being provided under the scope of this tender / contract.

The Power System is with neutral solidly earthed.

1.4.4.2 Reference Standards and Codes

The Equipment shall be designed, manufactured, tested, installed and commissioned in accordance with the latest revision of applicable IS / IEC or equivalent standards.

The Contractor shall adhere to sound design and construction practices with regard to codes and material specifications in order to warrant operational safety and ease of maintenance of plants as well as simplicity of control and stability in plant operation.

- IS 8686 - Static protective relays
- IS 3231 - Electrical relays for power system protection
- IS 1248 & IS 2419 - Indicating instruments
- IS 6236 - Direct recording electrical measuring instruments
- IS 722 (Part I to IX) - AC electricity meters
- IS 6875 - Control switches (LV switching devices for control and

auxiliary circuits)

- IS 2705 - Current transformers
- IS 3156 - Voltage transformers
- IS 5578 - Guide for marking of insulated conductors
- IS 11353 - Guide for marking and identification of conductors and apparatus terminals
- IS 1554 - PVC insulated cables up to and including 1000 volts
- IS 3842 (Part I to IX) - Application guide for electrical relays for AC systems
- IS 9224 (Part II) - Low voltage fuses
- IS 13947 - Low voltage switchgear and control gear
- IS 6005 - Code of practice for phosphating of iron and steel
- IS 5 - Colours for ready mixed paints and enamels
- IS 2147 - Degrees of protection provided by enclosures for LV Switch gear and control gear.
- IEC 60688 - Electrical measuring transducers for converting AC and DC electrical quantities to analogue or digital signals.
- IEC 60255 - Measuring relays and protection equipment.
- IEC 61850 - Communication networks and systems for power utility automation.

1.4.4.3 Reference Sections

Section 1.1	-	General Technical Requirements
Section 1.3.5	-	Control and Monitoring
Section 1.4.1	-	Power Evacuation Arrangement
Section 1.4.2	-	Power Transformers
Section 1.4.3	-	Switch-yard Equipment

Section 1.4.5	-	Switch-yard Installation and Tests on Completion.
Part - 2	-	Specific Requirements for the Project

1.4.4.4 Submittals and Approvals

The Contractor shall seek the prior approval of the KSEBL for the following through timely submittals.

- Design / setting calculations
- General Arrangement / Layout Drawings, Foundation Details, Schematic / Circuit diagrams and Specifications
- Interlocking / Inter Trip Matrix, Trip Logic diagrams, Synchronizing Logic.
- Detailed Bill of Materials (including type, make and ratings)
- Graphs showing performance
- Alarm List and Annunciator Facia / Window Inscription Details
- Relay setting calculations and data
- Test protocols and test reports / data
- Calibration certificates of testing and measuring equipment
- Inspection & Test Protocol (IT&P) of equipment
- Method Statement for Erection, Testing & Commissioning
- Design calculations for CT and PT sizing, Earthing system, Lightning protection system etc...
- The Contractor shall purchase equipment from reputed vendors only and the List of suppliers / manufacturers, supported with Brochures / Catalogue of Equipment, shall be submitted for KSEBL's approval.

Before delivery of equipment to site, the contractor shall submit all work test certificates / reports for approval and obtain despatch clearance from the KSEBL's representative. The equipment shall be dispatched only when all the required type and routine tests have been carried out and test reports have been approved by the KSEBL.

All testing and measuring / recording equipment used shall have valid calibration certificates and the same shall be submitted to the KSEBL. The details of calibrations shall be included in the test report along with copy of the calibration certificate.

1.4.4.5 Deliverable Documents

- Detailed dimensional drawings of control and relay panels showing all equipment mounted on them with complete lists of nameplates as detailed elsewhere in the specifications.
- Contact development drawings of all switches, relays etc...
- Outline drawings and internal wiring diagrams of the panels such as instruments, relays, meters, annunciators and other equipment showing external wiring terminations.
- Complete AC and DC schematic drawings of all elements of Control and Relay boards along with a detailed Bill of Quantity indicating the type, make and rating of each component.
- Complete schematic drawings for annunciation system.
- Cable interconnection drawings / Cable Schedules indicating terminal block numbers of cores, instruments / panels at which cable is to be connected etc...
- Details of protection schemes and annunciation system offered.
- Interlocking / Inter Trip Matrix, Trip Logic diagrams, Synchronising Logic.
- Detailed Bill of Materials (including type, make, ratings and functions).
- Alarm List and Annunciator Facia / Window Inscription Details.
- Relay setting calculations and data.
- Literature describing the instruments, relays and their characteristics, technical details, relay-setting calculations etc...
- Type test reports of all the equipment
- Routine Test report / Data and calibration reports of testing and measuring equipment.
- Quality assurance plan adopted for the manufacture of the equipment
- Inspection, Erection and Testing methodology
- Commissioning, operating and maintenance instruction manual for each relay and Multi function meters including numerical control equipment.
- Operation and maintenance manual covering full details of repair procedure.
- The other drawings considered necessary in addition to the drawing stated above.

1.4.4.6 Scope of Work

Detailed scope of work and technical details are given in **Part-2** (Specific Requirements of the Project) of this specification. Any item of work not specifically mentioned in the specifications but which are usual and / or necessary for the satisfactory operation of the equipment / systems supplied shall be deemed to be provided by the Contractor and included in the quoted Price. All work shall be complete in all details whether such details are mentioned in the specifications or not.

Any ratings, if mentioned, are indicative only and are a minimum for giving a base line. The Bidder should ensure that the ratings of the various equipment are sufficient to take care of the design requirements of the equipment offered for the concerned project. Any increase in rating during detailed engineering stage will not entitle the Successful Bidder / Contractor for any extra charges. The Contractor should submit for approval the calculations for arriving at the ratings of the various equipment.

1.4.4.6.1 Protection and Control Panels

Protection and Control panel for the control and protection of bays shall be equipped with the required control equipment, instruments, relays and all other accessories as detailed in **Part-2** (Specific Requirements of the Project) of this specification and outlined in the Schedules. Adequate spacing and clearances between auxiliary relays, contactors, various kinds of switches, annunciators, metering instruments, relays, control cable runs, push-buttons, test plugs / test terminal blocks etc... shall be provided for easy accessibility to any piece of equipment and for safety of personnel. Manufacturing of these panels shall not be started prior to KSEBL's approval. All protection relays shall be numerical type and meters shall be numerical / static type. Any other type of protection relays shall be provided only with the prior approval of the KSEBL.

1.4.4.6.1.1 Constructional Features

The panels shall be of single Simplex type and completely enclosed to ensure dust, moisture and vermin proof atmosphere. The enclosure shall provide a degree of protection not less than IP31 in accordance with IS 2147.

Control panels shall be rigid, free standing and floor mounting type and shall comprise of structural frames enclosed completely with specially selected smooth finished, cold rolled sheet steel of thickness not less than 2.5 mm (2 mm for non-load bearing and 2.5mm for bearing loads). The cubicle assembly shall be provided with doors on the rear having handles with built in locking facility made of metal handle. It shall have double leaf doors

with lift off hinges at the back for panels. There shall be sufficient reinforcement to provide level surface resistance to vibration and rigidity during transportation and installation.

The panel shall be of following dimensions.

Height: 2200 mm + 100mm (with 15mm anti vibration pad)

Width : 900 mm

Depth : 800mm.

Earth bus extension slot: 30 X 30 mm

The doors, removable covers and panels shall be gasketed all around with rubber gaskets. Ventilating louvers, if provided, shall have screens and filters. The screens shall be made of either brass or GI wire mesh.

Interior of the panel shall be provided with fluorescent luminary suitably guarded against impact and controlled by switches actuated by the access doors and suitable for 230V, 50Hz single phase supply.

Cable entries to the panels shall be from the bottom. The bottom plates of the panels shall be fitted with removable gland plates for fixing the cable glands, the size of which shall suit the external cables to the panels. Cable glands provided by the supplier shall be screened type, made of brass and shall be suitable for PVC armoured cables. Necessary foundation drawings showing cable entry positions and foundation bolt locations shall be supplied by the Contractor. Necessary arrangement shall be provided for bolting together adjacent panels as well as for fastening them to the floor. The opening required for mounting the equipment shall be punched or cut and filed smooth. Foundation Bolts and inter-panel coupling fasteners shall be in the scope of the supplier.

Metal sills in the form of metal channels properly drilled shall be furnished by the supplier along with anchor bolts and necessary hardware for mounting the panels. These shall be despatched well in advance of the dispatch of the respective panels, so that they may be installed and levelled when concrete foundations are poured. Panels shall have additional rolled channel plinth at the bottom with smooth bearing surface. The panels shall be fixed on the embedded foundation channels with intervening layers of anti vibration strips made of shock absorbing materials, which shall be supplied by the supplier.

A document holder on the inside of the door shall be provided.

All the panels in the control room shall be matched with other panels in the control room in respect of dimensions, colour appearance and arrangement of equipment in the front.

It shall be the responsibility of the supplier to ensure that the equipment specified and such

unspecified complementary equipment required for completeness of the protection/control scheme be properly accommodated in the panels.

1.4.4.6.1.2 Painting

All sheet steel work shall be phosphated in accordance with IS-6005 "Code of practice for phosphating iron and steel".

Oil, Grease, dirt and dust shall be thoroughly removed by emulsion clearing. Rust and scale shall be removed by picking with diluter acid followed by washing with running water, rinsing with slightly alkaline hot water and drying. After phosphating, thorough rinsing shall be carried out with clean water followed by final rinsing with dilute dichromate solution and oven drying. The phosphate coating shall be sealed with application of two coats of ready mixed stoving type zinc chromate primer. The first coat may be "Lush dried" while the second coat shall be stoved. After application of the primer, two coats of finishing synthetic enamel paint shall be applied, each coat followed by stoving. The second finishing coat shall be applied, after inspection of 1st coat of painting.

The exterior paint colour shall be light grey, shade No.631 of IS-5. The interior colour shall be white. Each coat of primer and finishing paint shall be of a slightly different shade to enable inspection of the painting. A small quantity of finishing paint shall be supplied for minor touching up required at site after installation of the panels.

Minimum thickness of painting shall be not less than 60-80 micrometres.

1.4.4.6.1.3 Mounting

All equipment on and in panels shall be mounted and completely wired to the terminal blocks ready for external connection. All equipment on front of the panel shall be mounted flush. All equipment shall be labeled properly in front side as well as inside the panels with device number.

The equipment shall be mounted such that removal and replacement can be accomplished individually without interruption of service to adjacent devices and are readily accessible without the use of special tools. Terminal markings shall be clearly visible. Terminal block shall also be properly labeled with permanent marking.

Cut outs and wiring for free issue items shall be according to the corresponding equipment manufacturer's drawings. Cut outs provided for future mounting or equipment shall be properly blanked off.

Digital Meters shall be mounted at a height not higher than 1750mm and not lower than

1500mm from the finished floor level.

The center-lines of switches, push buttons and indicating lamps shall be matched to give a neat and uniform appearance. Their center-lines shall not be located below 750 mm from the bottom of the panel. Likewise the center-lines of relays, meters and recorders shall not be less than 450 mm from the bottom of the panels.

No equipment shall be mounted on the doors. All the panels in the control room shall be matched with other panels in the control room in respect of dimensions, colour appearance and arrangement of equipment in the front.

All the equipment connections and cabling shall be designed and arranged to minimize the risk of fire and damage which may be caused by fire.

1.4.4.6.1.4 Panel Wiring

The panel shall be supplied completely wired internally to equipment and terminal blocks ready for the external cable connections at the terminal block. When panels are arranged to be located adjacent to each other, all inter panel wiring and connections between the panels shall be furnished and the wiring shall be carried out internally with proper sealing for avoiding the accidental entry of any dust.

All panel wiring shall be carried out with 650 / 1100 V grade, single core, stranded, tinned copper conductor with PVC insulation (FRLS type) and shall be flame, vermin and rodent proof. All circuits except current transformer circuits shall be wired using 2.5 mm² copper conductor and the current transformer circuits shall be wired using 4 mm² (minimum) copper conductor. Proper colour coding (Red, Yellow, Blue, Black, Green wires) shall be carried out for CT & PT circuits.

All internal wiring shall be securely supported, neatly arranged, readily accessible and connected to equipment terminal and terminal blocks. Wiring gutters and troughs shall be used for this purpose. Numbering ferrules of appropriate size / colours shall be used for wiring. All circuits directly connected to the Trip circuit shall be provided with a Red marker with the label "TRIP" engraved in white colour. Wires directly connected to trip circuit breakers or device shall be distinguished by the addition of red colored lettered ferrule. Numbers 6 and 9 shall not be included for the ferrules purpose.

Auxiliary bus wirings for AC and DC supplies, voltage transformer circuits, annunciation circuits and other common service shall be provided near the top of the panels running throughout the entire length of the panel. These buses shall have a nominal cross section

equivalent to a copper diameter of 6mm and shall be suitably insulated along their run. D.C. buses shall be divided into two sections to permit two independent supply points. Wire terminations shall be made with solder less crimping type of tinned copper lugs, which firmly grip the conductor. Insulated sleeves shall be provided at all the wire terminations. Engraved core identification plastic ferrules marked to correspond with panel wiring diagram shall be fitted tightly at both ends of each wire and shall not fall off when the wire is disconnected from the terminal blocks of each wire. The wire numbers shown in the wiring diagram shall be in accordance with relevant IS.

The panels shall be supplied completely wired internally to equipment and terminal block ready for the KSEBL's external cable connections at the terminal blocks. When panels are arranged to be located adjacent to each other all inter-panel wiring and connections between the panels shall be furnished and the wiring shall be carried out internally. Entries for the inter panel wiring shall be properly carried out with proper ceiling for avoiding the accidental entry of any dust.

1.4.4.6.1.5 Terminal Blocks

All internal wiring to be connected to the external equipment shall terminate on terminal blocks, preferably vertically mounted on the side of each panel. Terminal blocks shall be 650 / 1100V grade and have 10 A continuous rating, one-piece moulded, complete with insulated barriers, stud type terminals, washers, nuts, lock nuts and identification strips. Terminal block design shall include a white fibre marking strip with clear plastic, slip-on / clip-on terminal covers.

Marking on the terminal strips shall correspond to wire number on the wiring diagrams. Not more than 2 wires shall be connected to any terminal. Suitable supports shall be provided for the incoming cables. The terminal blocks shall be arranged to provide maximum accessibility to all conductor terminations.

Terminal Blocks accommodating terminations at voltages higher than 110V shall be partitioned off and the voltage clearly labelled. 415 / 240 V AC circuit terminals shall be segregated from other terminals and shall be fitted with non-inflammable transparent plastic covers to prevent contact with any live parts. Warning labels with red lettering shall be mounted thereon in a conspicuous position. Segregation of different Voltage levels within the terminal blocks shall be achieved using barriers. Voltage levels shall be clearly identified by labels. Terminal Blocks associated with external sources of supply shall be fully shrouded and fitted with a danger-warning label. All connections shall be made at the front of the terminal board and no live metal shall be exposed at the back.

Terminal blocks for current transformer and voltage transformer secondary leads shall be provided with test links and isolating facilities. Also current transformer secondary leads shall be provided with short circuiting and earthing facilities.

At least 20% spare terminals for all circuits shall be provided on each panel and these spare terminals shall be uniformly distributed on all terminal blocks.

Unless otherwise specified, terminal blocks shall be suitable for connecting the following conductors or purchaser's cable:

All circuits except CT circuits	-	2.5 mm ²
C.T Circuits	-	4 mm ²

There shall be minimum clearance of 250 mm between the first row of terminal blocks and the associated cable gland plate. Also, the clearance between two rows of terminal blocks shall be minimum 150mm.

Arrangement of the terminal block assemblies and the wiring channels within the enclosure shall be such that a row of terminal blocks is run parallel and in close proximity along each side of the wiring duct to provide for convenient attachment of internal panel wiring. The side of the terminal block opposite the wiring duct shall be reserved for the purchaser's external cable connection and cable trough should be provided for this. Adjacent terminal blocks shall share this field wiring trough.

All spare contacts of the Switches, contactors and Relays shall be wired to the terminal block.

1.4.4.6.1.6 Mimic Diagram

Coloured mimic diagram and symbols showing the exact representation of the system complete with symbols and colour strips to represent the Bus, feeders, transformers and semaphore indicators shall be provided in the front of the control panels. The control switches shall be mounted along with the mimic diagram. Mimic diagram shall be of anodized aluminum or plastic of approved fast colour material, which shall be screwed on the panel and can be easily cleaned. Mimic height for No.1 bus shall be 1450mm and that of No.2 bus shall be 1400mm from the ground level (for double bus stations).

The colour scheme and size of mimic diagram shall be as per IEC specifications and shall be subject to the approval of the KSEBL.

<u>Voltage</u>		<u>Colour of Mimic Diagram</u>		<u>Ref. Code</u>
400kV level	-	Salmon Pink	-	443 / IS-5

220kV level	-	Brilliant Green	-	221 / IS-5
110kV level	-	Signal Red	-	537 / IS-5
66kV level	-	French Blue	-	166 / IS-5
33kV level	-	Golden Brown	-	414 / IS-5
11kV level	-	Canary Yellow	-	309 / IS-5

Specific numbers shall be assigned to various isolators, earthing switches and circuit breakers on mimic diagram by the purchaser. The supplier shall undertake to paint the same in suitable colour without any additional price.

1.4.4.6.1.7 Nameplates and Markings

All equipment mounted on front and rear as well as equipment mounted inside the panels shall be provided with individual nameplates with equipment designation engraved. Also on the top of each panel on front as well as rear side large and bold nameplates shall be provided for circuits / feeders designation. These circuit tables shall be larger than the other nameplates.

All front mounted equipment shall also be provided at the rear with individual name plates engraved with the tag numbers corresponding to the one shown in the panel internal wiring to facilitate easy tracing of the wiring. The nameplates shall be mounted directly by the side of the respective equipment and shall not be hidden by the equipment wiring.

Nameplates shall be made of non-rusting metal or plastic material. All nameplates and labels on the **outer surface of panels** shall be engraved on **stainless steel**.

All nameplates and labels **inside the panels** shall be engraved on **plastic** laminated material. Nameplates and labels shall be permanently fixed and secured with noncorroding screws; adhesive or self-tapping screws are not acceptable. Nameplates shall be black with engraving lettering. The nameplates inscription and size of nameplate and letters shall be submitted to the KSEBL for approval.

Each instrument and meter shall be prominently marked with the quantity measured (ie. kV, A, MW). All relays and other devices shall be clearly marked with manufacturer's name, numbers and electrical rating data.

Below every relay, meters etc a label should be fixed showing its functional name and the CT ratio used in case of connection to multi-ratio CT's.

1.4.4.6.1.8 Semaphore Indicators

Automatic semaphore indicators shall be provided for automatic indication in the mimic diagram of position (open or close) of circuit breakers, isolators and earthing switches. They shall be of two coil type and their operating voltage shall be station DC supply (110V DC). They shall also have the supply failure indication during which the disc comes to neutral position when both units of indicators shall be so mounted on the mimic diagram that the close position shall complete the continuity of the mimic. Their strips shall be of the same colour as of the associated mimic.

1.4.4.6.1.9 Switches

Control and instrument switches shall be of rotary operated type preferably with silver to silver contacts of adequate making, carrying and breaking current rating and shall be provided with easily removable protective terminal covers and escutcheon plates clearly marked to show operating position and shall be suitable for flush mounting with only switch front plate and operating handle projecting out. The connections shall be from the back. The contact assembly at the back of the switch shall be enclosed in dust proof removable covers.

The selection of operating handles for the different types of switches shall be as follows:

Breaker control switches	- Pistol grip black.
Synchronizing switches	- Pistol grip black, keyed handle.
Selector switches	- Pistol grip, black.
Instrument switches	- Round Knurled black.
Protection Transfer	- Pistol grip, lockable and black switch.

Circuit breaker and isolator control switches shall be 3-position, spring return to neutral type. The control springs shall be strong and robust enough to prevent inadvertent operation due to light touch. Ammeter selector switches shall have make before break type contacts so as to prevent open circuiting of CT secondaries when changing the position of the switch. Voltmeter selector switch for AC shall be suitable for reading all line to line voltage for effectively earthed systems.

1.4.4.6.1.10 Indicating Lamps

Indicating lamps shall be of miniature switchboard type LED (bunched type) suitable for panel mounting with rear terminal connections. Lamps shall be provided with series

connected resistors preferably built on the lamp assembly to avoid short-circuiting of control supply in the event of short-circuiting of lamp. The supply for these lamps shall be from DC station battery unless stated otherwise. Lamp covers shall be translucent to diffuse light. The transparency of covers and wattage of the LED's provided shall be adequate to ensure clear visibility from the location of the operator's table in the control room having high illumination intensity. Integral inscription plates engraved with their functions shall be provided. Unless otherwise stated, the lamp covers shall be coloured as:

- 'Red' for indicating closed position of breakers, isolators and earth switches.
- 'Green' for indicating open position of breakers, isolators and earth switches.
- 'Blue' for Spring Charged indication.
- 'Blue' for control supply monitoring.
- 'White' for Trip circuit monitoring.
- 'Amber' for Auto Trip.
- 'White' and 'Amber' for miscellaneous indications.

1.4.4.6.1.11 Push-buttons

Push buttons shall be of momentary contact type with rear terminal connection. These shall be suitably shrouded to prevent inadvertent operation. Integral inscription plates engraved with their functions shall be provided. All push buttons shall have two normally closed and two normally open contacts comprising rivets of pure silver.

1.4.4.6.1.12 MCBs and Switches

Each control panel shall be provided with necessary arrangements for receiving, distributing, isolating and protection of DC and AC supplies for various control, signalling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with MCB units. Selection of the main and sub-circuits MCB ratings shall be such as to ensure selective clearance of sub-circuit faults. Alarm Indication shall be provided for Tripping of MCB's by providing fault / alarm auxiliary contacts in each MCB.

1.4.4.6.1.13 Earthing

All panels shall be equipped with an earth bus securely fixed along with inside base of panels. All metallic cases of relays, instruments and other panel mounted equipment shall be connected to the earth bus by independent copper wires of size not less than 2.5 mm².

VT and CT neutral or common lead shall be earthed at one place at the terminal blocks where they enter the panel. Such earthing shall be made through links so that earthing may be removed from one group without disturbing continuity of earthing system for other groups.

1.4.4.6.1.14 Instruments, Meters and Recorders

All instruments, meters and recorders shall be enclosed in dust proof, moisture resistant, black finished cases and shall be suitable for tropical use. They shall be calibrated to read directly the primary quantities. They shall be accurately adjusted and calibrated at works and shall have means of calibration, check and adjustment at site. Their ranges and the ratios of associated instrument transformers are given in the schedule of requirements. The bidder shall confirm that the instruments, meters and recorders offered by him are suitable for connecting to the instrument transformers having the technical particulars given in the specification. All accessories including the test switches and test plugs, where applicable shall be furnished. Their elements shall be shock resistant and shielded from external magnetic fields.

Indicating instruments shall be flush mounted and shall comply with the latest standards applicable. All indicating meters shall be Digital Multi-function Meters (DMM) of Class 0.2S capable of displaying various parameters like voltage, current, MW, MVAR, MWh, MVARh, power factor, frequency etc... The Digital Multi-function Meters shall be provided in duplicate. The LED digits shall be of sufficient size so as to have easy readability from the operator work table. The Digital Multi-function Meters shall have communication facility as per latest protocols which shall be finalised during detailed engineering in consultation with KSEBL.

Energy Meters

3 phase 4 wire TOD meters with the following specifications should be provided.

Frequency	- 50 Hz +/- 5%
P.F.	- 0.5 PF Lag - Unity - 0.5 P.F Lead
Burden	- 0.2VA max. per Volts / Amp. Input 3VA max. on Aux. Supply
Display	- MW, MWh, MVAh, MVARh, MD, I, V, pf & Hz shall be available by scrolling. There can be 1, 2, or 3 modes of display, which facilitate more parameters. More accurate reading on power etc... up to 6 decimal places shall be provided in Mode 3. It should retain the last recorded reading even under power failure. Default setting for any

parameter - say kWh- shall be given.

The meter shall display import & export. Shall have data retrieval & logging facility. Necessary software for feeding settings, commissioning, testing etc... and required inter facing cables shall be supplied with each meter.

Accuracy class - 0.2S (MWh & MVARh)

The energy meters of 0.2S - accuracy shall be connected to the secondaries of Potential Transformers and Current Transformers (rated for 1 A) respectively. The CTs shall have an accuracy of at least Class 0.2S and for Potential Transformers the accuracy class shall be minimum 0.2. Meters shall be compensated for temperature errors and factory calibrated to directly read the primary quantities without the use of the additional multiplying factor. Multiplying factor, if unavoidable shall be multiple for 10 and shall be subject to purchaser's prior approval. Number of digits provided, shall be adequate to cover at least 1000 hrs. of operations.

The current coil of the meters shall have a continuous over load capacity of 200% for both accuracy and thermal limits. Also the current coils shall withstand at least 10 times the rated current for 0.5 second without loss of accuracy. The meters shall have retransmitting contacts, the impulse rate of which shall be suitable for remote indicating or summing system.

1.4.4.6.1.15 Test Blocks

Switch board type, back connected semi flush mounting type test blocks with contacts suitably rated shall be provided with links or other device to enable of a series device into circuit without causing open circuit in the CT secondary or to enable short circuiting of the CT Secondary. Test block covers shall be removable from the panels and shall be provided with suitable sealing arrangement to prevent unauthorised access to the test studs. A 3-phase 4-wire Link type TTB with back connection (IMP or similar superior make) shall be provided for Energy meter and shall be mounted near to the meter. All terminals, shorting links and screws shall be of brass and nickel plated to prevent corrosion. All meters (A, MW, MVAR etc...) shall be connected after TTB for testing their accuracies along with Energy meter calibration.

TTB / Test plug (Type - combi test system RXTP18 + RXTH18 + extractor of M/s ABB or equivalent) shall be provided for Relays and shall have facility to short the CT connections internally, upon plugging without using any shorting wires externally. There shall be

adequate spare terminals. TTB may be placed adjacent to the Relay.

1.4.4.6.1.16 Transducers

The Transducers (for use with Recording / Indicating Instruments and Telemetry / Data Communication application) shall in general conform to IEC: 60688-1 and have the following features:

- Each transducer shall be housed in a separate compact case and have suitable terminals for inputs and outputs.
- The Transducers shall have an output of 4-20 mA.
- The response time of the transducers shall be less than 1 sec.
- The accuracy class of transducers shall be 0.5 or better except for frequency transducer, which shall be 0.2

1.4.4.6.1.17 Annunciation System

Alarm annunciation system shall be provided for the control board by means of visual and audible alarm in order to draw the attention of the operator to the abnormal operating conditions or the operations of the some protective device. The annunciation shall be divided into the following two categories.

- i. Emergency annunciation.
- ii. Warning annunciation.

The annunciation equipment shall be suitable for operation on DC supply as specified in the specification.

i. Emergency annunciation.

This annunciation is used to draw the attention of the operator when the circuit breaker is tripped automatically. The audible annunciation shall be provided by means of a Hooter. The visual annunciation shall be flickering of common facia window provided on the respective panel on which the control of the tripped breaker is located. The tripped breaker shall be identified by the flickering of the corresponding position indication lamp.

ii. Warning annunciation.

The annunciation is used to draw the attention of the operator to the occurrence of an abnormal operating condition and then the tripping of the circuit breaker. The

audible annunciations shall be provided by means of a bell and visual annunciation by flickering of the respective facia window. Certain numbers of alarms under this category have to be time delayed with the time delay adjustable between 2 to 10 seconds. The supplier shall provide arrangements for this purpose.

The annunciation shall be of visual and audible type. The audible annunciation for the emergency signals and warning signals shall be by means of the Hooter and Bell respectively. The audible alarm shall continue until the sound signal cancel push button is pressed. The sound signal cancel push button shall be common for cancellation of audible alarm Hooter and Bell.

The visual annunciation shall be provided by annunciation facia mounted on the top row of the control panels. Necessary switching relays for the same shall be mounted inside the panel. The Annunciator facia shall be provided with translucent glass or plastic cover plates of white colour with inscriptions in black letter. The size of the facia window shall be 35mm x 30mm and the size of the lettering shall not be less than 5mm. Alarm inscriptions shall be engraved on each window in not more than three lines and shall be visible only when the facia lights on. The cover plates of the facia window shall be capable of easy removal to facilitate replacement of LED's. The transparency of covers and wattage of the LED's (bunched type) provided in the facia window shall be adequate to ensure clear visibility of the inscription from the location of the operator's table in the control room having high illumination intensity.

"Accept", "Reset" and "Lamp Test" push buttons for the annunciators shall be provided.

In case of static Annunciator scheme, special precaution shall be taken by the supplier to ensure that spurious alarm conditions do not appear due to influence of external magnetic field on the Annunciator wiring and switching disturbance from the neighbouring circuits within the panels. The modules of the Annunciator should be mounted in such a way that it can be replaced easily. 20% spare facia window shall be provided and wired to the Terminal blocks.

Visual and audible annunciation for the failure of D.C supply to the annunciation system shall also be provided and this annunciation shall operate on a 230 Volts AC supply with separate fuses. A separate voltage check relay (adjustable setting) for the failure of supply shall be provided and if the failure of supply exists for more than 2 to 3 sec, a facia shall light up and the bell shall sound. A separate push button shall be provided for cancellation of this bell alone but the facia window shall remain steadily lighted till the supply to the annunciation system is restored. The sound of the audible alarm (bell) provided for this

annunciation shall be different from the audible alarm for warning signals.

The annunciation system described above shall meet the following requirements:

1. The annunciation system shall be capable of catering for at least 20 simultaneous signals at a time.
2. One spring return type switch shall be provided on each panel to make provision for isolation of signaling circuits.
3. One self-resetting push button shall be provided each for testing emergency annunciation and warning annunciation systems and for testing, the annunciation supply failure monitoring circuit. One self-resetting push button shall also be provided on each panel for testing the fascia window lamps. These testing circuits shall be so connected that while testing is being done it shall not prevent the registering of any new annunciation that may land during the test.
4. Provision shall be made for switching off the entire annunciation system.
5. The self returning push button for acknowledge sound cancel and lamp test shall be common for both emergency and warning annunciations and shall be located in a suitable Control panel.
6. The annunciation shall be of repetitive type and shall be capable of registering the fleeting signals. Minimum duration of the fleeting signals registered by the system shall be 15 milliseconds.

Following annunciation shall be provided as a minimum depending upon the functions:

1. Distance protection Main – I Operated (for OH feeders).
2. Distance Protection Main – II Operated (for OH feeders).
3. Over-current / Earth Fault Operated (as the case may be).
4. Bus protection operated.
5. Differential Protection Operated.
6. Bucholz Trip (for Transformer Protection).
7. Winding Temperature Trip (for Transformer Protection).
8. Oil Temperature Trip (for Transformer Protection).
9. Pressure Relief Device Trip (for Transformer Protection)
10. Breaker re-closed (for feeders) .
11. Breaker failure protection operated.

12. Breaker trip circuit faulty.
13. Breaker transfer tripped.
14. Breaker lock-out.
15. Carrier fail.
16. Back up protection operated.
17. P.T Fuse failed.
18. SOTF protection operated.
19. Power Swing detected.
20. Inter Trip Received (for Transformer Protection).
21. Direct trip received.
22. Carrier received.
23. Control Center Trip Received.
24. Breaker pole discrepancy (for Breakers with Single Pole operation).
25. Breaker low SF₆ (for SF₆ Breakers).
26. Breaker low air (for Breakers with Pneumatic Drives).
27. Drive Mechanism faulty.
28. Auto re-close lock out.
29. Protection faulty.
30. MCB Tripped.
31. DC fail.
32. Aux. A.C. Fail.
33. }
34. } Spare
35. }
36. }

The above scheme is only for an indicative purpose and the actual scheme shall be finalised during detailed engineering in consultation with KSEBL.

1.4.4.6.1.18 Details of Protection and Control

Adequately sectionalized and graded protective relaying system shall be provided for transmission lines, transformers and bus bars so as to automatically isolate the faulty equipment and, thus, minimize the damage to the equipment in the event of faults and abnormal conditions. All main protection relays shall be of numerical type and communication protocol shall be as per IEC-61850.

All relays shall conform to the requirements of relevant standards. Relays should be numerical or static (modular type, with prior approval) and shall be suitable for flush mounting on the front with connections from the rear. Relays shall be rectangular in shape and shall have dust-tight dull black enamel painted case with transparent cover removable from the front.

All protective relays shall be with proper built-in test facilities. Test blocks and switches shall be located suitably for testing. The auxiliary relays and timers shall also be modular type supplied in draw out cases and shall be self reset type.

All AC relays shall be suitable for operation at 50 Hz. Voltage operated relays shall be suitable for 110V VT secondary and current operated relays for 1 Amp CT secondary.

All Numerical relays shall be provided with self monitoring so that an alarm shall be displayed locally.

The Numerical relays shall have a minimum of following features:

- Measurements and Recording functions including:
 - True RMS values.
- Event recorder with the Last 75 events, 1ms time stamped (as a minimum).
- Fault recorder with last 5 faults (as a minimum).
- Disturbance recorder with storage of 5 records for 3 seconds each (as a minimum).
- Sampling frequency not less than 1 KHz.

The supplier shall ensure that all the terminals of the contacts of the relays are readily brought out for connections as required in the final approved scheme. The type of the relay case size offered shall not create any restrictions in the availability of the contact terminals for wiring connections.

DC / DC converter shall be provided wherever necessary in order to provide a stable auxiliary supply for relay operation. Provision of DC cell for the protective relays, as reliable

standby power supplies will, however, not be acceptable.

For 220kV and major 110kV stations, the protection functions shall be subdivided into two groups each being independent and capable of providing uninterrupted protection even in the event of one of the protection groups failing. Wherever two sets of DC sources are available, the relays shall be electrically and physically segregated into two groups (Gr. A and Gr. B) to obtain redundancy, and to take protection systems out for maintenance while the equipment remains in service. Grouping shall be done to the extent possible in such a way that each group can independently carry out protective functions with near equal redundancy. Interconnection between these two groups shall not generally be attempted. However, if found absolutely necessary such interconnection shall be kept to the bare minimum.

Even in cases when only one battery source is available, segregation of protection and trip circuits in two groups may be considered by giving DC supplies through separate fuses or MCB's.

The protection in respect of transmission lines, transformers, bus bars and other provisions shall be as follows:

1.4.4.6.1.18.1 Transmission Line Protection

Protection	400 kV	220 kV	110 kV / 66 kV	33kV / 11kV
Main I- Distance protection	Y (Refer 1.4.4.6. 2.2 Note)	Y (Refer 1.4.4.6. 2.2 Note)	Y	N
Main II- Distance protection or directional comparison protection or phase segregated line differential protection	Y	Y	N	N
Directional IDMT type E / F relay	Y	Y	Y	Y
Directional IDMT over current and earth fault back up protection	Y (alarm)	Y (alarm)	Y	Y
Two stage over voltage protection	Y	N	N	N
Auto re-closing	Y (Single phase & three phase)	Y (Single phase & three phase)	Y (Three phase)	N

Transmission lines with distance protection shall, in general, have carrier aided inter-

tripping or blocking feature. Separate cores of current transformer and voltage transformer shall be used for Main-I and Main-II.

1.4.4.6.1.18.2 Transformer Protection

Protection	400 kV	220 kV / 110 kV	66 kV	33kV
Differential protection	Y	Y	Y	Y (above 10MVA rating)
Over fluxing protection	Y	Y	N	N
REF protection	Y	Y	Y	Y
Backup directional O/C and E/F protection (HV and LV side) or Impedance protection	Y	Y	Y	Y
Buchholz, WTI and OTI (for 1 MVA and above), MOG with low oil level alarm, OSR for OLTC, PRD, SA on both primary and secondary sides of transformers located outdoors and connected to over head lines	Y	Y	Y	Y
Tertiary winding protection	Y	Y (above 100MVA rating)	N	N
Over load alarm	Y	Y	N	N

Note:

1. Y – Required; N – Not required; Y/N – Optional.
2. WTI: winding temperature indicator, OTI: oil temperature indicator, PRD: pressure relieve device, OSR: oil surge relay, MOG: magnetic oil gauge, SA: surge arrester.

1.4.4.6.1.18.3 Bus-bar Protection & Local Breaker Back-up Protection (Breaker Failure Protection)

Bus bar protection and local breaker backup protection shall be provided in 220kV and higher voltage interconnecting sub-stations as well as in all generating station switch-yards. The bus bar protection scheme shall have provision for future expansion.

1.4.4.6.1.18.4 Disturbance Recorders, Event Loggers & Time Synchronisation Equipment

Each 400 kV and 220 kV line shall be provided with facility for disturbance recording, distance to fault locator and Time Synchronising Equipment (TSE). Event logger, either

stand alone or as part of sub- station or switch-yard automation system, shall be provided for each 220kV and higher voltage class sub-station or switch-yard. TSE complete with antenna, all cables, processing equipment etc..., shall be provided to receive synchronizing pulse through GPS compatible for synchronization of event logger, disturbance recorder and SCADA / automation system of the sub- station or switch-yard.

1.4.4.6.1.18.5 Protection through Power Line Carrier Communication (PLCC)

Power line carrier communication (PLCC) equipment complete for speech transmission, line protection, and data channels shall be provided on each transmission line of voltage rating 110kV and higher. The protection system for 400kV and higher voltage transmission line and the line compensating equipment shall have one hundred percent back up communication channels. Each 400kV or 220kV line shall be provided with two protection channels in addition to one speech plus data channel for each direction. In case of 220kV or 110kV lines, the speech and data channel can also be used for protection wherever possible. The compatibility of PLCC equipment at each end of the feeders shall be ensured. Optionally, the above functionality may be achieved using wide band communication based on optical ground wire (OPGW) or any other technology. KSEBL prefers digital communication using OPGW or similar methods over conventional PLCC methods wherever feasible. The finalisation of above scheme as to whether PLCC / OPGW is to be employed shall be made during detailed engineering in consultation with KSEBL depending on the actual site condition.

1.4.4.6.1.18.6 Control Concept

All the breakers in sub- stations and switching stations shall be controlled and synchronized from the switch-yard control room or control room of the generating station. Disconnectors of 220kV and higher rating shall have control from remote as well as local whereas the earth switches shall have local control only. Disconnectors and associated earth switches shall be provided with electrical as well as constructional mechanical interlocks. Provision for operation of circuit breakers and disconnectors from remote control stations may also be provided wherever required.

Close command to feeder breaker from SCADA or manually shall be through synchronizing switch with a key common to that of machines ensuring that only one switch can be placed in 'ON' position at a time. The close command shall also be through check synchronizing relays with provision for closing under dead bus or dead-line conditions.

The control scheme shall ensure that the earth switches cannot be closed with any of the

feeder CB in closed position or line is charged from remote end.

Software required for testing and commissioning of the Relays shall be supplied free of cost in a CDROM (including necessary communication interfaces and cables with suitable connectors).

1.4.4.6.1.19 Trip Circuit Supervision Relays

The trip circuit shall be supervised by means of relays. The scheme shall continuously monitor the complete trip circuit from the tripping relay to the trip coil of breaker, before closing and after closing of the breaker.

The scheme shall detect:

- i. failure of the trip supply.
- ii. open circuit of trip circuit wiring.
- iii. failure of any interposing relays used and.
- iv. failure of mechanism to complete the tripping operation.

The relays shall have necessary contacts to be connected to either the alarm bell or to the Annunciator available in the control panel for visual and audible indication of the failure of trip circuit.

1.4.4.6.1.20 DC Supply Supervision

DC supply supervision scheme shall be provided in each panel as part of the Annunciator through a separate system of DC No voltage relay. In the event of failure of DC supply to Annunciator, a bell operated from AC shall be energized. The alarm should be acknowledged through the alarm acknowledge push button of the respective panel. The Relays used for monitoring shall preferably have reverse flag, which drop when the relay is de-energized. Otherwise, an indicating lamp shall be provided with each monitoring relay for indication of its operation.

1.4.4.6.2 Description of Protections

The typical description of each protection and the associated equipment are described below. The Contractor shall quote the protection equipment meeting the following requirements. The Contractor may also quote any alternative / additional protections or relays considered necessary by him for providing complete effective and reliable protection. The acceptance of this alternative / additional equipment shall be with the KSEBL.

i. Busbar protection

ii. Line Protection (Main)- Numerical type

220 kV feeders shall be provided with Main I and main II relays and shall be based on different operating principles / logic.

iii. OH Line / EHT Cable protection (Main)

A separate over-current & Earth fault relay shall be provided as back up protection for feeders up to 110 kV.

iv. Feeder back-up protection

Separate Direction Over-current and directional Earth fault relay shall be provided for feeders up to 110 kV.

v. Auto reclosing relay (both external and inbuilt in numerical protection)

vi. Local Breaker Backup protection relay(50 LBB) - for all panels

vii. Tripping relay (86) - High Speed tripping relay with trip relay supervision

Note: The above scheme is not an exhaustive one and the detailed scheme shall be finalised in consultation with KSEBL during detailed engineering.

1.4.4.6.2.1 Bus-bar Protection

The bus bar protection scheme shall:

- be able to match the CT ratios selected for feeder and machines.
- have maximum operating time up to trip impulse to trip relay for all types of faults of 15 milliseconds at 5 times setting value.
- give hundred percent security.
- incorporate check feature relays.
- incorporate continuous supervision of CT secondaries against any possible open circuit and if it occurs shall render relevant zone of protection inoperative.
- not give false operation during normal load flow in bus bars.
- incorporate suitable non-linear resistors to limit peak voltages to 1000 volts in case of high impedance scheme.
- include individual high speed tripping relays (operating time not to exceed 10 milliseconds) with minimum 10 pairs of hand reset contacts.

- be of transient free operation.
- permit any extension of the schemes on future expansion without much modification or change of CT's.
- In built LBB feature.
- Dead Zone protection.
- Minimum 4 zones.
- Able to function with single bus coupler CT function.

The above requirements are indicative. Exact specifications will be supplied along with tender documents and clarified during pre-bid queries and engineering.

1.4.4.6.2.2 Line Protection (Main) (Distance Protection - Non-switched)

The relay shall be numerical type and shall have the following features:

The relay shall be modular in construction. The protection algorithm shall use the fault voltages and currents as well as the superimposed voltages and currents to arrive at a secure trip decision in the shortest possible time. The scheme shall provide protection against all types of faults on OH lines viz. line-to-line, line to earth and multi phase without switching.

The characteristics shall be quadrilateral for both ground and phase faults with independently adjustable reactive and resistive reach.

There shall be minimum of three forward zones and a non-directional zone. The zone reach setting ranges shall be sufficient to cover the line length appropriate to each zone, as under.

- 1st zone shall have instantaneous operation and relay shall be settable to protect 80 % to 90% of the protected line section.
- 2nd zone will operate with time delay and will be set to protect 100% of the protected line section and 50% of the next line section.
- 3rd zone will operate with time delay larger than that in the second zone and will cover the entire length of the protected line and the next line section.
- 4th reverse zone reach shall be at least equal to 1st zone.

Following features shall be available as standard and wired as required:

- i. Carrier aided scheme options such as permissive under reach, over reach,

zone 1 extension and blocking.

- ii. Secured directional response under all conditions (achieved by memory voltage polarization or healthy phase voltage polarization as appropriate)
- iii. PT fuse failure detection scheme and appropriate precautions in measurement to avoid a mal-operation. It shall have as a minimum following features:
 - a. monitor all three-phase fuses of CVT and associated cable against open circuit.
 - b. inhibit trip circuits on operation and initiate annunciation.
 - c. have an operating time of less than 7 milliseconds.
 - d. remain inoperative for system earth faults.
- iv. Appropriate logic to take care of Switch On To Fault condition (SOTF).
- v. Power swing blocking feature with facilities for fast detection of power swing, selective blocking of zones, selective unblocking criteria for earth faults, phase faults and three phase faults.
- vi. Selection of single pole or three pole or both tripping schemes.
- vii. Fault locator with an accuracy of at least 3%.
- viii. Independent Directional Earth Fault protection to take care of highly resistive faults. The DEF Scheme shall have IDMT characteristics with a choice of various IDMT curve.
- ix. Display of voltage, current and power on demand.
- x. Self-diagnostic features with Watch-Dog contact for Alarm annunciation.
- xi. Communication interface with IEC 61850 protocol.
- xii. Built in auto re-close functions with facilities for single pole / three pole / single and three pole tripping.
- xiii. Independent Directional over current protection Scheme shall have IDMT characteristics with a choice of various IDMT curve.
- xiv. Independent Definite time over current protection.
- xv. Shall have LBB, Disturbance & Event Recording, report generation features.
- xvi. Have an adjustable characteristic angle setting range.
- xvii. Have suitable shaped characteristic to prevent relay operation during

maximum load conditions.

Note: -

The 220kV and 400kV feeders shall be provided with protection scheme as follows:

1. For lines more than 10 km
 - i. Main I scheme- Distance Relay, Directional Over current & Earth fault.
 - ii. Main II scheme-Distance Relay, Directional Over current & Earth fault.
2. For lines less than 10 km
 - i. Main I scheme- Current differential, Distance, Over current & Earth fault.
 - ii. Main II scheme- Current differential, Distance, Over current & Earth fault.

The 110 kV feeders shall be provided with protection scheme as follows:

1. For lines more than 10 km
 - i. Main scheme - Distance Relay, Directional Over current & Earth fault.
 - ii. Backup scheme (separate) - Directional Over current & Earth fault.
2. For lines less than 10 km
 - i. Main scheme - Current differential, Distance, Directional Over current & Earth fault.
 - ii. Backup scheme (separate) - Directional Over current & Earth fault.

1.4.4.6.2.3 EHT Cable Protection (Main)

The differential protection is preferred to distance protection, as the main protection for EHT cable feeders. Hence the general requirements of the C&R panel for EHT cable feeders is same as that of the EHT overhead feeders, except for the differential protection relay.

The EHT feeder differential protection shall integrate the following features:

- Numerical, phase segregated current differential.
- Integrated back up directional over current & earth fault protection. Both IDMT and DT with highset shall be incorporated.
- Suitable for optical (820 or 1320 nm) link. Depending on the length of the cable feeder, a suitable optical link shall be selected.
- User friendly front fascia.

- Check (Guard) relay.
- Necessary LED indications / display.
- Protection signalling supervision.
- Inter tripping facility.
- Metering capability.
- Capable of recording events sequence / fault data.
- Inbuilt disturbance recorder.
- Test facility for communication channels / directional checking.
- Comply IEC 61850 as communication standard.
- Trip circuit supervision.
- Circuit breaker fail detection.
- Suitable for CT secondary current of 1A and PT secondary voltage of 110V AC (phase to phase).

A separate over current & earth fault relay shall be provided as a back up protection.

Note:-

The 220kV cable feeders shall be provided with protection scheme as follows :

Main I scheme : Current differential,Distance,Over current & Earth fault

Main II scheme : Current differential,Distance,Over current & Earth fault

The Main I and Main II relays shall be based on different operating principles / logics.

The 110 kV (& below) cable feeders shall be provided with protection scheme as follows:

Main scheme : Current differential,Distance, Directional Over current & Earth fault

Back up scheme (separate)-: Directional Over current & Earth fault.

1.4.4.6.2.4 Feeder Back-up Protection

a. Directional over current relay

The relay shall:

- have IDMT characteristics with a definite minimum time of 3 seconds at 10 times setting.

- have a variable setting range of 50–200% of rated current with adjustable time multiplier setting.
- Include hand-reset indicators.

b. **Directional earth fault relay**

The relay shall:

- have IDMT characteristics with a definite minimum time of 3 seconds at 10 times setting.
- have an adjustable setting range 20–80% of rated current.
- include hand reset setting indicators.

The characteristic angle and directional sensitivity shall be subject to approval of KSEBL.

1.4.4.6.2.5 Auto Re-closing Relay

The relay shall:

- have three phase re-closing facilities.
- have a continuously variable three phase dead time range of 0.1–2 seconds.
- have a continuously variable reclaim time range of 5–25 seconds.
- have facilities for selecting check synchronising or dead line charging features. It shall be possible at any time to change the required feature by re-connection of links.
- Incorporate a four- position selector switch from which single phase / three phase / single and three phase auto re-closure and non-auto re-closure mode can be selected.
- be of single shot type.
- include check synchronising relay, which shall:
 - a) have a time setting continuously variable between 0.5–5 seconds with a facility of additional 10 seconds.
 - b) have a response time within 200 milliseconds with the timer disconnected.
 - c) have a phase angle setting not exceeding 35°.

- include dead line charging relay, which shall:
 - a. have two sets of relays and each set shall be able to monitor the three phase voltage.
 - b. have one set connected to the line CVTs with a fixed setting of 20% of rated voltage.
 - c. have one set connected to the bus CVTs with a fixed setting of 80% of rated voltage.
 - d. incorporate necessary auxiliary relay and timers to give a comprehensive scheme.
- Have positive phase selections under all operating conditions. The scheme should be such as to have Main-I – Main-II fully segregated such that shutdown and testing on one Main protection should not affect the other Main protection. The auto re-closure should be available in the above case.

1.4.4.6.2.6 Local Breaker Back-up Protection Relay (50LBB)

The relay shall trip out other breakers on the bus in case of failure of a particular breaker. The LBB protection relay operation shall also block auto re-closing scheme.

The relay shall:

- be triple pole type.
- be of numerical / solid state design.
- be suitable for operation at 110 volts DC supply.
- have operating time less than 15 milliseconds and resetting time below 15 milliseconds.
- have three over current elements. Each element shall be arranged to get individual initiation from the corresponding phase of line protection.
- Have a setting range of 5-80% of rated current.
- have a continuous thermal withstand capability of two times rated current irrespective of the setting.
- Have three separate timers one for each phase with a continuously adjustable setting range of 0.1-1 seconds.
- Have suitable number of auxiliary relays to make a comprehensive scheme. The

scheme shall be so engineered that in the event of persisting breaker lockout condition and simultaneous incidence of fault shall result in instantaneous tripping of the concerned bus bar to which the faulty breaker is connected.

1.4.4.6.2.7 Tripping Relay (86) High Speed Tripping Relay with Trip relay supervision

The relay shall:

- Be instantaneous (operating time not to exceed 10ms.).
- Reset within 20ms.
- Be DC operated.
- Have adequate contacts to meet the requirement of scheme, other functions like auto re-close relay, LBB relay, event logger, disturbance recorder, fault Locator, etc...
- Be provided with operation indicator for each element / coil.
- All contacts shall be reset with a single reset pushy rod.
- Trip relay supervision shall cover the series NC contact of the trip relay.

1.4.4.6.3 Typical Schedule of Equipment

1.4.4.6.3.1 220kV Feeder Control and Relay Panel

The panels shall comprise of the following as a minimum:

- i. 1 no. circuit identification label.
- ii. Mimic diagram.
 - a) 1 No. mimic diagram and symbol.
 - b) 3 No. Semaphore indicators for Isolators.
 - c) 1 No Semaphore indicator for Breaker.
 - d) 1 No. Semaphore indicator for Earth Switch.
- iii. Control Switches and indicating lamps of LED array.
 - a) 1 No. three position spring return to neutral position control switch for circuit Breakers.
 - b) Three nos. Indicating lamps, Red, green and amber (Amber for 'Auto Trip position) for circuit Breakers.

- c) 6 Nos indicating lamps with Red and Green Colour lenses for Isolators.
- d) 2 Nos. Indicating lamps with Red and Green Colour lenses for Earth Switch.
- e) 6 Nos. lamps with plain lenses for indicating trip circuit healthy condition both pre and post close condition of breaker of 2 sets of 3 Nos. trip coil circuits of the Circuit Breakers.
- f) 1 No. Synchronizing Switch.
- g) All other accessories required for the control scheme.

iv. Relays.

- a) 2 Nos. distance protection schemes with Numerical technology.
- b) 1 No. Directional IDMT type relay.
- c) 1 No. Carrier service selector-switch 'IN-OUT' if the same is not included with the distance scheme.
- d) One set high speed tripping relay (Hand Reset).
- e) 2 No. spare auxiliary tripping relays.
- f) 2 No. D.C. supply monitoring relays.
- g) 2 Sets of Trip Circuit supervision relays (both pre-close and post-close supervision).
- h) 1 No Auto Re-close relay if required.
- i) All other auxiliary relays, contacts etc... required for the proper functioning of the protection scheme.
- j) LBB protection relay (2 stage)

v. 1 set Disturbance and Event Logger with Time synchronization equipment.

vi. Annunciator

One set as per scheme with accept, reset and lamp test push button as per Clause 1.4.4.6.1.17 giving target Indication for the following as a minimum:

- 1. Distance protection Main – I operated.
- 2. Distance protection Main – II operated.
- 3. Bus protection operated.
- 4. Breaker re-closed.
- 5. Breaker failure protection operated.

6. Breaker trip circuit faulty.
7. Breaker transfer tripped.
8. Breaker lock-out.
9. Carrier fail.
10. Back up protection operated.
11. P.T. Fuse failed.
12. SOTF protection operated.
13. Power Swing detected.
14. Direct trip received.
15. Carrier received.
16. Control Center Trip Received.
17. Breaker pole discrepancy.
18. Breaker low SF6.
19. Breaker low air (for Breakers with Pneumatic Drives).
20. Drive Mechanism faulty.
21. Auto re-close lock out.
22. Protection Faulty.
23. MCB Tripped.
24. DC failed.
25. Aux. A.C. Failed.
26. } Spare.
27. } Spare.
28. } Spare.
29. } Spare.

vii. Indicating Meters:

All indicating meters shall be Digital Multi-function Meters (DMM) of Class 0.2S capable of displaying various parameters like voltage, current, MW, MVAR, MWh, MVAh, power factor, frequency etc... The Digital Multi-function Meters shall be provided in duplicate. The LED digits shall be of sufficient size so as to have easy readability from the operator work table. The Digital Multi-function Meters shall

have communication facility as per latest protocols which shall be finalised during detailed engineering in consultation with KSEBL.

The Energy meter shall be installed at about eye-level from ground level.

viii. Test Terminal Blocks.

- a) Test Terminal block for the metering circuits.
- b) Test Terminal block for the Main-I & Main-II relays, Back-up relay etc...

ix. Internally Mounted Equipment.

As per requirement.

1.4.4.6.3.2 110kV Feeder Control and Relay Panels

This shall be of simplex type comprising of:

- i. 1 No. circuit label.
- ii. 1 No. mimic diagram.
- iii. 3 No. semaphore indicators for isolators (for Double Bus Stations otherwise 2 No).
- iv. 1 No. semaphore indicators for circuit breaker.
- v. 1 No. semaphore indicator for earth switch.
- vi. Control Switches & indicating lamps:
 - a) 1 No. three position spring return to neutral position control switch with locking arrangement for circuit breaker.
 - b) 1 No. three position non lock pattern spring return to neutral position control switch for earth switch.
 - c) 3 No. indicating lamps (LED) with red, green and amber coloured lens (amber for auto trip) for circuit breakers.
 - d) 2 sets of push buttons and lamp for trip circuit healthy check.
- vii. Annunciator: 1 set facia with accept, reset and lamp test push buttons for the following:
 - a) Distance protection operated.
 - b) Back up protection operated.
 - c) Bus protection operated (for stations with Busbar Protection).
 - d) Carrier fail.

- e) SOTF protection operated.
- f) Direct trip received.
- g) Carrier received.
- h) Control Center Trip Received.
- i) Breaker pole discrepancy (for CB's with Single Pole operation).
- j) Breaker re-closed (for CB's with Auto Reclosure).
- k) Breaker low SF6.
- l) Breaker low air (for Breakers with Pneumatic Drives).
- m) Drive Mechanism Faulty.
- n) Auto-reclose lock out.
- o) Protection faulty.
- p) Trip Circuit Faulty.
- q) PT fuse fail.
- r) Breaker lockout.
- s) MCB tripped.
- t) Control D.C. Failed.
- u) Aux. AC Supply failed.
- v) 4 No. as spares.

viii. Indicating meters:

- a) All indicating meters shall be Digital Multi-function Meters (DMM) of Class 0.2S capable of displaying various parameters like voltage, current, MW, MVAR, MWh, MVAh, power factor, frequency etc... The Digital Multi-function Meters shall be provided in duplicate. The LED digits shall be of sufficient size so as to have easy readability from the operator work table. The Digital Multi-function Meters shall have communication facility as per latest protocols which shall be finalised during detailed engineering in consultation with KSEBL.
- b) 1 No. TOD Energy meter.

ix. Test terminals:

Test terminal blocks for the metering circuit and protection relays.

x. Internally mounted equipment:

As per requirements for both control & protection.

xi. Relays:

- a) 1 No. numerical distance relay.
- b) 1 No. Bus PT selection relay.
- c) Two O/C and one E/F relay.
- d) 1 No spare high speed tripping relay (hand reset).
- e) 1 No. carrier source select switch with IN / OUT positions if the same is not incorporated with the distance scheme.
- f) 2 No. DC supply monitoring relays.
- g) One set high speed tripping relay.
- h) 2 Sets of Trip Circuit supervision relays (both pre-close and post-close supervision).
- i) All other auxiliary relays, contacts etc... required for the proper functioning of the protection scheme.

1.4.4.6.3.3 66 kV & 33 kV Feeder Control & Relay Panels

This shall be of simplex type comprising of:

- i. 1 No. circuit label.
- ii. 1 No. mimic diagram.
- iii. 2 No. semaphore indicators for isolators.
- iv. 1 No. semaphore indicator for circuit breaker.
- v. 1 No. semaphore indicator for earth switch.
- vi. Control Switches & indicating lamps:
 - a) 1 No. three position spring return to neutral position control switch with locking arrangement for circuit breaker.
 - b) 2 No. three position non lock pattern spring return to neutral position control switch for Isolator switch.
 - c) 3 No. indicating lamps (LED) with red, green and amber coloured lens (amber for auto trip) for circuit breakers.
 - d) 2 sets of push buttons and lamp for trip circuit healthy check.

vii. Annunciator:

1 set facia with accept, reset and lamp test push buttons for the following:

- a) Protection operated.
- b) Breaker low SF6 (for SF6 Breakers).
- c) Drive Mechanism faulty.
- d) Protection Faulty.
- e) Control D.C. Failed.
- f) Auxiliary AC Supply Failed.
- g) Trip Circuit Faulty.
- h) MCB Tripped.
- i) Control Center Trip Received.
- j) 2 No. as spares.

viii. Indicating meters:

- a) All indicating meters shall be Digital Multi-function Meters (DMM) of Class 0.2S capable of displaying various parameters like voltage, current, MW, MVAR, MWh, MVARh, power factor, frequency etc... The Digital Multi-function Meters shall be provided in duplicate. The LED digits shall be of sufficient size so as to have easy readability from the operator work table. The Digital Multi-function Meters shall have communication facility as per latest protocols which shall be finalised during detailed engineering in consultation with KSEBL.
- b) 1 No. TOD Energy meter.

ix. Test terminals:

- a) Test terminal blocks for the metering circuit.
- b) Test terminal block for the protection relays.

x. Internally mounted equipment as per requirements for both control & protection.

xi. Relays:

- a) A numerical inverse-over current and earth fault relay with high set unit shall be provided on 33 kV line.

The relay shall be of 1A, Microprocessor based selectable IDMT curve, having 2 O/C and 1 E/F unit with high set units and flag / LED operation indicators on each unit with provision for reset and having following features:

1. Low burden.
 2. Serial interface for automation application using IEC 61850.
 3. Self supervision of software and hardware.
- b) 1 No. DC supply monitoring relays.
 - c) One set high speed tripping relay (Hand Reset).
 - d) One set Trip Circuit monitoring relays (both pre-close and post-close supervision).
 - e) All other auxiliary relays, contacts etc... required for the proper functioning of the protection scheme.

1.4.4.6.3.4 Control & Relay Panels for Primary side of Transformer (220, 110, 66 kV)

This shall be of simplex type comprising of the following as a minimum:

- i. 1 no. circuit identification label
- ii. Mimic diagram:
 - a) 1 No. mimic diagram and symbol.
 - b) 2 No. Semaphore indicators for Isolators (1 No for Single Bus Stations).
 - c) 1 No Semaphore indicator for Breaker.
- iii. Control Switches and indicating lamps of LED array.
 - a) 1 No. three position spring return to neutral position control switch for circuit Breaker.
 - b) Two No. three position spring return to neutral position control switch for 220kV and 110kV class Isolators (One no for Single Bus Station).
 - c) Three No. Indicating lamps, Red, Green and Amber (Amber for 'Auto Trip position) for circuit Breaker.
 - d) 4 No indicating lamps with Red and Green Colour lenses for Isolators. (2 No. for Single Bus Stations).
 - e) 4 No. lamps with plain lenses for indicating trip circuit healthy condition both pre and post close condition of breaker of 2 sets of trip coil circuits of the Circuit Breakers (2 No. lamps one trip coil for 66kV Breakers).
 - f) All other accessories required for the control scheme.
- iv. Relays:

- a) 1 No. Differential protection scheme with Numerical technology.
 - b) 1 No. IDMT type three element relay for Over-current protection.
 - c) 1 No. IDMT type single element relay for Earth Fault protection.
 - d) 1 No. REF Protection.
 - e) 1 Set high speed tripping relay (Hand Reset).
 - f) 1 No Inter-Tripping Relay.
 - g) 2 Sets of Trip Circuit supervision relays (both pre-close and post-close supervision).
 - h) 2 No. spare auxiliary tripping relays.
 - i) 2 No. D.C. supply monitoring relays.
 - j) 1 No Trip relay supervision for high speed tripping relay
 - k) All other auxiliary relays, contacts etc... required for the proper functioning of the protection scheme.
- v. Annunciator:

One set as per scheme with accept, reset and lamp test push button as per Clause 1.4.4.6.1.17 giving target Indication for the following as a minimum:

- 1. Differential protection operated.
- 2. REF protection operated.
- 3. Bus protection operated (for stations with Busbar Protection).
- 4. Over-Current Protection operated.
- 5. Earth Fault protection operated.
- 6. Breaker failure protection operated (for 220kV class).
- 7. Bucholz Alarm.
- 8. Bucholz Trip.
- 9. Winding Temperature Alarm.
- 10. Winding Temperature Trip.
- 11. Oil Temperature Alarm.
- 12. Oil Temperature Trip.
- 13. Pressure Relief Valve Trip.
- 14. Transformer Inter- trip operated.

15. Control Center Trip Received.
16. Breaker trip circuit faulty.
17. Breaker low SF6 (for SF6 Breakers).
18. Breaker low air (for Breaker with Pneumatic Drives).
19. Drive Mechanism faulty.
20. Protection Faulty.
21. MCB Tripped.
22. DC failed.
23. Aux. A.C. Failed.
24. } Spare.
25. } Spare.
26. } Spare.
27. } Spare.

vi. Indicating Meters:

All indicating meters shall be Digital Multi-function Meters (DMM) of Class 0.2S capable of displaying various parameters like voltage, current, MW, MVAR, MWh, MVAh, power factor, frequency etc... The Digital Multi-function Meters shall be provided in duplicate. The LED digits shall be of sufficient size so as to have easy readability from the operator work table. The Digital Multi-function Meters shall have communication facility as per latest protocols which shall be finalised during detailed engineering in consultation with KSEBL.

1 No. 3-phase 4 wire TOD meter. The Energy meter shall be installed at about eye-level from ground level

The Winding temperature and Oil temperature indicators shall be provided in the panels for remote metering.

vii. Test Terminal Blocks:

- a) Test Terminal block for the metering circuits.
- b) Test Terminal block for all the protection relays.

viii. Internally Mounted Equipment as per requirement.

1.4.4.6.3.5 Control & Relay Panel for Transformer Secondary Side (220, 110, 66, 33 kV) and for Primary Side (33 / 11 kV)

This shall be of simplex type comprising of the following as a minimum:

- i. 1 no. circuit identification label.
- ii. Mimic diagram.
 - a) 1 No. mimic diagram and symbol.
 - b) 2 No. Semaphore indicators for Isolators (1 No for Single Bus Stations).
 - c) 1 No Semaphore indicator for Breaker.
- iii. Control Switches and indicating lamps of LED array:
 - a) 1 No. three position spring return to neutral position control switch for circuit Breaker.
 - b) Two Nos. three position spring return to neutral position control switch for 220kV and 110kV class Isolators (One no for Single Bus Station).
 - c) Three No. Indicating lamps, Red, green and amber (Amber for 'Auto Trip position) for circuit Breaker.
 - d) 4 No. indicating lamps with Red and Green Colour lenses for Isolators. (2 Nos for Single Bus Stations).
 - e) 4 Nos. lamps with plain lenses for indicating trip circuit healthy condition both pre and after close condition of breaker of 2 sets of trip coil circuits of the Circuit Breakers (2 Nos lamps one trip coil for 66kV and 33kV Breakers).
 - f) All other accessories required for the control scheme.
- iv. Relays:
 - a) 1 No. IDMT type three element relay for Over-current protection.
 - b) 1 No. IDMT type single element relay for Earth Fault protection.
 - c) 1 No. REF Protection.
 - d) 1 No Master Trip Relay (Hand Reset).
 - e) 1 No Inter-Tripping Relay.
 - f) 2 Sets of Trip Circuit supervision relays (both pre-close and post-close supervision).
 - g) 2 No. spare auxiliary tripping relays.

- h) 2 No. D.C. supply monitoring relays.
 - i) Auxiliary tripping relays for Bucholz, OT & WT trip & alarm, Low oil Level Alarm etc... (for 33/11kV only).
 - j) All other auxiliary relays, contacts etc... required for the proper functioning of the protection scheme.
- v. Annunciator:

One set as per scheme with accept, reset and lamp test push button as per Clause 1.4.4.6.1.17 giving target Indication for the following as a minimum:

1. REF protection operated.
2. Over-Current Protection operated.
3. Earth Fault protection operated.
4. Breaker failure protection operated (for 220kV class).
5. Transformer Inter- trip operated.
6. Bucholz Alarm (for Primary side of 33 / 11kV Transformers only).
7. Bucholz Trip (for Primary side of 33 / 11kV Transformers only).
8. Winding Temperature Alarm (for Primary side of 33 / 11kV Transformers only).
9. Winding Temperature Trip (for Primary side of 33 / 11kV Transformers only).
10. Oil Temperature Alarm (for Primary side of 33 / 11kV Transformers only).
11. Oil Temperature Trip (for Primary side of 33 / 11kV Transformers only).
12. Pressure Relief valve Trip (for Primary side of 33 / 11kV Transformers only).
13. Transformer Inter- trip operated.
14. Breaker trip circuit faulty.
15. Breaker low SF6 (for SF6 Breakers).
16. Breaker low air (for Breaker with Pneumatic Drives).
17. Drive Mechanism faulty.
18. Protection Faulty.
19. MCB Tripped.
20. DC failed.
21. Aux. A.C. Failed.

22. } Spare.

23. } Spare.

vi. Indicating Meters:

All indicating meters shall be Digital Multi-function Meters (DMM) of Class 0.2S capable of displaying various parameters like voltage, current, MW, MVAR, MWh, MVAh, power factor, frequency etc... The Digital Multi-function Meters shall be provided in duplicate. The LED digits shall be of sufficient size so as to have easy readability from the operator work table. The Digital Multi-function Meters shall have communication facility as per latest protocols which shall be finalised during detailed engineering in consultation with KSEBL.

The Winding temperature and Oil temperature indicators shall be provided in the panels for remote metering.

vii. Test Terminal Blocks:

- a) Test Terminal block for the metering circuits.
- b) Test Terminal block for all the protection relays.

viii. Internally Mounted Equipment as per requirement.

1.4.4.6.3.6 Station Transformer Protection

The following protection will be provided on the transformer:

i. 11kV or 6.6kV or 3.3kV side of transformers

- a) Digital IDMT over current and earth fault relay with high set instantaneous element (50 / 51 / 64.).
- b) T/F winding temp high alarm / trip control.
- c) T/F oil temperature high alarm and trip.

ii. LV side of the transformers

Digital IDMT over current & earth fault protection with high set instantaneous element (50 / 51 / 64).

1.4.4.6.4 Disturbance Recorder

A disturbance recorder (station level) complying with the latest applicable standards and latest software shall be provided, if included in the Specific Requirements of this specifications. The detailed requirement and scheme shall be finalised in consultation with

KSEBL during detailed engineering.

1.4.4.6.5 Event Logger

An event logger (station level) complying with the latest applicable standards and latest software shall be provide,if included in the Specific Requirements of this specifications. The event logger shall be complete with all associated equipment. The detailed requirement and scheme shall be finalised in consultation with KSEBL during detailed engineering.

1.4.4.6.6 Time Synchronisation Equipment

The specification listed below are not exhaustive and complete, but only an indication to the minimum requirements necessary.

- The Time synchronisation equipment shall receive the co-ordinated Universal Time (UTC) transmitted through Geo Positioning Satellite System (GPS) and synchronise equipment to the Indian Standard Time in a substation.
- Time synchronisation equipment shall include antenna, all special cables and processing equipment etc...
- It shall be compatible for synchronisation of Event Loggers, Disturbance recorders and SCADA at the substation.
- Equipment shall operate up to the ambient temperature of 50 degree centigrade and 100% humidity.
- The synchronisation equipment shall have 2 micro second accuracy. Equipment shall give real time corresponding to IST (taking into consideration all factors like voltage & temperature variations, propagation & processing delays etc...).
- Equipment shall meet the requirement of IEC 60255 for storage & operation.
- The system shall be able to track the satellites to ensure no interruption of synchronisation signal.
- The output signal from each port shall be programmable at site for either one hour, half hour, minute or second pulse, as per requirement.
- The equipment offered shall have six (6) output ports. Various combinations of output ports shall be selected by the KSEBL, during detailed engineering, from the following:
 - Voltage signal: Normally 0-5V with 50 milli Seconds minimum pulse duration. In

case any other voltage signal required, it shall be decided during detailed engineering.

- Potential free contact (Minimum pulse duration of 50 milli Seconds.).
- IRIG-B.
- RS232C.
- The equipment shall have a periodic time correction facility of one second periodicity.
- Time synchronisation equipment shall be suitable to operate from 110V DC available at Substation.
- Equipment shall have real time digital display in hour, minute, second (24 hour mode) & have a separate time display unit to be mounted on the top of control panels having display size of approx. 100 mm height.

1.4.4.6.7 Synchronising Panel

The specification listed below are not exhaustive and complete, but only an indication to the minimum requirements necessary.

The synchronising instruments shall be mounted either on a synchronising trolley or on a synchronising panel. The panel / trolley shall be equipped with double analog voltmeters and double analog frequency meters, synchroscope and lamps fully wired. The size of voltmeters and frequency meters provided in the synchronising panel shall not be less than 144 X 144 sq.mm. Suitable auxiliary voltage transformers wherever necessary shall also be provided for synchronising condition. In case the synchroscope is not continuously rated, a synchroscope cut-off switch shall be provided and an indicating lamp to indicate that the synchroscope is energised, shall also be provided.

Synchronising check relay with necessary ancillary equipment's shall be provided which shall permit breakers to close after checking the requirements of synchronising of incoming and running supply. The phase angle setting shall not exceed 35 degree and have voltage difference setting not exceeding 10%. This relay shall have a response time of less than 200 milliseconds when the two system conditions are met within present limits and with the timer disconnected. The relay shall have a frequency difference setting not exceeding 0.45% at rated value and at the minimum time setting. The relay shall have a continuously adjustable time setting range of 0.5-20 seconds. A guard relay shall be provided to prevent the closing attempt by means of synchronising check relay when control switch is kept in

closed position long before the two systems are in synchronism.

The synchronising panel shall be draw out and swing type which can be swivelled in left and right direction. The synchronising panel shall be placed along with control panels and the number of synchronising panel shall be as indicated in Purchase Order. The incoming and running bus wires of VT secondary shall be connected and run as bus wires in the control panels and will be extended to synchronising panel for synchronisation of circuit breakers. The selector switch provided for each circuit breaker in respective control panels shall be lockable type with a common key so that only one selector switch is kept in synchronising mode at a time.

Alternatively, the trolley shall be of mobile type with four rubber-padding wheels capable of rotating in 360 degree around the vertical axis. Suitable bumpers with rubber padding shall be provided all around the trolley to prevent any accidental damage to any panel in the control room while the trolley is in movement. The trolley shall have two meter long flexible cord fully wired to the instruments and terminated in a plug in order to facilitate connecting the trolley to any of the panels. The receptacle to accept the plug shall be provided on the panel.

The Synchronising panel generally shall consist of the following:

- Swing type synchronising panel on either ends of the control panel suit (bay) shall be provided for 110kV to 400kV substations. The local control for each circuit breaker (at the substation main control board or at the switchgear) shall be such that when selected the voltages on either side of the circuit breaker are connected to the synchronizing panel.
- Each synchronizing panel shall consist of:
 - i. Two (2) digital voltmeters.
 - ii. Two (2) digital frequency meters 45 - 55 Hz.
 - iii. One (1) indicating synchroscope
 - iv. Two (2) lamps to indicate presence of "incoming" and "running" voltages.
 - v. Parking place for common, removable Synchronizing Selector Switch Key.
- The synchronizing panel shall give indications only and its synchroscope shall not be part of the controlling circuit of each circuit breaker.
- Each circuit breaker shall be provided with a synchro-check relay, which shall be mounted on each circuit breaker relay panel. The relay shall be permanently

supplied with the voltages being compared.

- Synchro-check relay shall determine whether conditions are correct for permitting closure, having regard to voltage and slip frequency.
- Voltage monitoring relays shall be provided to over ride the synchro- check contact in the event of the circuit being dead on one or both sides of the circuit breaker. Failure of a monitoring relay shall not allow the unwanted over ride of the synchro-check contact if the VT voltages are still present.
- The synchro-check and voltage monitoring relays shall be continuously rated for operation up to 115% of normal voltage and frequency between 45 – 55Hz.

1.4.4.6.8 Inspection and Tests

During the course of manufacture, KSEBL's representative shall have the right to inspect the materials, workmanship, labour and the progress of manufacture of the equipment under order and may reject any item which is found defective or unsuitable for the purpose intended or which is not in accordance with the intent of this specification. The Contractor upon demand by the KSEBL or its representative shall rectify the defects or replace such defective or unsuitable materials. The Contractor shall provide all reasonable inspection facilities to KSEBL's inspecting personnel.

Equipment shall be capable of performing satisfactorily up to Contractor's maximum guaranteed values. All tests required by specification, including repeat tests and inspections that may be necessary owing to failure to meet any tests specified shall be made at Contractor's expenses. If equipment fails to pass the specified tests, KSEBL shall have option to reject the unit. Additional tests shall be made to locate the failure and after reconstruction, testing shall be repeated to prove that the rebuilt equipment meets the specifications in all respects.

Each equipment shall be subjected to routine tests as specified in Indian Standards or IEC and other functional tests as required in the presence of KSEBL's representatives, if so desired by the KSEBL. All test reports shall be submitted and got approved by the KSEBL before despatch of the equipment.

Any other tests which are considered necessary by the manufacturer of the equipment have to be conducted at site. Special tools and tackles required, if any, for the pre-commissioning tests shall be arranged by the Bidder / Contractor and also shall be clearly indicated in the offer.

The relays should have high immunity to electrical and electromagnetic interference.

The relays should confirm to following (but not limited to) mandatory type tests for safe operation of the relay:

- a) High frequency disturbance test as per IEC 61000-4-1.
- b) Fast transient disturbance test as per IEC 61000-4-4 level III.
- c) Electrostatic discharge as per IEC 61000-4-2.
- d) Radio frequency interference as per ANSI C 37.90.2.
- e) Impulse test as per IEC 61000-4-3.
- f) Relay characteristics, performance and accuracy test as per IEC 60255.
- g) Steady state Characteristics and operating time.
- h) Dynamic Characteristics and operating time for distance protection relays and current differential protection relays.
- i) For Disturbance recorder and Event logger only performance tests are intended under this item.
- j) Tests for thermal and mechanical requirements as per IEC 60255-6.
- k) Tests for rated burden as per IEC 60255-6.
- l) Contact performance test as per IEC 60255-0-20 (not applicable for Event logger, Distance to fault locator and Disturbance recorder).
- m) Steady state & Dynamic characteristics test reports on the distance protection relays, as type test, shall be based on approved test programme on simulator / network analyser / PTL. Alternatively, the files generated using Electromagnetic transient Programme (EMTP) can also be used for carrying out the above tests. Single source dynamic tests on transformer differential relay shall be / should have been conducted based on general guidelines specified in CIGRE committee 34 report on Evaluation of characteristics and performance of Power system protection relays and protective systems.

The following tests shall be carried out at the factory in the presence of KSEBL's representative. The Supplier shall give at least 15 (fifteen) days advance notice of the date when the tests are to be carried out. KSEBL shall have the right to select any quantity of the items from the lot offered for testing or offered for inspection and in the event of failure in test(s), the purchaser shall have the right to reject all the offered equipment(s). Six (6) copies of the certificates shall be supplied before shipment of equipment for approval. The

equipment shall be shipped only after approval of the test certificate.

- a) Checking the wiring of circuits and the continuity.
- b) One-minute applied voltage test. All equipment on panel and wiring shall be tested for a withstand voltage of 2000 volts to earth and between different voltages circuits.
- c) Insulation resistance of the complete wiring, circuit by circuit with all equipment mounted on the Board before and after H.V. test mentioned under 2 above.
- d) Routine tests according to the relevant national standard on the instruments, relays and other devices.
- e) Scheme checking and conducting operational tests to verify various scheme logics like tripping, inter-tripping, inter-locking etc... All circuits & wirings shall be tested with simulated functional condition for proper operation.

Any other tests which are considered necessary by the manufacturer of the equipment have to be conducted at shop. Special tools and tackles required, if any, for the factory acceptance tests shall be arranged by the Bidder / Supplier and also shall be clearly indicated in the offer.

1.4.4.6.9 Cabling System

The control, protection, metering and instrumentation cables shall be manufactured based on IEC publications for cables or any other equivalent international standards. All cables shall be of 650 / 1100 V screened copper conductors, fire resistant, low smoke, and PVC sheath with different number of conductors to comply with the functional requirement.

Special cables used such as RTD wiring, signal pickup etc... shall also be screened. RTD's shall have 3-wire connection for lead compensation. All multi core cables shall be distinctively identical using separate colour for each core or by printing core numbers.

For 1A CT's, 4 mm² copper cables shall be used. For essential small motors such as isolator operating motor, circuit breaker spring charging motor etc..., 6 mm² copper cable shall be used.

For support of the power and control cables, cable ladder system shall be used. The system shall comprise of cable ladders, cable trays, mounting rails, supports, clamps etc... The ladders / trays shall be of different types and sizes adaptable to its special field of use.

The cable trenches in the yard shall be so designed that water collected in the trenches shall easily get drained out.

1.4.4.6.10 Spares

Spares required for 5 years of maintenance shall be supplied. For all electronic cards, 100% spare shall be provided. For all protective relays (including high speed trip, Monitoring and Trip circuit supervision relays), one relay of each kind, Meters, Indicating Lamps, Control Switches, Annunciator spares, Test Terminal Block etc... shall be available as spare. Any other spares recommended by the manufacturer as essential for the satisfactory and trouble free operation of the equipment as per Clause 1.1.32 of this specification. The same shall be listed out in detail in the offer.

1.4.4.6.11 Tools and Instruments

One no. Test kit (preferably Omicron / Programma / Megger / equivalent make approved by the KSEBL) for testing all the relays supplied shall be provided along with a Laptop preloaded with the required configuration / setting / testing software for the same along with every ten sets of the Control & Relay Panel. All necessary interfaces including connecting cables, protocol converters, connectors etc... required for communicating with the relays and connecting to the Laptop and Test Kit shall be supplied.

Necessary manuals giving complete information on installing, configuring, trouble shooting etc... of the software including methodology for data retrieval / display of the data stored in the relays, changing relay settings etc... shall be also provided. Software required for the configuration, setting change, maintenance, trouble shooting, retrieval and display of stored data etc... of the relays and the testing software etc... shall be provided in CD / DVD also.

1.4.5 Switch-yard Installation and Tests on Completion

1.4.5.1 Introduction

The scope of these specifications is to stipulate the basic general guidelines to the Bidder / Contractor regarding the switch-yard tests on completion of the switch-yard, compliance to the latest published edition (prior to the date of closing of tender) of the international standards and recommendations specified throughout the specifications for the testing of the complete equipment and other general requirements as per **Section 1.1**, which are required for verifying the performance of the plant / equipment being provided under the scope of this tender / contract.

Any item of tests not specifically mentioned in the specifications but which are usual and / or necessary for verifying the satisfactory operation of the equipment / system shall be deemed to be provided by the Contractor and included in the quoted Price. Testing of the equipment / plant shall be complete in all details whether such details are mentioned in the specifications or not.

1.4.5.2 Reference Standards and Codes

The testing procedure, measurement and methods shall be in accordance with the latest revision of applicable IS / IEC or equivalent standards.

The Contractor shall adhere to sound testing practices with regard to codes and test equipment in order to warrant operational safety and ease of testing of plants as well as assuring trouble free control and stability in plant operation.

• IEC 60129	-	Isolators
• IS 3156	-	Voltage Transformers.
• IS 2705	-	Current Transformers.
• IS 3070	-	Lightning Arrestors.
• IS 9921	-	Isolators.
• IS 2544	-	Porcelain Insulators.
• IS 2026	-	Power Transformers.
• IEC 62271-100 & 60060	-	Circuit breakers.

1.4.5.3 Reference Sections

Section 1.1	-	General Technical Requirements.
Section 1.3.14	-	Site Installation, Field Testing & Tests on Completion.
Section 1.4.2	-	Power Transformers.
Section 1.4.3	-	Switch-yard Equipment.
Section 1.4.4	-	Switch-yard Control, Protection & Instrumentation.
Part - 2	-	Specific Requirements for the Project.

1.4.5.4 Deliverable Documents

- Drawings, circuit diagrams and specifications.
- List of suppliers / manufacturers of testing equipment.
- A complete list giving details of testing equipment and auxiliaries.
- Operation and Maintenance manual of supplied testing equipment.
- Copy of Valid calibration certificate of testing and measuring / recording equipment.
- Test reports / data.
- Methodology of testing.
- Operation and maintenance manual covering full details of testing procedure.

1.4.5.5 KSEBL's other Requirements

All the equipment shall be tested at site to know their condition and to prove suitability for required performance. All equipment shall be finally tested and commissioned by the manufacturer's Commissioning engineer to the satisfaction of KSEBL's Engineer. **Before testing of equipment at site, the contractor shall ensure that he has obtained approval of all work test certificates, along with the previously submitted detailed testing and commissioning procedure / plan from the KSEBL / Engineer-in-Charge. All punch points associated with the erection of the concerned equipment should also be cleared before starting of the testing and commissioning procedure.**

All testing and measuring / recording equipment used shall have valid calibration certificates and the same shall be submitted to the KSEBL. The details of calibrations shall be included in the test report along with copy of the calibration certificate.

Any other tests which are considered necessary by the manufacturer of the equipment have to be conducted at site. Special tools and tackles, testing equipment, test facilities / set-up, labour and other resources etc... required, if any, for the erection / pre-commissioning / commissioning tests shall be arranged by the Bidder / Contractor and also shall be clearly indicated in the offer.

1.4.5.6 Installation of Switch-yard Equipment

1.4.5.6.1 General

- All electrical installation shall confirm to the Indian Electricity Act, IE Rules and Regulation in force, in the state, by electrical inspectorate.
- All works under this contract including the installation of the equipment shall be got inspected and approved by the relevant authorities like Electrical Inspectorate etc..., if required.
- The circuit breaker, current transformers, lightning arresters, power transformers etc..., shall be examined on receipt for damages. The contractor shall assemble, install and connect the equipment wherever necessary as per manufacturer's recommendations. The assembly of the unit including their operating mechanism, site adjustments shall also be carried out as per guiding instructions from the manufacturer. The equipment shall be placed and levelled carefully on their respective structures. All the preparatory works such as civil foundations, any concrete channels etc..., shall be completed prior to this.
- The operating mechanism and control circuit of the equipment shall be tested for proper opening, closing and position indication. The opening and closing tests shall be made from control points as in service operation.
- Earthing of supporting structures and metal parts of operating mechanism operating cabinets, operating handles at ground potential shall be ensured. Where moving parts are involved, flexible copper conductors shall be used.
- Before charging the equipment, contractor shall submit the completion report for each equipment indicating rectifications / modifications carried out during erection, site test certificates with observations, rectifications carried out.
- Contractor shall also indicate the correctness of operational and safety interlocks. Site test certificates shall also indicate the corresponding values obtained in the factory test.

- The conductor / jumpers shall be correctly and effectively connected to the terminals of equipment. The faces shall be cleaned with fine cloth and lightly coated with petroleum jelly before use. However, if contacts are silver plated, they shall not be cleaned with emery paper. The connection shall be flexible to withstand stresses during switching operation.
- The control cabling shall be effectively crimped to the cable lugs which shall be bolted tight after ensuring that the contact faces are clean. Small wiring that is necessary between units in accordance with the diagram of connection shall be made complete.

1.4.5.6.2 Installation of Transformers

- The transformer and its accessories and mountings like radiators, conservator, Silica-gel Breathers, marshalling box, rollers etc... shall be assembled at site after cleaning by the contractor in proper sequence as per manufacturer's Drawings.
- Contractor shall place the transformer on the channel at the location indicated in the layout drawing of outdoor yard. Suitable stopper shall be provided both in front as well as rear of transformer to keep it stationary in its position. For the front wheels such stoppers shall be screwed on the channels.
- BDV value for the transformer oil shall be tested before energisation of Power Transformer. Drying of transformer shall be carried out to get required dielectric strength as per relevant Indian Standards.
- Oil shall be filled up to the mark shown.
- Wherever the power / control cables project above ground, for termination to cable box / marshalling box, the same shall be run in GI pipes of suitable cross section up to the height of 2.0 m from ground and the same shall be supported properly and pipe ends shall be sealed with epoxy compound.
- The contractor shall ensure the following sequence of erection of transformers:
 - Unpacking of closed / packed cases and compare with the packing list.
 - Physical check and inspection, pay particular attention to:
 - a) Tank sides or cooling tubes / radiators dented.
 - b) Protruding fitting damaged.
 - c) Oil sight glass broken.

- d) Bushings cracked or broken.
- e) Bolts loose due to vibration in transit.
- f) Oil leakage.
- Transportation to erection site.
- Erection on foundation / channels.
- Assembly of transformer.
- Checking of oil level filtration / drying of oil.
- Alignment.
- Anchoring and tack welding.
- Mechanical check.
- Wiring and sealing of assembled parts.
- Laying, meggering, termination, dressing and clamping of cables.
- Tagging and marking of cables.
- Testing of cables.
- Preparing Earthing station, earthing of transformers using earthing strip, measured earth resistance shall comply with IER (latest revision).
- Testing of assembled part.
- Testing and calibration of meters, relays, CTs, PTs, etc...
- Connection of busbars / cables to primary and secondary of transformers.
- Series of tests on transformers as per supplier's / KSEBL engineer's instructions, IS:1886 and manufacturer's recommendations.
- Submission of completion report in the format.
- Charging of transformer.
- Loading of transformer.
- Painting work.
- Handing over to Site-in-Charge / KSEBL's representative.

Note: All high voltage tests shall comply with IS 2071 Part I and II and all works in connection with the transformer shall comply with IS 1886 and IER (latest revision).

- The following provision shall be made for transformer oil soak pit and oil collection pit:
 - For a single transformer installation oil soak pit capacity shall be 110% of transformer oil capacity.
 - For multi transformer installation oil soak pit capacity shall be 30% of individual transformer oil capacity and in addition to it an oil collection pit of 150% capacity of largest transformer shall be provided.
 - Oil soak pit dimension, shall be all around 800mm more than the overall (length & width) dimension of transformer including radiator.

1.4.5.6.3 Installation of Circuit Breaker

1.4.5.6.3.1 General

- The circuit breakers shall be assembled and erected on the support structures as per the manufacturer's instructions and drawings and shall be aligned accurately and levelled on the support structures.
- Perfect operation of the circuit breaker shall be ensured after erection by manual operation. Each bearing of the operating mechanism shall be properly lubricated.
- The contractor shall follow the following sequence of erection of Circuit Breaker:
 - Transportation to the place of installation from contractor's stores.
 - Unpacking the cases and physical inspection of the components for breakages, missing parts or damage as compared with the packing list.
 - The foundation must be plane and horizontal so that the Circuit breaker rest firmly on foundation.
 - Assembly and erection of the circuit breaker shall be done strictly as per the instruction and drawings from the manufacturer. Corresponding part of each pole marked in the packing list shall be strictly adhered to. Breaker installation shall be checked for proper levelling and alignment.
 - Adjust the operating rods between poles and the operating mechanism as directed by manufacturer, before closing the breaker at full speed. Check the "indicating distance" by operating the breaker slowly to the closed position.

1.4.5.6.3.2 Wiring of Circuit Breaker Operating Cubicle

- Laying, meggering, termination, dressing and clamping of control cables, bus-bars, jumpers etc...
- Testing and marking of cables.
- Cleaning of all insulating surfaces with dry cloth or as indicated by the manufacturer.
- Functional tests on the circuit breaker.
- Painting of all accessories, structures etc...
- Earthing of all the metal parts and structures not intended to be live.
- Submission of site test certificates, completion report etc..., in the proper format.
- Handing over to Site engineer / KSEBL's representative.

1.4.5.6.4 Installation of Isolator / Disconnecting Switch

- The poles of the disconnecting switches shall be aligned accurately and levelled on the supporting steel structures. Sequence of installation of disconnecting switch parts shall be carried out as recommended by manufacturer.
- Perfect operation of disconnecting switch, earthing switches shall be ensured after erection by manual operation. Working clearance between adjacent structures and switch blades in open position shall be checked.
- The switches shall be adjusted so as to permit operation with ease by one man.
- Each bearing of the operating mechanism shall be properly lubricated.
- Laying, termination of power and control cables, checking of internal wiring connections.
- The contractor shall also check for the key interlocking of the earthing switch with the main disconnect switch. Earthing between units, earthing terminals to structure, operating handle to structure and ground mat should be effective and neatly taken through structures and foundation. Ground mat shall be positioned right below the operating handle of the disconnect switch, visible at all times.

1.4.5.6.5 Installation of Current Transformer

- Current transformers shall be mounted on the steel supporting structure with secondary terminal boxes in pre-determined position so that cable can be conveniently taken without much bends and twisting.

- Interconnection wiring should be kept as short as possible, both for economy and to produce low burdens. The cable shall be taken neatly through suitable galvanised iron conduits to trench sections wherever required.
- Apart from general earthing, one terminal of the secondary of current transformers shall be earthed solidly through adequate section of solid copper conductor.

1.4.5.6.6 Installation of Lightning Arrestors

- The lead connecting lightning arrester with line should be direct without any splice or other joint and the connection should be effective to carry the lightning discharge currents.
- The lightning arrester shall be positioned in such a way that short and straight leads can be run from the earthing terminal of the arrester to the earth electrode specifically provided for this purpose.
- The arrester exhaust ports should be directed away from the equipment and other arresters.

1.4.5.6.7 Installation of Connecting Materials in Switch-yard

- The arrangement of connections shall be such that the connected apparatus are not subjected to any mechanical stress due to expansions, contractions etc... of the connections.
- The connections shall ensure good electrical contact. The connector and joints shall be rigid to withstand all mechanical and electrical stresses. Suitable bimetallic clamps shall be used for all the connections between the conductors of different materials.
- All live parts shall have sufficient practical clearances from earthed parts and ground. The clearances of strung busbar shall be decided considering the effect of sag. In applying clearance an allowance shall be made to cater for variation in making foundation and in the dimensions of structures and buildings.
- The contractor shall be responsible for supplying and installing the various conductors required for connection of the various equipment. The tenderer's scope shall include all bolts, nuts and washers required for installation. All connections etc..., shall be so made that stress between connecting terminals will be reduced to the minimum.

- The physical layout of the system shall be such that the system extension or conversion can be carried out with minimum changes and easy methods. Further, it shall be ensured that all civil works for the foundations are completed by the contractor before taking up erection of structure.

1.4.5.6.8 Installation of Grounding / Earthing

- Entire system shall be earthed in accordance with the provisions of the relevant IEC recommendations / IS code of practice IS 3043-1987 and Indian Electricity Rules, so that the values of the step and touch potentials in case of faults, are kept within safe permissible limits.
- The principal requirements of the grounding are:
 - a) Low resistance and adequate current carrying capacity.
 - b) Uniform and near uniform ground potential on all structural Metal work on all metal enclosures and / or supports of equipment and apparatus.
- The resistance of earthing network shall be less than 0.5 ohm for the network of outdoor yard under all conditions. The earthing network shall be as per actual site conditions.
- The contractor's scope of installation will also include all the civil work associated with complete earthing network.
- All earth connection shall ensure a permanent low resistance contact. Earth connections required to be removed for the purpose of testing of equipment / earthing network shall have bolted connection and joints fastened.
- All earthing connections shall be visible for inspection.
- Switch-yard fencing and all equipment located at switch-yard shall have two separate distinct earth connections.
- Structure parts shall not be used as a means of earthing.
- Lightning arresters and transformer neutrals shall be connected to two independent earth electrodes as per IS 3043.
- Air termination rods of lightning protection systems shall be connected to earthing network as per IS 3043.
- The grounding connection to the lightning arresters, air termination points of lightning protection system shall be as short as possible. Sharp turns in these

conductors shall be avoided.

- It has to be ensured that main earth bus in the installation as well as earth buses in individual sections / areas shall form complete ring and they shall be interconnected.
- Duplicate earthing (two separate and distinct connections with earth) shall be employed for all equipment.
- Wherever burying of earth conductors are specified, they shall be buried as per approved drawings.
- Wherever earth conductor crosses the road, it shall be taken through GI pipes.
- At all terminations of earth conductors on equipment, sufficient length shall be left for easy movement of the equipment from its position for alignment purposes.
- Wherever not detailed, the route of the conductor and location of the earth pit shall be arranged, so as to avoid obstructions, crossing etc..., according to convenience at site and shall be got approved by the KSEBL's representative in charge of the work.

1.4.5.6.8.1 Joints / Termination of Earth Strips

- All joints of bare galvanised earth strips shall be welded so as to form rigid earth ring. All such welded joints shall be given necessary coating of cold galvanised paint as per relevant standards and a coat of suitable bitumen compound to prevent corrosion. Welded joints shall form part of laying of earth conductors and they shall not be considered as terminations for payment purposes. No extra costs shall be applicable for joints of all the earth conductors.
- In case the joints are made by using suitable connectors the entire joint shall be fully sealed by suitable compound so that no metallic part is exposed.
- The contractor shall make his own arrangements for the necessary crimping tools, soldering equipment, drilling machines and other tools and tackles which are necessary for completing the installation.

1.4.5.6.9 Tools and Tackles for Erection & Commissioning

- The contractor shall provide all tools / tackles, jigs and fixtures, alignment tools, testing kits, testing meters / instruments, breaker, handling devices, all consumable items and construction equipment as required in installing the work, complete in all

respects and shall include but not be limited to bolts, nuts, rivets, welding rods, shims, wedges, packing sheets, packing compounds, oil, flushing oil, protective greases and oils, all materials required for proper installation and protection of individual equipment in storages, and during erection, testing and commissioning.

- This shall also cover proper alignment, tack welding, tagging, laying, marking of and connection of cables, fabrication, supply and installation of all support structures for installation of various electrical equipment and cables.
- Supply and installation of first aid boxes, shock treatment charts, rubber mats, keyboard.
- The rubber mats shall be provided in front of all control panels / switch-gears to comply with Indian Electricity Act.
- Erection, testing and commissioning of various equipment shall be done strictly as per manufacturer's instructions.
- All plant and equipment, the painting of which has been damaged during transportation / erection or by corrosion, shall be given two coats of paint after removal of scales, rust, oil etc...
- All iron frame work erected shall be provided with one under coat of primer and one top coat of finish paint.
- Cable shall be always laid in conduit up to 2 metre of height in case of vertical run to avoid mechanical damage.
- Cable shall be laid in separate racks according to voltage levels and between two cables horizontal clearance equal to diameter of cables shall be provided in the hooks.
- Maximum cross section areas of cable passing through conduit shall not exceed 60% of cross section of conduit.
- Approved type of danger boards, boards inscribing 'EARTHED', 'DO NOT CLOSE', 'MEN AT WORK' etc..., shall be provided in sufficient numbers.
- Special care shall be taken to make the enclosed equipment protected against entry of rats, lizard, and creeping reptiles which may create electrical short circuits.

1.4.5.6.10 Stages of Completion Works

The stages of completion of various works shall be as follows:

1.4.5.6.10.1 Completion of Erection

- Equipment shall be considered to be completely erected when the following activities have completed:
 - Moving of all equipment to the respective foundations.
 - Aligning the equipment.
 - Fixing of anchor bolts or tack welding as required.
 - Drying of equipment as required and testing of oil for dielectric strength.
 - Assembling of all accessories such as relays, CTs, PTs, meters, instruments etc... as described in job specification.
 - Filtration and filling of oil as required.
 - Cable laying termination with continuity checking.
 - Applying of finish coat of paint.
 - Completion of earthing system.
 - Removing of unwanted materials and covering of all openings including cable openings, conduits etc...
- In other words, erection shall be considered to be complete where the equipment is ready for testing with all other associated equipment required for commissioning. In this matter the opinion of KSEBL shall be final.

1.4.5.6.10.2 Completion of Testing

- Testing of equipment shall be considered as complete after the following operational tests:
 - Testing / Commissioning of all panels and equipment as specified.
 - Checking of all circuits / schemes for correct connections and continuity.
 - Reworking as required during testing and retesting.
 - Charging of the equipment

1.4.5.7 Tests

Tests shall be conducted on the following equipment:

- Power transformers / Auxiliary / Station service transformers.

- Circuit breakers.
- Surge arrestors.
- Instrument transformers.
- Isolators / Earth Switches.
- Switch-yard control, protection, and instrumentation equipment.
- Switch-yard auxiliary equipment.
- LT Switchboard / LT Systems / Battery & Battery chargers / DC Systems.
- Lighting Systems / Fire Fighting systems.
- PLC / SCADA / Communication Systems and its associated equipment.
- Earthing systems.
- Any other equipment as required by the KSEBL's site representative

The site tests as per relevant standards shall be conducted for all the switch-yard equipment.

The tests to be carried out on the equipment at pre-commissioning stage shall include but not limited to the following:

1.4.5.7.1 Circuit Breaker

- IR test on each pole by Meggar (Between poles and lower poles to ground).
- IR / Voltage tests on control and auxiliary circuits.
- Measurement of Pole resistance value (Measurement of resistance in the main circuit).
- Mechanical operating tests.
- Speed curves shall be obtained with the help of a suitable operation analyser to determine breaker contact movement during opening, closing, auto-reclosing and trip free operation under normal as well as limiting operating conditions (control voltage, pneumatic pressures etc...). The test shall show the speed of contacts at various stages of operation, travel of contacts, opening time, closing time, shortest time between separation and making of contacts at break make operation etc...
- Tests to measure the difference in the instants of closing / opening of contacts between poles. Check for closing and opening time and simultaneous closing of all

poles through oscillograph.

- Measurement of the capacitance.
- Functional check of breaker operation on minimum and maximum specified control voltages.
- Checking of interlocks with isolators & earthing switches.
- Measurement of contact resistance.
- Checking of operation and tripping of protection release.
- Checking tightness of termination connectors and earthing connections.
- Checking of insulators for cracks etc...
- Tripping of circuit breaker at reduced or over voltage i.e. at 60% & 110%.
- Checking of Gas pressure, Sealing and packing.
- Checking of leakage.

1.4.5.7.2 Isolator / Disconnecting Switches

- IR test by HV Meggar on main poles.
- IR test on control circuits.
- Measurement of contract resistance for all three phases.
- Functional checking for manual and electrical operations.
- Checking of interlocking with earth switch.
- Checking of earth switch operation.
- Checking tightness of main connections.
- Checking tightness of earthing connections.
- Checking of insulators for cracks.

1.4.5.7.3 Lightning Arrester

- Continuity check (for metal oxide type only).
- Check for connection to ground.
- Check insulators for cracks.

- HT and IR test of each element.
- Check reading of leakage current.

1.4.5.7.4 Current Transformer

- IR test on each winding, winding to earth and between windings.
- Checking of winding ratios by primary injections set.
- Polarity check on each winding.
- Continuity check for all windings.
- Check for connections to correct taps.
- Checking of oil level.
- Checking of continuity and IR values for cables from CT to Marsh Box.
- Checking tightness of earthing connections.
- Checking of insulator for cracks.
- Check output after loading of the main circuit.

1.4.5.7.5 Potential Transformer

- IR test on each winding, winding to earth and between windings.
- Polarity check on each winding.
- Continuity check for all windings.
- Turns ratio test.
- Check for connections to correct taps.
- Checking of oil level.
- Checking tightness of earthing connections.
- Checking of insulator for cracks.

1.4.5.7.6 Power Transformer

- Checking of ratio, polarity and phase relationship. The ratio shall be checked on all taps and between all the windings and the results should tally with the supplier's test report. Polarity, vector group and inter-phase connections shall be checked and

verified.

- Resistance of winding on all tap positions shall be measured with the use of Kelvin bridge meter.
- IR values between windings and between winding to earth shall be checked.
- Magnetising current and iron loss should be measured and compared with the values obtained during test at supplier's works.
- Operation of tap changer shall be checked.
- Buchholz relay mounting position, operation etc... should be checked. Testing of buchhloz relay for alarm and trip conditions.
- Setting / Operation of Magnetic oil level gauge shall be checked.
- Setting / Working of oil / winding temperature indicator shall be checked (checking of alarm / trip circuits).
- Check oil pumps (if any), cooling systems etc...
- Check wiring from various accessories to marshalling box.
- Check oil sample both from top and bottom of the tank, selector switch tank on tap changer etc... (BDV test).
- Temperature rise test with maximum possible load carried out at the tapping with the highest load losses.
- Sweep Frequency Response Analysis (SFRA) Test shall be carried out on 220kV transformers during pre-commissioning at site. The values / data shall be furnished to the KSEBL for future reference.
- Measurement of winding group test.
- IR, wiring and operational tests on all control devices in control cabinet oil level indicator, winding and oil temperature indicators etc...
- Checking of earthing of transformer tank (flexible from top cover to tank) other parts, neutrals.
- Check insulators for cracks.
- Checking for oil leakage and arresting of leakages (if observed).
- Checking for open position of all the valves (except drain and filter valves).
- Filtrations of oil by using line filter, vacuum pump, and heater set.

- Measurement of PI Value.
- Checking of silica-gel breather.
- Checking of other points given in manufacturer's commissioning manual.

1.4.5.7.7 Insulators

- Check tightness of connections.
- Check for minor damage / cracks after cleaning.
- Check IR value using Meggar.
- Verification of number of disks as per drawings.
- Check, heating at termination point during shut down.

1.4.5.7.8 ACSR Conductor

- Check for continuity.
- Check for tightness of connections for all the termination points.
- Check for phase sequence marking and for their correctness.
- Physical verification.

1.4.5.7.9 Earthing

- Check tightness of all each connections.
- Check earthing of all metallic equipment, busbar supporting structures, yard fencing steel structures of yard, rails, gates, building column (if steel) all electrical equipment, water pipe lines etc... as per the drawing / specification.
- Measurement of earth resistance for each electrode.
- Measurement of total earth resistance.

1.4.5.7.10 Lightning Protection

- Check continuity of all the earth strips / shield wire.
- Check tightness of all connections.
- Measure earth resistance of each electrode and combined system.

1.4.5.7.11 Miscellaneous

- Checking continuity of the system.
- Checking of phase sequence from overhead line to consumer end.
- Checking safe accessibility of all operating points.
- Check availability of control / auxiliary supply.

The Contractor shall submit all the test reports for KSEBL's approval. If the test result of any equipment is not acceptable to KSEBL, the Contractor shall re-test the equipment after making necessary corrections / modifications, or replacement of the equipment or its parts at his expense. Finally, all the tests and certificates are to be signed by the KSEBL's Engineer.

2 PART-2 SPECIFIC REQUIREMENTS

2.1 General Requirements

2.1.1 Introduction

This section covers KSEBL's specific technical conditions and requirements for the project. The scope of this specification include responsibility for complete design, detailed engineering, equipment and components fabrication and inspection at manufacturers works, supply, installation of supplied equipment / items at site, all civil works to install the equipment / components supplied, site testing, commissioning, provision of necessary assistance for site testing, commissioning of equipment / components supplied, reliability and warranty confirmation of Mechanical, Electrical, Control, Protection, Instrumentation and Automation system etc... for the plants supplied.

It is not intended here to describe the design, arrangement or installation, or to specify each and every component required for the completeness of the plants or to select each material for safe and reliable operation of the proposed plants / equipment. In general the plant shall be complete in all respect with its equipment and accessories as required to make a complete, highly reliable and maintainable installation, conforming to the highest standards of engineering design, safety and workmanship and in conformity with the existing powerhouse structure and retained turbine header / manifold / distributor.

Every component required for the completeness of the plants / equipment and suitable material required for safe and reliable operation of the proposed plants / equipment is deemed to be included.

The layouts and arrangements shown are indicative and are to be considered as the minimum requirement. The final layout shall be that proposed by the Contractor and approved by the KSEBL.

The bidder should ensure supply of machines to suit the existing layout of Powerhouse building. Being a renovation project, the bidders are advised to carry-out a site inspection to ascertain the suitability of their proposed equipment with the pre-existing / retained systems in place.

The Contractor shall strictly observe the Specific requirements detailed out in the following sections in conjunction with the general requirements given in various sections of **Part-1** of this Specification.

2.1.2 General

The capacities, ratings, sizes, quantities and materials specified in Common Technical specifications – Part-1 and in this specification are to be considered as the minimum requirements to be provided. It is the responsibility of the Contractor / Manufacturer to determine the required capacities, rating, sizes and quantities and select the appropriate material based on the guidelines given in the following specifications.

If the evaluated requirements are higher than the minimum requirements, specified in Part-1 and the following specifications, then the evaluated capacity / rating / size / quantities for the equipment shall be provided. If the evaluated requirements are less than the minimum requirements, then the minimum requirements shall be complied with.

If any discrepancy is observed in capacities, ratings, sizes, quantities and materials specified in Technical specifications – Part-1 and in the following specifications, then the requirements given in this specification shall prevail. In case of any specific doubts or issues, clarifications shall be obtained from the KSEBL before proceeding.

The requirements / ratings indicated in the specifications are the required minimum for giving a base line for tendering purpose only. This aspect shall be considered by the Bidder while quoting and the Bidder should ensure that the ratings of the various equipment offered are sufficient to take care of the design requirements of the systems / components offered for the concerned project. Any increase in rating during detailed engineering stage will not entitle the Successful Bidder / Contractor for any extra charges. The Contractor should submit for approval the calculations for arriving at the ratings of the various equipment during detailed engineering and in conformity with the existing powerhouse structure and retained turbine header / manifold / distributor.

The work of this Section is integral with the whole of the contract documents and is not intended to be interpreted outside the context.

Contractor's responsibility with respect to the turnkey-bid is for the erection, test-run, commissioning and handing over of the power station to KSEBL. It shall be the responsibility of the Contractor to see that the power generated from the Units can be fed to the grid, without disturbance to the present system. Further the power generated shall be compatible with the present system in all respects.

The complete earthing of station and equipment are in the scope of the contractor. The cost of earthing is assumed to be included in the cost of respective equipment.

2.1.3 Scope of Supply

The scope of supply shall be as per, but not limited, to the following:

- Three (3) Spherical type Main Inlet Valves and their auxiliaries / controls.
- Three (3) Vertical Pelton Turbine and its auxiliaries / controls except for the embedded retained turbine header / spiral casing.
- Three (3) Refurbishment of the embedded retained turbine header / manifold / distributor.
- One (1) Spare Pelton Turbine Runner.
- Three (3) set (4 jet / unit) of Needle injector assembly, Deflector servomotor & knives and servomotor to suit new governor including needle, throat rings, packing, self lubricating bushes, etc...
- One (1) Spare Jet Assembly and Deflector assembly.
- Three (3) Electro-hydraulic turbine governor system complete with all accessories.
- Three (3) Generator, Neutral Grounding Cubicles, LAVT Panels etc...
- Three (3) Static excitation system complete including dry indoor type excitation transformers etc...
- One (1) Spare dry indoor type excitation transformer.
- Three (3) Unit dry indoor type auxiliary transformers.
- One (1) Spare dry indoor type auxiliary transformer.
- Segregated Phase Bus ducts / MV cable systems.
- LV Systems, Battery charger & DC system, Emergency Power systems, UPS, Switch boards etc...
- Static Excitation equipment.
- Synchronising equipment.
- Protection and Control equipment for Generators, Transformers (GT, UAT, SST & Power Transformers), Feeders, Switch-yard equipment etc...
- Automation System (DCS / SCADA) covering entire power house (3+3=6 machines) and Switch-yard Equipment.
- Annunciation systems.

- Cable Tray work, cabling system for Powerhouse and Switch-yard (including Power, Control, Signalling, Instrumentation, SCADA, Communication system, Fire Protection, Air-conditioning and Ventilation etc...) complete with cable terminations, cable glands and lugs etc...
- Low voltage switchgear panels.
- Fire detection and Protection systems for Generator, Generator Transformer, Powerhouse, Switch-yard etc...
- Above ground Earthing system.
- Local control panel for auxiliaries.
- Control & Relay panels.
- HT / LT Motors.
- Cooling Water system complete.
- Compressed Air system complete.
- Oil handling system complete.
- Air-Conditioning and Ventilation systems.
- Lightning Protection systems. (Lightning Protection system of powerhouse only)
- General Power and Lighting systems for Power house, Switch-yard etc...

Control and instrumentation cables are required for 3x25 MW machines & switchyard and SCADA cables are required for 3x50 MW machines for interfacing with new SCADA. As 3x50 MW machines are already automated using PLC / DCS systems interfacing of this systems with new SCADA system is required to operate all machines from the new SCADA system, as only a single common control room is intended for the station.

The approximate quantity required is given in Schedules A1 and A2 – Price Schedule for Supply & Services (BoQ1 & BoQ2), attached with the Contract documents.

The bidder should supply machines to suit the existing powerhouse building and embedded retained turbine header / spiral casing.

2.1.3.1

All the E & M components shall be procured only from reputed manufacturers / companies approved by the KSEBL. For this the equipment shall be sourced only from a Vendor / Manufacturers list submitted by the Contractor and approved by the

Engineer-in-Charge or his representative prior to the start of procurement actions. The Vendor list should clearly mention the equipment details and complete address of the Vendor / manufacturer etc... Complete credentials including brochures / catalogue etc... of the Vendor / Manufacturer and their product / equipment etc... shall be also submitted for the approval process.

2.1.3.2

The bidder shall source the Governing System, Excitation System, Protection System and Control System including PLC / DCS / SCADA from reputed indigenous vendors. These vendors shall have satisfactorily carried out commissioning and after sales service including supply of spares from India for at least last seven (7) years as on date of bidding. The bidders shall clearly specify the proposed vendors for each of these items in the Schedule of Technical Particulars and approval of the vendors shall be issued by KSEBL during detailed engineering only from the above list of vendors. Bidders shall not specify “Equivalent Make” in the list of vendors and it is made clear that bids having response in the list of vendors as “Equivalent Make” shall be treated as non-responsive bid. The proposed vendor for each of the above stated items should furnish an undertaking to depute the Service Engineer within 48 hours of reporting the defects by KSEBL after the Defects Liability Period. The details of experience of the vendor and undertaking as above shall be provided by the successful bidder at the time of vendor approval, failing which the vendor may not be approved.

2.1.4 Drawings and Design Data

2.1.4.1 Format of Drawings

2.1.4.1.1

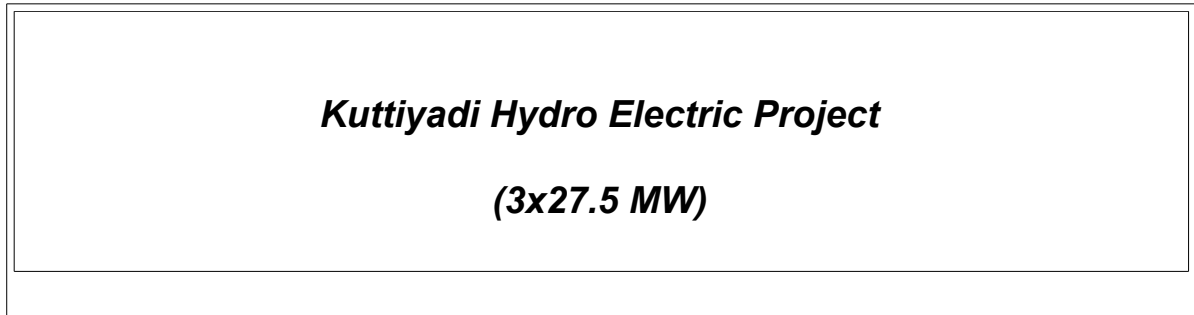
The drawings of the Work shall be ISO standard sheet sizes as indicated in Clause 1.1.13.9 of Part-1, with a left-hand border of 30 mm and all other borders 20 mm.

2.1.4.1.2

Drawings shall have the title block placed in the bottom right corner with a space of approximately 75 mm x 150 mm immediately above it for use by the KSEBL to indicate approval or otherwise.

2.1.4.1.3

The “Project Name” field of the title block shall prominently display the following information in the upper part of the block:

**2.1.4.1.4**

The title block shall also contain the drawing number and its title, the date and scale, serial number, revision no, issue and revision dates and the names of Contractor and KSEBL (“KERALA STATE ELECTRICITY BOARD LIMITED” with Logo / Emblem on the Left Hand side) shall be prominently displayed and shall be subject to approval by the KSEBL.

2.2 Specific Requirements – Powerhouse

2.2.1 Introduction

This section covers KSEBL's specific technical conditions and requirements for the various equipment in the **3 x 27.5 MW Kuttiyadi Power House**. Renovate, Modernize, Uprate and place in service the following items and systems of the plant.

2.2.2 Mechanical Equipment in Powerhouse

2.2.2.1 Main Inlet Valve and Auxiliaries

Three sets of Inlet Valve including all instrumentation and protection devices such as position & pressure indicating switches etc... Upstream & downstream seals, all packing, pressure piping, lubricating points, piping, servomotor system for opening and closing, automatic valve control system which can be operated locally from the turbine floor and remotely from the control desk in the control system, pressure piping, valves for oil and water, bypass valve one manually operated and one hydraulically operated with new piping from the upstream to the downstream side, local and remote automatic controls from turbine floor and control room complete. Penstock drain valve with piping shall be provided.

The main inlet valves of the turbines shall be Spherical valve type as per Section 1.2 of Part-1, suitable for Gross Head and discharge required for over load capacity of the turbine / generator and connecting to the existing penstock and retained spiral casing / turbine header / distributor piping. These Valves shall be provided upstream of each turbine inlet replacing the existing valves so that the units can be isolated for maintenance. These valves shall be operated automatically and shall be suitable for all operating conditions of transient and maximum water hammer.

All associated equipment such as servomotors, oil pressure units, counterweights etc..., shall be included in the offer. The valve shall close automatically under normal and emergency shut down conditions. The valve will be complete with inlet pipe, outlet pipe, with expansion joint, by-pass arrangement, required for equalization of pressure on either side of the valve, etc... The valves shall normally be opened in balance conditions. Opening and closing time of the valves shall be designed by the Contractor to suit operational parameters of the system. Provision shall be made to drain penstock upstream and downstream of each valve.

Operating servomotors shall be sized for opening the valve with minimum system oil

pressure. The closing mechanism shall close the valve under the most adverse combination of hydraulic torque on valve rotor due to emergency closure at maximum turbine discharge. Oil-N₂ pressure accumulator shall be of sufficient capacity for one opening and two closing (C-O-C) minimum without recharging of the tanks.

The Contractor shall ensure that the diameter and other relevant requirements of the valve are suitable for the Penstock to be connected to it.

The control of MIV shall be **fail-safe mode**. Replacement of air release valve with latest technology having features of auto operation to decompress the pressure line and its piping has to be incorporated. New duplex filters to be supplied for feeding to high pressure water servomotors / service seal for operation of valve. Self lubricating bushes is preferred for tunnings. Separate panel for service seal and maintenance seal to be provided for valves.

The valves shall normally be opened in balance conditions. The valve operating mechanism shall consist of oil / water operated servomotor. The valve shall be opened by pressure oil against counter weight and closed by penstock water pressure. The valves shall be operated with a fail-safe mechanism. The servomotor shall be double acting, one side with oil pressure and other side with penstock water pressure. The valve shall be opened by applying oil pressure against counter weight / penstock water pressure in the servomotor. In the case of oil pressure failure, the valve will automatically close with counter weight / penstock water pressure, without waiting for any external command.

Note:- Closing by counter weight mechanism is not possible due to space restriction, and hence MIV opening / closing shall be either oil / water or water / water only ensuring failsafe operation.

Float switches are to be provided to sense the flooding and initiate MIV closing. This is for avoiding flooding at MIV pit.

2.2.2.2 Turbines

Three sets of Vertical shaft 4 jet Impulse Turbines (Pelton Wheel) of capacity suitable to generate generator output of 27.5 MW + 10% COL complete (with bearing) compatible for housing in existing turbine header / spiral casing / distributor piping & runner pit and with mechanical over-speed device attached to the turbine shaft to directly close nozzles and main inlet valve regardless of the governor function, including re-engineering. The weighted average efficiency of turbine is expected to be greater than 91%. The rated speed of the machine is 600 rpm with clockwise rotation when viewed from Non-Drive. One number spare runner also shall be supplied.

Operation of nozzle and deflector shall be fail safe mode. Closing of deflector should work under spring force and closing of needle should work under both spring force as well as penstock water pressure. Opening of nozzle and deflector should be by using oil pressure against spring force / water pressure. Contactless linear position transducers may be used for accurate needle and deflector position feedback. Limit switches shall be provided to get the feedback of complete opening and closing of deflector and needle. Pressure accumulator shall be provided with Nitrogen bladder.

A tail race level monitor shall be installed with alarm and tripping facility. Also flood level indication float switches shall be provided.

For the guide bearing, sufficient numbers of temperature sensors and scanners shall be provided. Digital vibration monitoring system shall be installed for the machine for real time measurement of shaft and bracket vibration with alarms and tripping facility. Separate vibration monitoring panels and provision for integrating with the central SCADA system shall be provided.

2.2.2.2.1 Turbine Characteristics

Each turbine shall be capable of producing 27.5MW at the generator terminals when operating under rated net head with nozzle opening of about 80-85 %. The turbine shall have adequate capacity commensurate with the 10 % continuous overload capacity of the generators. The turbine would have output higher than the rated output when operating at heads higher than the rated head. The supplier may offer his nearest standard design. The maximum output both at maximum and minimum heads shall be stated in the offer.

The Turbines shall have the rating as follows:

Type	=	Vertical Shaft single runner 4 jet Impulse Turbine (Pelton Wheel).
Rated output	=	Suitable to produce 27.5 MW+10% COL at the Generator Terminals.
Rated weighted average efficiency	=	91.0% (Minimum).
Frequency	=	50 Hz.
Synchronous speed	=	600 rpm.

The details of the hydraulic system and basic data for design of turbines are given below:

Max Gross Head	=	666.2928 m. (2186 ft)

Average Net Head	=	643.128 m. (2110 ft)
Maximum Net Head	=	662.0256m. (2172 ft)
Minimum Net Head	=	609.60 m. (2000 ft)
Discharge at rated output	=	4.87 m ³ /sec. (171.96 ft ³ /sec.)
Discharge at Maximum Net Head	=	4.94 m ³ /sec. (174.33 ft ³ /sec.)
Diameter of main penstock (External)	=	2000 mm upto anchor 6 and then 1900 mm.
Length of main penstock	=	2065 m from BFV to trifurcation.
Diameter of each feeder penstock	=	1000 mm.
Length of each feeder penstock	=	45 m (approx.)

(Average Net Head given above is design figure. The head loss due to ageing and other factors in the water conducting system shall be taken care of while designing the turbine. More over, total capacity of the station (operating at full load (3x27.5MW) shall be ensured by the contractor. *All the three machines shall be able to operate at its full capacity simultaneously*). The Contractor shall decide the actual head after giving due allowance to the losses in tunnel and penstocks. The specific speed of the turbine shall be as per the best modern practice and of proven design and operation).

2.2.2.2.2 Needle Injector Assembly & Servomotor

Three sets - Replace the existing needle injector assembly complete with deflector assembly with new Needle injector assembly, Needle servomotors, Deflector servomotor & knives and servomotor to suit new governor including needle, throat rings, packing, self lubricating bushes, etc... (4 jets / unit) to suit the retained embedded turbine header / spiral casing / distributor piping. Servomotor feedback arrangements for needles shall be externally provided for easy access and maintenance.

2.2.2.2.3 Turbine Housing, Runner Pit, Distribution Pipes etc...

Three sets – Refurbish turbine housing and embedded distribution pipes. Replace the existing checker plates and supports inside the runner pit cover including cost of materials.

2.2.2.2.4 Impulse Runner

Four sets (including 1 spare) - Replace turbine runner with high efficiency statically balanced 13-4 Cr-Ni stainless steel impulse runner having integrally cast buckets to suit the

existing turbine housing and to give 27.5 MW + 10% COL at generator terminals.

2.2.2.2.5 Rails for Runner removal

Three sets – Replace the rails at the bottom of the runner pit including fixing, alignment etc... for runner removing including cost of materials. Equipment for dismantling runner also to be supplied.

2.2.2.2.6 Turbine Shaft

Three sets - The runner shall be connected to the shaft by through bolts and nuts and proper locking arrangement. Jacking screws shall be provided to separate the runner from shaft during dismantling of runner. A single forged steel shaft with integrally forged coupling flanges at top and bottom for connecting to generator shaft and runner, skirt for guide bearing with coupling bolts and guard and stainless steel sleeve where shaft passes through shaft gland, to suit the higher torque, higher axial water thrust, higher runaway speed etc... on account of uprated capacity shall be provided.

2.2.2.2.7 Guide Bearing

Three sets - The bearing shall be capable of being operated continuously without damage, at any speed from rated speed to runaway speed. The normal bearing temperature at rated output shall not exceed 60 °C. The maximum temperature of the bearing shall not exceed 70 °C. Oil for the first filling of bearings including 10% extra shall be provided.

The bearing oil coolers shall be external heat exchanger type.

Sufficient numbers of temperature sensors and scanners shall be provided. Digital vibration monitoring system shall be installed for the machine for real time measurement of shaft and bracket vibration with alarms and tripping facility. Separate vibration monitoring panels and provision for integrating with the central SCADA system shall be provided.

2.2.2.2.8 Self-Lubricating System

Three sets – Provide new self-lubricating system.

2.2.2.2.9 Brake Jet Valve

Remove the existing brake jet valve assembly and plug-in the penstock. (Replacement is not required).

2.2.2.2.10 Vibration monitoring Device & Water Flow Measurement

Three sets – Vibration monitoring device for continuous vibration monitoring (both shaft and bracket vibrations) and water flow measuring device for measurement of water flow through turbine (preferably Ultra-sonic type and shall be mounted on downstream side of MIV on each machine) shall be provided.

2.2.2.2.11 Mechanical Over-speed Tripping

Three sets – Provide mechanical over-speed tripping device to the turbine shaft to directly close needles, jet deflectors and main inlet valve regardless of the governor function.

2.2.2.2.12 Monitoring, Control and Protection

Provide fresh feedback monitoring, control and protection devices on turbine side.

2.2.2.3 Governors

Three sets – Supply of Governor with panels, oil sump, pressure accumulator etc... and installing modern digital type Electro-hydraulic turbine governors with all accessories having main components like redundant having hot standby feature Digital Turbine Controller, Hydraulic Control Unit, Oil Pressure System, Accumulator System, Servomotors etc... with provision for manual, local and remote starting and stopping. The scope include online oil filtering system etc... LVDH (low vacuum De hydrated) type filter machine. The governors are installed to control the speed of the units during the start up and synchronizing sequences. The governors are also used for controlling the speed during the normal running / operation of units to meet the variation of load.

The governing system shall be complete with all necessary devices for complete automatic and remote control, synchronizing, load / frequency control, start / stop, emergency stop etc... Remote control will be from control room in the powerhouse. Partial control such as gate limit, speed and load adjustment, manual operation before synchronizing shall also be possible from unit control of the unit.

Governor shall be capable of supplying sufficient oil to servomotor for operating of nozzles. The governor oil pressure system shall be designed for three operations such as closing, opening and automatic closing of nozzles in case of failure of oil pumping system.

The normal pressure of operation of the system shall not be less than 50kg/cm². The speed signal for the governor and speed switches shall be derived from the device mounted on the shaft.

Each governor shall be provided with a nitrogen pressure accumulator tank of sufficient capacity so that two closing and one opening operation can be done without recharging of the tank. Various instruments / devices, safety valves, blow off valves, pressure gauges / level gauge / switches for automatic replenishing shall be provided.

The electronic regulating functions of governor i.e., speed setting, nozzle limit setting, start, stop, main circuit breaker position, shutdown etc... shall be available to operate while the unit is in manual mode in case governor electronic regulator is non-operative.

Means shall be provided for the independent adjustment of the opening and closing times of the nozzles. The time for nozzle closing under full load throw off shall be adjustable to limit the speed rise and pressure rise within guaranteed values.

The scope includes complete replacement of the turbine governing system including the replacement of the nozzles and its servomotors. Hence the renovation work includes the dismantling of the existing nozzles along with the servomotors from the distributor flanges, dismantling of governor panel, air pressure and oil pressure systems, electro hydraulic transducers, all the associated piping etc...

Operation of nozzle and deflector shall be fail safe mode. Closing of deflector should work under spring force and closing of needle should work under both spring force as well as penstock water pressure. Opening of nozzle and deflector should be by using oil pressure against spring force / water pressure. Contactless / encoder linear position transducers may be used for accurate needle and deflector position feedback. Limit switches shall be provided to get the feedback of complete opening and closing of deflector and needle. Pressure accumulator shall be provided with Nitrogen bladder / Piston type arrangement depending on the design pressure. OPU system has to be provided with redundant Oil Pump-Motor having bumpless changeover. The oil volume and pressure of governor OPU system shall be sufficient to perform 3 full operation of the servo motor. Online oil filtering system has to be provided. A single common LVDH (Low Vacuum De hydrated) type filter machine shall be provided.

Modern digital type electro hydraulic turbine governor with all related accessories like programmable controllers, micro processors, hydraulic control units, electro hydraulic transducers, load frequency control etc... shall be installed. The installed governor shall be using advanced microprocessors and updated software versions available as on date of installation and should be of a make with proven successful operation record in similar hydro power houses. A reliable power supply shall be provided for powering the governor electronic circuits. The power supply for the governor shall be from two independent DC

station battery source (110 V), one as primary and other as secondary. Switch-over from primary to secondary will follow automatically on failure of primary and return to the primary source automatically following restoration of primary supply. The power supply shall include redundant converter (DC-DC) connected to station battery sources such that failure of any regulated output voltage shall cause instantaneous transfer to a redundant converter without affecting normal governor operation in any way. Contacts shall be provided to alarm on power supply failure and local indication shall be provided to identify the failed functional block. The Contractor shall provide full details of the proposed power supply system for approval by the KSEBL. The governing system shall be immune from false operation or failure from high voltage, high frequency transients that may be induced in the control circuitry and power supplies internal and external to the governor system. To reduce the transients coupled from external sources, shielded cables shall be used for connection to the external equipment and surge suppression devices shall be installed on inductive devices. Special precautions shall be taken to limit exposure of sensitive governor electronic circuits connected to remote equipment. These circuits shall be isolated by means of solid state optically coupled or transformer coupled isolation amplifier. All inductive devices, such as relays and solenoids shall be provided with suppression devices to limit surge voltages that may be generated when the coil circuits are interrupted. The governing system shall be designed and tested for surge withstanding capability in accordance with applicable ANSI/IEEE Standard. The governing system shall be designed and tested to be insensitive and immune to radiated high frequency interference such as that coupled from portable radio transmitters.

The governor shall have the facility to operate in load control / nozzle opening control mode, Restricted Governor Mode (RGMO) and Free Governor Mode (FGMO) of operation and the response shall be conforming to prevailing regulations. There shall be provision for charging the generator to dead bus. The governor shall have a dedicated processing unit with redundancy other than that of SCADA / DCS system processor but shall be made configurable from the main SCADA system. Real time governing parameters and process values shall be made available at SCADA. The parameters of the governing system shall be made configurable through computer interface / terminal. The configuration software with key if any (3 copies), communication cables and necessary hardware (laptop / desktop) shall be supplied. Hardware locks shall be avoided. The jet selection and governor control shall be capable of both auto and manual mode. (Jet selection depending on load changes to be finalised during detailed engineering). The software for the digital governor shall be capable of quick programme running. In case of any power supply failure,

the programme and parameters shall remain indefinitely retained. The governor shall have auto test programme for checking permanently for correct operation of the main governor components. The correct execution of the software shall also be permanently checked for which suitable self-monitoring and diagnostic features / Watchdog functions shall be provided. The digital governor shall be 100% hot redundant and have modular construction with suitable configuration to enable quick and easy maintenance / replacement in case of faults. The maintenance operation of the digital governor shall be feasible by use of an automatic internal checking programme and also step by step manual internal checking programme with the help of instruction manual. Adequate number of test points on the front face of each card for an easy detailed analysis of each sub-assembly shall be provided.

The present Permanent Magnet Generator (PMG) shall be replaced with a suitable Speed Signal Generator (SSG) to effectively measure the speed / frequency of the units to control the operation of speed switches for the smooth control of the start-stop sequences as well as the speed load characteristics of the generating unit. Speed sensing shall also be provided by using PT Signal (V to F converter). A suitable creep detector shall be incorporated.

The governor control panel with all indication and local controls is to be provided at turbine floor. All necessary indications to be made available on unit panel in generator floor. Interactive touch Display unit (HMI) shall be provided at Generator floor / Turbine floor for each machine. All controls shall use DC voltage at 110 V.

The governing system should have provision for recording and displaying generator and governor parameters like voltage, current, MW, MVAR, frequency, power factor, needle and deflector positions, oil pressure etc... in real time with numerical and graphical display. Turbine Discharge monitor shall also be installed.

Mandatory spares: 10% spares for every hardware component / module with minimum of one number of each.

Note: Combined OPU for MIV and Governor is totally un-acceptable. Hence separate OPU to be supplied.

2.2.3 Electrical Equipment in Powerhouse

2.2.3.1 Generators

- Three (3) Synchronous Generators, direct driven, Vertical Shaft complete with stator, rotor, shaft, thrust and guide bearings, generator instruments, safety devices

etc...

- Three (3) sets CO₂ fire protection systems.
- Three (3) sets brakes complete with air compressor, piping, valves etc..., for braking, brake dust collection system etc...
- Three (3) sets of thrust and guide bearing complete with oil pump, piping, valves etc... including High Pressure Oil lubricating System for lubrication of the thrust bearing pads at the time of starting / stopping / during alignment check, irrespective of type of design of thrust pads.
- Three (3) sets sole plates, foundation bolts, anchor plates etc... required for proper erection, levelling and alignment of the generators and their components.
- All special tools and devices for handling, assembly, installation, erection, maintenance, dismantling and testing of the generators and auxiliaries.
- Oil for the first filling of bearings including 10% extra.
- Any other item not specified above but necessary to complete the assembly, machining, erection, commissioning and testing of generators, excitation system and auxiliaries.
- Recommended spares for 5 years operation of the machines.

2.2.3.1.1 Type and Rating

The rating and other details of the generator are given below:

Type	- Vertical Shaft.
Generator voltage	- 11 kV $\pm$ 5%.
Frequency	- 50 Hz $\pm$ 3%.
Power factor	- 0.9.
No of Phases	- 3.
Rated continuous power	- 27.5 MW + 10% COL
Rated speed	- 600 rpm.
Direction of rotation	- Clock-wise when viewed from Non-Drive end.
Range of voltage variation between Phases, for Rated output	- $\pm$ 5%.

Range of frequency variation	- $\pm 3\%$.
Short circuit ratio	- Not less than 0.8.
Inertia constant	- Not less than 1.0.
Stator winding connection	- Star.
Stator winding temperature rise (Max.)	- 90°C .
Rotor winding temperature rise (Max.)	- 90°C .

The 27.5 MW Vertical shaft Synchronous Generator shall be capable of delivering a guaranteed rated output of 30.56 MVA continuously and maximum output of 33.61 MVA at the terminals, at power factor 0.9, rated voltage 11 kV $\pm 5\%$ and frequency in the operating range 50 Hz $\pm 3\%$ without exceeding the temperature rise as specified above.

The generator manufacturer shall co-ordinate with the turbine supplier so that the turbine to be coupled to the generator is matched in respect of speed, runaway speed, Moment of inertia, overload capacities, coupling and other relevant requirements.

The rotor poles and stator coils shall be possible to be taken out or in without removal of the whole rotor and without disturbing UGB. The rotor pole shall be interchangeable. On-line shaft vibration monitoring system shall be provided near to all bearing. Also body vibration sensors shall be provided for generator. Sufficient working space for maintenance of bearings shall be ensured.

A High Pressure Oil Pumping system shall be provided. Adequately designed brake pads with suitable brake dust collection system shall be provided. A brake dust extraction system shall be provided for sucking and collection of brake dust produced during braking operation of unit. The brake dust collection unit shall have suitable collecting bins for collecting heavy dust and light dust collection shall be through properly designed fabric based filter. In addition to this rotor jacking facility shall be accompanied on the same system.

The carbon dust shall be prevented from entering the winding by providing a properly designed carbon dust extraction system for sucking and collection of carbon produced by the brushes and the dust duct shall be exhausted outside the powerhouse building to prevent pollution inside the powerhouse. Adequate provision shall be made for preventing oil or oil vapour from entering the generator cooling system. For this properly designed Oil vapour extraction and collection system is to be provided for upper guide bearing and lower guide bearing.

Provision shall be made to measure the partial discharge of each machine. The required adaptor shall be provided. One portable PD monitor and suitable calibrator and required accessories shall be supplied. A suitable shaft current detector with relay shall be provided and wired to give an alarm and to provide necessary control / trip functions and the same shall be time stamped in the SCADA system. The generator shaft shall be earthed through a brush to avoid leakage currents flowing into bearing pads. Creep detection system with necessary control functions shall be provided. Generator neutral shall be grounded through NGT with isolator.

All bearings shall be provided with oil level monitors, moisture detectors, water flow indicators, water pressure monitors etc...

The generator shall be provided with water cooled closed circuit air circulation type cooling system having sufficient surface air coolers. The coolers of generator stator and bearing shall be equipped with backwash facility.

The upper guide bearing oil coolers shall be plug-in type and lower guide bearing oil coolers shall be external heat exchanger type.

A self-weighing CO₂ based firefighting system shall be provided for each generator barrel. The system shall work automatically on occurrence of fire inside the generator barrel. The system should provide heat and smoke detectors and shall have dedicated control panel for each generator.

2.2.3.1.2 Generator Neutral Earthing

Neutral point of the star connected stator of each generator shall be grounded through a 11000/220V, single phase, dry type transformer with loading resistor of adequate rating connected across the secondary winding. Suitable terminal arrangement with neutral isolating switch shall be provided. The isolating switch shall be of manually operated type with external indication of position, and auxiliary switch with required number of contacts for interlock shall be provided. All the above neutral grounding equipment shall be housed in a drip proof enclosure. The generator ground protection should cover 100% of the stator winding.

2.2.3.2 Excitation System

Three (3) sets - Static Excitation System with Manual and Auto Channel as per Clause 1.3.4.6.2.1 shall be provided.

All controls, protection and operation of the equipment shall be either pneumatically or

electrically operated, suitable for operation through remote control panels and computerised control system located at the powerhouse control room. With rated AC supply voltage, the excitation system shall be capable of delivery continuously, with in rated temperature rise, any voltage from 0 to 110 percent of the field current required when the generator is operating at 105 percent of rated voltage, 110 percent rated load and rated power factor.

Static excitation system with Automatic Voltage Regulator (AVR) shall be used with redundant full wave fully controlled Thyristor bridges. 2 AVR + 2 MCR exciter scheme. Provision for both AC and DC field flashing should be provided. The excitation system shall have two 100% redundant Automatic Digital Voltage Regulator channels, say DVR1 and DVR2. Each channel has its own independent regulator and control system. Each channel DVR1 or DVR2 shall be capable of being selected as "on-duty" or "standby". Each channel shall have dedicated AVR and MCRs. Facility for automatic online change over from DVR1 to DVR2 and vice-versa shall be provided. Manual change over from one regulator to another shall also be possible from front panel. (Suppose DVR1 is having AVR1 and MCR1 and DVR2 is having AVR2 and MCR2. Then, automatic and manual changeover from AVR1 to AVR2, AVR1 to MCR1 and vice versa shall be possible with bump less operation.) There shall be 100% redundancy between each thyristor bridge and the channels. (If the thyristor bridges are named Thy1 and Thy2, any of AVR1, MCR1, AVR2 and MCR2 shall be capable of operating with any of the bridges Thy1 or Thy2.) There shall be separate firing circuit for each redundant bridge, so that the 100% redundancy of the bridges and DVRs is not affected by the failure in common firing circuit, pulse coupling transformer etc...

The exciter shall have Voltage control, PF control, VAR control modes of operation and all relevant limiters. Field discharge system using solid state switches may be incorporated. Appropriate devices for filtering / suppressing harmonics distortion are to be incorporated. The exciter shall have dedicated processing unit with redundancy other than that of SCADA / DCS system processor. Real time excitation parameters and process values shall be made available at SCADA.

The parameters of the excitation system shall be made configurable through computer interface / terminal. The configuration software and necessary cables shall be supplied. Hardware locks shall be avoided

Four numbers new exciter transformers (including one spare) adequately designed for the generating units shall be provided. The proposed excitation transformers shall be suitable to be used in the space available in the powerhouse.

Automatic voltage regulator shall have 2x100% auto channels and automatic changeover.

In the event of failure of auto channels, manual control shall be possible.

The excitation system shall be adequate to supply continuously 1.1 times the excitation voltage and current required by the generator at its maximum continuous output and 100% rated voltage and also for supplying twice the excitation current at its maximum continuous output and 110% rated voltage for duration of one minute.

The excitation system shall be immune from false operation or failure from high voltage, high frequency transients that may be conducted in the control circuitry and power supplies internal and external to the excitation system. To reduce the transients coupled from external sources, shielded cables shall be used for connection to the external equipment and surge suppression devices shall be installed on inductive devices. Special precautions shall be taken to limit exposure of sensitive excitation system electronic circuits connected to remote equipment.

Mandatory spares: 10% spares for every, with minimum of one number for all hardware component/module.

2.2.3.3 Control, Protection & Instrumentation

The scope of works under the current tender includes but not limited to the following:

1. Supply and installation of modern numeric relay incorporating unit control, protection, metering and instrumentation.
 - a) Three (3) sets - Generator control panels: Computerized Generator control panels with remote / local operation.
 - b) Three (3) sets - Turbine control panels: Computerised Turbine control panels in generator floor with remote / local operation.
 - c) Three (3) sets - Unit Vertical panels: Vertical panels such as Transformer protection panels, unit protection panels with modern automatic computerized control, supervision and protection device working on microprocessor based data acquisition and control system with remote / local operation.
 - d) One (1) set - A common annunciation panel: This common panel is for the annunciations from KHEP 3 units + KES 1 unit and KAES 2 units (totally for all 6 Units).
 - e) One (1) set - Temperature-measuring devices: Provide oil temperature, winding temperature-measuring devices for local and remote indications with annunciation and trip

- f) Three (3) sets - Unit Control desk: Control desk for units.
 - g) Three (3) sets - Provide instrumentation & protection for 35 MVA three phase transformers.
 - h) Three (3) sets - Provide new LAVT panel and NGR cubicle.
2. Control room SCADA: Installing microprocessor based automatic sequence equipment with auto synchronizer, one for each unit, one for common system along with man-machine interface process computers and Data Acquisition system for monitoring, control and protection with manual overriding provision incorporating PLC with 100% redundancy. Bidders may also offer a Programmable Automation Control (PAC), instead of PLC, if so desired. A common manual synchronizing panel to be provided. The signals from the existing DCS/PLC system shall be connected to proposed SCADA System, so that total monitoring and important controls of the entire power house is available at the main control room. The existing control for Gen#4 (KES) is by using GE Fanuc PLC series 90-30 and Gen#5&6 (KAES) is through Max DNA DCS system. The proposed SCADA system should be able to communicate with both this system so that all important controls and data of these machines are available in the proposed SCADA. It is proposed to operate all this six machines from the new control room through a single window in the proposed SCADA system.
- It shall be possible to communicate all relevant real-time data of the station to the State LDC and Back up LDC SCADA System. Remote Operations (Close / Open) from LDC shall be provided.
3. This SCADA system has to communicate with the proposed 220 kV GIS SCADA Systems.

PLC with SCADA control as detailed in 1.3.5.6.1.2 is intended for the station.

Required protection, metering, indication, control equipment & other devices as required by the specific design offered to complete the system in all respects.

This section covers the KSEBL's requirements for the 27.5 MW generating units as follows:

- Local Unit Control & Metering panels - 3 sets
- Unit Protection & Metering panels - 3 sets
- Local unit auxiliary control panels - 3 sets
- Control, metering & relaying panel for Generator Bays - 3 sets

• Remote Control & metering panel for AC auxiliary supplies	- 1 set
• Testing instruments	- 1 set
• Spares for 5 years maintenance	- 1 set
• Cabling system for control, protection, Metering and instrumentation	- As Required.

Any other item, not specified here, but essential for the satisfactory system operation.

2.2.3.3.1 Automatic Synchronizing Equipment

The automatic Synchronizing equipment (A common synchronising equipment with redundancy) shall be designed to permit automatic control of turbine speed, voltage and breaker closing for connection the generator to a running system with minimum disturbance to the machine or the system. The automatic synchronizer design shall include voltage acceptor, speed monitor, voltage monitor and synchronizing checking device.

2.2.3.3.2 Manual Synchronizing Equipment

In case the automatic synchronizer is out of order, the operator, using the manual synchronizing equipment, will synchronize the units. The manual synchronizing panel shall comprise of:

- Incoming and running voltmeter.
- Incoming and running frequency meter.
- Synchroscope with synchronizing lamps.
- Synchronizing pulse sent indication (Green) separately.
- Synchronizing check device with indication bypass switch.

2.2.3.3.3 Temperature Scanners

Temperature scanners and suitable printer shall be installed for stator windings, bearing temperatures and transformers including cables from temperature sensors. The scanners shall have two alarm settings for high temperature for each point adjustable over the entire range.

There shall be one scanner for each generating unit along with generator transformer. Each scanner shall have at least 32 channels. The scanners shall have a communication port for SCADA interface.

2.2.3.4 Computerized Supervisory Control and Data Acquisition System (SCADA)

The purpose of the computerized control system is to provide Supervision, Control And Data Acquisition for the three generating units of 27.5 MW +10% COL capacity (each), their associated transformers and auxiliaries, switch-yard including three Generator Transformers, four 110 kV feeders, valve house and common station auxiliaries from a single control location for automatic operation of the entire power plant in an efficient and cost effective way without compromising safety.

It is required to monitor, operate and control all the six machines, 4 feeders, transformers and auxiliaries from the SCADA System. Hence necessary systems, hardware and software for interfacing and integrating Machine#4, Machine#5 & 6, including annunciation panels etc... to be provided to achieve the same. The units 4, 5 & 6 will be operating from their available PLC / DCS units. But these PLC / DCS systems have to be interfaced with new SCADA system to provide an operational layer of control and monitoring from the new SCADA. The scope includes supply of SCADA software for the new machines which have drivers for control and monitoring of 4, 5 & 6 machines through their existing PLC / DCS systems. The interface with 4, 5 & 6 machines shall be able to do monitoring as well as supervisory control of these machines.

The SCADA system have to be provided for the entire power house which includes generators 1 to 6, their respective bays, 4 feeders and their bays, auxiliaries and 11 kV switchgear. Since gen#4, 5 & 6 and Vadakara-1&2 are having their own PLCs / DCS the field level control and sequence will be accomplished by these controllers. However the proposed SCADA software shall have the drivers for this PLC / DCS to form an interface so that controls, monitoring and logs are available in the new SCADA.

Most of the plant operations shall have state of the art control system with minimum operator intervention. All the operations shall be automatically controlled from the dedicated local SCADA / DCS .The SCADA system shall comprise of PLC / DPU units controlling various sections of the operations integrated to a common network with control centre computers with state of the art SCADA HMI software.

SCADA Control Centre shall comprise of the following equipment:

- i. Data Base Computers (DBC) in redundant server configuration. Each DBC shall be equipped with master database of SCADA and it shall be mirrored each other. Provision for modification in one shall be updated in the other one automatically.
- ii. Redundant servers connected to the redundant optic fibre Ethernet ring network.

- iii. Operator Workstations each with two sets of LED backlit monitors and all necessary accessories and software.
- iv. Fixed Engineering stations and diagnostic stations with all necessary accessories and software.
- v. Mobile engineering station with all necessary accessories and software.
- vi. Necessary networking hardware and software (Routers, gateways, switches, optic converters etc...)
- vii. Printers ,all necessary accessories and software.
- viii. Large Screen LED based Display with display controller acting as a video mimic.

State of the art DCS / PLC systems shall be used for machine control. The PLC / DCS used shall be of a make proven successful operation in similar hydro plant. Each functional block shall be controlled and monitored through a pair of redundant controllers. The programmable controllers / PLCs to be supplied shall be modular in architecture and microprocessor based design suitable for harsh industrial environments. All power supply cards, I/O module connections and other external interfaces shall be provided with suitable surge protection devices to protect the controllers and internal circuitry from external surges. Unless otherwise specified, the equipment shall be in compliance with IEC 61131 standard.

All PLC units used in the control and monitoring system shall be, of the same manufacturer and of the same product family. Interchangeability and inter-operability of PLCs used shall be established by the Contractor.

The power supply for PLC should be redundant. Input to the power supply should be from 110v DC station battery. Any DC DC converters used also should have hot redundant configuration.

For each type of PLC, the supply shall include all equipment and services for operating and maintenance, such as manufacturer's standard firmware, licensed PLC programming and debugging tools, test equipment, all software with license for use and source codes for the application programs, spare parts and full documentation along with training. Each PLC shall have long life internal battery backup / non-volatile memory for storing running data and programs. All software and firmware supplied must be of latest release / version.

All hardware and software required to make PLC program changes including mobile engineering station (Lap top) should be provided. All required operating system / control and SCADA in Six (6) sets should be supplied. Hard-ware keys will not be allowed.

All software supplied shall be of the latest version as on date of commissioning.

Appropriate comprehensive licenses for permanent use of the software shall be supplied for complete set of software before commissioning of the DCS / SCADA.

The control room is prone to vibration as a result of various equipment operating on different plant floors. The supplier shall use appropriate resilient mounts / anti-vibration pads / other suitable methods for eliminating vibration on DCS system panels and accessories. The vibration isolators shall also take care of low-frequency/high-frequency vibration of internal components and plugged in PCBs in the panels. The DCS vendor shall visit the control room and measure / collect all necessary data in this connection and shall ensure that the DCS and accessories supplied conform to the above requirements with respect to vibration. Audible Diagnostic alarms are required for all hardware and software failures in Operation stations. Status such as fan failure, temperatures etc... are to be displayed. Temperature monitoring RTDs are to be installed in all consoles and the same shall be made available in display.

System Loading of DCS / SCADA

Loading here refers to the use of memory, CPU time and communication capacity.

An on-line facility shall be provided to monitor the system loading and provide, as a minimum, average and peak loading figures for individual processors.

The loading shall consider the "worst case" of high system activity. Maximum loading on various sub-systems shall be as follows:

- 80% - I/O Capacity and other Hardware.
- 70% - Processor, including user memory.
- 70% - Communication network if deterministic.
- 15% - Communication network if non-deterministic.

The system design shall be such that there shall not be any degradation of system performance at the worst case of high system activity considering present and future requirements.

The vendor shall submit calculations to prove ability of system architecture and equipment to meet these requirements.

Vendor shall demonstrate the loading values during FAT and also at site. In case the system fails to conform to the above requirement, the vendor, at his cost, shall supply all the necessary additional / improved hardware and software and do the re-engineering to

meet these values.

The SCADA system shall use dual redundant fail safe Ethernet ring topology networks for communication between DPU / PLC and control center computers. The networks shall be designed for minimum 100 Mbps real time and full duplex (bi-directional) communications. The networks shall be configured using redundancy of servers, routers and switches, in dual ring switched Ethernet topology, to achieve high operational availability for top order events. The system availability shall analyze and calculations shall focus on availability of the control system for the top order event such as "Availability to retrieve all process data from UCB / LCBs and operate all breakers". The overall system unavailability shall be computed by considering individual device unavailability in a fault tree analysis using MTTR, MTTF and MTBF values of each device as supplied by its manufacturer.

Universal time synchronization system complete with redundant master clocks, at least Nine (9) Nos. of slave clocks, antenna and any other instrumentation / provisions required for time synchronization of all the equipment of the control system as well as protection system equipment, with Global Positioning System (GPS), so that each piece of equipment shall be synchronized individually. Method of clock synchronization with GPS clock reference shall preferably be IRIG-B.

It shall be the complete responsibility of the contractor to integrate the control and monitoring of Gen #1, #2 & #3, switch-yard equipment, 11 kV switch-gear and any other auxiliaries of the powerhouse and for integrating gen#4, gen#5 & gen#6 to the new SCADA system. The gen#4 has GE-fanuc PLC and gen#5 & 6 have MAX DNA DCS. The SCADA shall be able to communicate to this PLC / DCS. Also the screens for control and monitoring of all switch yard equipment, auxiliaries and all generators need to be provided on the new SCADA.

The SCADA / DCS software used shall be of a make proven successful in operation of similar capacity hydro power plants. The GUIs and various screens of the operator stations shall be designed according to KSEBL's requirement. Software along with necessary licenses, required for performing intended duties in an efficient manner, shall be provided in addition to the software explicitly specified for each individual equipment. The software shall be modular in structure, facilitating changes and extensions of the system. Complete literature including program listings in source language for application and customized application software shall be provided. All documentation and computer print-outs shall be in English only. All software shall comply with open system standards, shall make optimal use of CPU, main memory, and disk space, and shall not cause any problem for the operating systems.

The system shall be capable of providing various levels of access through password operated access control system such as “Viewer”, “Operator”, “Engineer” and “Administrator”.

All hardware and software required to make program changes including mobile engineering station (Lap top) should be provided. The software should be of latest version as on date of commissioning.

All required operating system / control and SCADA software with lifelong license in six (6) sets should be supplied. Hardware keys will not be allowed.

Six copies of all the control programmes and flow-charts connected with the system should be supplied in **pdf** format along with soft copy.

Contractor shall provide free upgrade for the all software's necessary for the entire system during defect liability / AMC period. The contractor shall inform KSEB Ltd any revisions and the details shall be made available to the KSEB Ltd on request. Even after defect liability / AMC period the contractor should be liable to supply the same on payment basis.

Also as part of contract the contractor shall extend their expertise for minor additions / modifications / configuration changes to the subsystems as and when required, for a period of three years defect liability. Such additions or changes shall be free of cost during this period. The contractor shall provide technical upgrades after this period on payment basis.

This Local SCADA System shall be capable of communicating all the relevant real time information of Generators, Transformers, Feeders to the State and Back up Load Despatch Centre (LDC) is required. Remote Operations (Close / Open) from LDC shall be provided. The Communication media between power house & State Load Despatch Centre and power house & Back-up Load Despatch Centre is already operational.

This Local SCADA System shall be integrated with KSEBL Central SCADA System which has main and back up servers at Kalamassery (State Load Despatch Centre) and Thiruvananthapuram (Back-up Load Despatch Centre) through communication channel provided by KSEBL in 60870-5-104 or latest protocol as per the station specific signal list.

The SCADA software used shall have provision for a secure web interface, which is able to run from a web browser on a PC / Mobile device over a secure private network. The Static IP for the same will be provided by the purchaser.

The design principles and general requirements for the system are given in Part-1 **“Common Technical Specification”**.

Mandatory spares: 10% spares for every, with minimum of one number for all hardware

component/module. This includes CPU cards, operator console hardware, auxiliary consoles, control station hardware, I/O system hardware, communication system hardware, network interface cards, power supplies, cables, racks, fans and all such accessories.

2.2.3.5 Segregated Phase Bus-duct

Three (3) sets - The existing three phase 11kV bus duct and bus bars shall be replaced with new segregated phase bus duct and bus bar having sufficient current carrying capacity. Manholes shall be provided at suitable locations for disconnecting bus bars. Connections to the new excitation transformers and unit auxiliary transformers shall be taken from these bus bars. All tapping points from the 11kV bus duct shall be perfectly sealed. Space heaters with control shall be provided to prevent moisture deposition and heat up the bus bars and its supporting insulators. Porcelain type supporting insulator shall be used. The bus duct shall be capable for mounting CTs having sufficient short circuit rating.

The segregate phase bus-duct (for each unit) shall comprise of:

- Bus ducts forming the main current carrying leads from the generator barrels to the Generator transformer for each 27.5 MW +10% COL unit.
- Bus ducts of suitable rating forming the current carrying leads for tap-off to the 500kVA unit auxiliary transformers.
- Bus ducts of suitable rating forming the current carrying leads for tap-off to the excitation transformers.
- Bus ducts of suitable rating forming tap-off and connection to the voltage transformer and surge protection cubicle (LAVT cubicle).
- Set of flexible isolating links for isolation of all tap-off ducts and generator terminals.
- Set of supporting structures, columns, frames, wall plates, hangers, mounting plates, hardware etc...
- Sets of items not specified above, but are necessary for the satisfactory operation of bus ducts.
- Set of voltage transformers and current transformers.
- All special devices, tools, testing equipment etc... required for installation, testing, commissioning and maintenance of the bus ducts.
- One set of spares required for 5 years of normal operation for each unit.

2.2.3.6 LAVT and NGT Cubicles

The supply & installation of new LAVT & NGR cubicle as per specification is in the scope of this contract. Any civil work in this regard for the equipment supplied by the contractor will be in the scope of the contract.

2.2.3.6.1 LAVT Cubicle

Two sets of draw-out type voltage transformers with two cores each for metering, protection and control with necessary protection, isolating facility and grounding devices shall be provided in the LAVT cubicle for each unit.

2.2.3.6.2 Neutral Grounding Cubicle

Neutral grounding cubicle shall be located on generator floor at the point where the generator 11kV terminals take off. The cubicle shall contain single-phase dry type transformers and loading resistor of appropriate rating to carry generator neutral current and also one manually operated suitable rated disconnection switch.

2.2.3.7 Bus Protection Panel

One Bus Protection Panel shall be installed.

2.2.4 Auxiliary Electrical Equipment

2.2.4.1 Station Power Supply System

The station power supply system shall comprise of the following equipment:

- One (1) No. 11kV/433V, 3-phase, outdoor type, two winding 500kVA Station Service Transformer (SST). **The SST is not in the scope of supply under this contract.**
- One (1) No. 415V main station service board for the powerhouse with incomers from SST and sufficient outlets.
- Three (3) 415V Unit auxiliary boards for machines.
- Four (4) 11kV/433V, 3-phase, dry type, indoor, two winding 500kVA UATs (including one spare).

All the station service and auxiliaries will be suitable for operation with 415V, 3 phase, 4 wire, 50Hz or Single-phase 230V AC system. The AC supply requirement of unit auxiliaries, powerhouse, switch-yard etc... shall be met by Station Service Transformer.

There shall be 7 incomer ACBs, from UAT1, UAT2, UAT3, UNIT 4, DG, Emergency & SST

and one bus coupler ACB. All incomer and bus coupler ACBs shall be of 4 poles. There shall be outgoing ACBs to each Unit Auxiliary Boards and common Auxiliary board. The common Auxiliary LT board shall be fed from both bus bars. All incomer, outgoing and tie feeders shall be equipped with ACBs at both ends. The incomers and bus coupler ACBs shall be properly interlocked. One outgoing ACB shall be provided as spare on both bus sections. The UAB shall be provided with one incomer from main LT Bus also.

[The scope of supply is for 4 No. of SSBs (1 for each machine and one main station service board only). One emergency feeder is also there. Emergency & SST are different feeders. Incomers required are UAT-1, UAT-2, UAT-3, UNIT 4, DG, SST & Emergency feeder. Even though the DG sets are not in scope of supply of this contract, but there shall be provision for incomer supply from DG set. The Unit 4 and UAT-4 are one and the same, but the cabling of unit-4 to Main station supply board incomer feeder is not included in scope. The type of connection of various incomers of SSB Panel is through cables only. The Emergency feeder is fed from regional source. The terms Common Auxiliary LT board & LT switchboard refers to the same boards.]

The requirements / ratings indicated above for UAT are the required minimum for giving a base line for tendering purpose only. The SST is not in the scope of supply under this contract. This aspect shall be considered by the Bidder while quoting and the Bidder should ensure that the ratings of the various equipment in the LV AC System, including the Transformers, are sufficient to take care of the design requirements of the equipment offered for the concerned project. Any increase in rating during detailed engineering stage will not entitle the Successful Bidder / Contractor for any extra charges. The Contractor should submit for approval the calculations for arriving at the ratings of the various equipment during detailed engineering.

2.2.4.1.1 LT Switchboard

The powerhouse shall be equipped with one low-tension switchboard located on the generator floor availing LT supply from the station service transformer and in the case of standstill condition of the generator from external source. There shall be separate feeders to each unit auxiliary board with sufficient protective interlocking facility. The LT Panel should be equipped with coupling facility for the segregation of LT Bus.

Sufficient number of outgoing circuits shall be provided for the auxiliary service in the station.

[The location / layout / SLD based on the specification are in the scope of this contract.]

2.2.4.2 DC Supply System

- One (1) set Battery chargers, 415V, 3-phase, 50 Hz input, 110V DC output voltage, each having sufficient capacity to supply the total constant DC load and FC and FCBC operating modes for the above battery complete with all auxiliary equipment including alarms for AC Input fail, Charger fail, Under / Over Voltage, Earth Fault, DC Output Fail, Overload, Battery Under voltage etc..., Status Indications, Metering and associated controls. Potential free contacts shall be provided for remote alarming of "AC input fail" and "DC Output" Fail conditions to the Control room and SCADA.
- Three (3) set 110V DC distribution board for powerhouse, equipped with one main incoming and sufficient feeders (plus 20% spare) with moulded case circuit breakers for distribution, complete with all necessary auxiliary equipment for each unit.
- One (1) set Emergency distribution board equipped with one incoming and adequate number of feeder distribution moulded case circuit breakers with all necessary auxiliary equipment
- One (1) set Tools, handling devices, testing instruments for erection, testing and maintenance of the complete system.
- One (1) set Spare parts sufficient for 5 years of operation.

[The 110V Battery bank is not in the scope of supply of this contract. Existing battery bank is 400 AH 110 V DC. Required sizing calculation shall be provided by the bidder. The requirement is 3 sets DCDBs, one each catering each machines and one set of emergency lighting DB. The 110 V DC SLD is in the scope of this contract. Emergency DB is to be wired for the emergency loads such as lighting etc...Emergency DB shall be fed from same DC battery.]

Note: -

1. The capacity for the above Battery shall be sufficient for all equipment in this contract. Provisions shall also be made for 20% spare capacity. The contractor shall submit detailed calculations for the determination of the capacity of the Battery, for KSEBL's approval.
2. MCB's shall be used for protection in the chargers. An alarm will be provided for MCB tripped condition. In case protection fuses are used internally inside the chargers, these fuses have to be provided with auxiliary alarm contacts for local and

Remote Alarm.

2.2.4.3 Uninterrupted Power Supply

Two (2) set Uninterrupted power supply panel with associated equipment, 30 kVA (Minimum) with plante / tubular type battery set. The system shall be complete with Alarm annunciators, Indications, Metering etc... with 6 hour backup. The system will also be capable of and have provision for remote monitoring and control from SCADA. Separate AC DB shall be supplied for the UPS system with sufficient protection and indication.

One (1) set Spare parts sufficient for 5 years of operation.

2.2.4.4 Heaters

An adequate number of electric heaters shall be provided within the generator housing to prevent condensation of moisture within the housing, when the generator is idle. An on-off thermostat or equivalent instrument with adjustable settings shall be provided for automatic control of the heaters.

2.2.4.5 Lighting & Grounding

2.2.4.5.1 Illumination

Renew the existing station lighting system including changing of cables and controls.

The illumination system shall be designed on basis of best engineering practice and shall ensure uniform, reliable, aesthetically pleasing, glare free illumination. The design shall prevent glare / luminous patch seen on VDU / LCD screens, when viewed from an angle.

DC lighting shall come on automatically on failure of normal AC supply. These shall be switched off automatically after the normal AC supply is restored and luminaries have attained their full glow.

Lighting panels, fixtures, receptacles, poles, masts, distribution boards, switch boxes, conduits, junction boxes etc... shall be properly installed and earthed.

Modern efficient LED lamps having true colour lighting shall be used for machine hall. A few incandescent lamps will also be provided. For control room lighting modern efficient LED lamps shall be used. Adequate lighting to the powerhouse premises shall be done using light fittings of modern efficient LED lamps with suitable controls.

All outdoor fixtures shall be weatherproof type.

All luminaries and their accessories and components shall be of the type readily replaceable by the available Indian makes. All fixtures and accessories shall be of reputed make and non-corrosive type. Acrylic covers / louvers shall be of non-yellowing type.

The constructional features of lighting distribution boards shall be similar to AC / DC distribution boards described elsewhere. Outgoing circuits shall be provided with MCB's of adequate ratings.

Wiring shall be by multi-stranded PVC insulated colour code cable laid in GI conduits. Wiring for lighting circuits of AC, and DC systems shall be run in separate conduits throughout. Minimum size of the wire shall not be less than 1.5sq.mm Copper or 4 sq.mm Aluminium. Wire shall conform to IS: 694 and wiring installation shall be as per IS: 732.

Conduits shall be of heavy-duty type, hot dip galvanized steel conforming to IS: 9537. In corrosive areas, conduits shall have additional suitable epoxy coating.

At least one 5/15A, 230 V universal socket outlet shall be provided in offices, stores, cabins, control room, switch gear room etc... 20A, 230 V AC industrial type receptacles shall be provided strategically in all other areas including switch gear room and control room. All these receptacles shall be 3-pin type and controlled with a switch. Suitable numbers of 63 A, 3 phase, 415 V AC industrial type receptacles with control switches shall be provided for the entire plant for welding and other purposes, particularly near all major equipment and at an average distance of 50 m. [Switchyard lighting system is not in the scope of this tender. Scope include powerhouse indoor & outdoor (excluding yard). DC lighting shall be from the existing DC battery source.]

2.2.4.5.2 Earthing System

The scope include providing Above Ground Earthing system that will enable connecting the equipment / installations to be earthed to the existing earth mat through risers to be provided as part of this contract or existing ones, if any. [Equipment earthing shall be done only with existing nearby available risers as per approved layout. The existing risers shall be used and no civil work in this regard is expected and if needed, same shall be in the scope of this contract. Switchyard earthing system is not included in the scope of this contract.]

The Earthing System shall be constructed to comply with the requirements of the applicable standards and connected equipment. Design calculations shall be submitted for approval during detailed Engineering phase. The earthing system shall provide:

- Adequate protection of personnel against dangerous voltages, current arcs.

- Low earthing impedance for the transformer neutrals and the generator neutral and sufficiently low neutral conductor impedance.
- The system shall also take care of limitation of the induced or capacitively transformed voltages on low voltage network, weak current on electronic cables, circuit panels and other equipment.
- A path for the short-circuit, earth fault and double earth fault currents expected to flow through the earthing system and not through other conducting parts of building constructions to a hazardous extent.

2.2.4.6 Communication System

Not in the scope of this contract.

2.2.5 Auxiliary Mechanical Equipment

2.2.5.1 EOT Crane

Renovation of EOT crane is not in the scope of this contract. The existing EOT crane can be used within the reach of it and for use at anywhere else the contractor shall arrange the facility by themselves.

2.2.5.2 Cooling Water System

The scope include supply of cooling water pumps, motors, strainers, non-return valves, piping etc... including cooling water pipes from pump house & distributor pipe lines including all piping works to and from cooling water tank, main water header, distributor lines etc... and provide all instrumentation and protection devices, all cooling water valves shall be motor operated valves and provide necessary controls after dismantling the existing system.

The system shall be designed to meet the cooling water requirements of the generator air coolers, guide bearing, thrust bearing, turbine guide bearing and transformer coolers at a suitable pressure.

The water from the tailrace pool is fed into the cooling water bus by means of an intake pipe. From the cooling water pit, water is pumped by means of cooling water pumps installed in the pump room.

A common cooling water pump installation shall be provided comprising of three motor driven pumps of sufficient capacity (two pumps for normal operation and one pump as

stand by), for continuous supply of water to the air coolers of generators, oil coolers of the bearings of turbines and generators, oil coolers of the sump tank of the oil pressure systems of the turbines and oil coolers of the main transformers.

The pumps shall be installed in pump room (existing) and will draw water from the tailrace. Provision will be made for the automatic starting of the stand-by cooling water pump when one of the cooling pumps in operation fails.

The pumps shall be of vertical turbine type directly driven by 3 phase 415VAC squirrel cage induction motors with the impeller located below minimum water level in the sump so that the pump can be started without priming. The pump motor shall be mounted on common base plate. The impeller of pumps will be made in stainless steel / bronze alloy, pump casing in steel casting and shaft in stainless steel.

The strainer shall be fitted with pressure switches to give alarm in case the pressure differential across it exceeds a pre-set value. Pressure gauges shall also be provided to indicate water pressure at its inlet and outlet. The pumps shall be of centrifugal type.

The cooling water system, including the emergency water tank shall be reconditioned / modified so as to cater to the complete requirement of all the turbines, generators, power transformers and connected equipment, including future additions, if any. The cooling water pressure shall be such that it shall be possible to discharge the outlets from the coolers directly into the tailrace even under conditions of maximum tailrace level.

Water is pumped from a sump connected to the tailrace of the powerhouse to a pump room through inlet baskets pre-filtering the water at 25mm. Water is then filtered at 1.5mm through the filters and then distributed to the units and water tank before being discharged back to the tailrace. Each pump shall have its own separate suction line whereas the discharge pipe of each pump shall be connected to a common header through a strainer.

Motorized self cleaning strainer with discharge capacity $1\frac{1}{2}$ times the pump discharge shall be provided after each pump to supply silt free clean water to various cooling circuits. The strainers shall be cleared off accumulated silt automatically through a motorized rotating arm mechanism. Cleaning operation will be operable through pressure differential switch and timers.

The strainer shall be a complete unit with suitable isolating valves at the inlet and outlet, being controlled by a single hand-wheel and gears. The strainer design shall be such that there is smooth flow of water without excessive losses inside the strainer. A differential pressure gauge across the strainer, fitted with pressure switches to give alarm in case the pressure differential across it exceeds a pre-set value, shall be provided. Pressure gauges

shall also be provided to indicate water pressure at its inlet and outlet.

A separate motor and pump of sufficient capacity is to be provided for emergency cooling water system to pump water from tail race to overhead tank. The motor driven pump shall also be installed in pump room. The pump will be of vertical turbine type, and will be started automatically with operation of the fire detectors and to maintain required storage in overhead tank. Provision will also be made for manual starting of the pump. Strainer, valves, pipes, motor starters and other accessories required to complete the emergency water supply system shall be provided.

Suitable Emergency cooling water supply system shall also be provided to care of any instance of failure of both the main and standby pumps. In case of failure of both the main as well as standby pumps, a motorized valve on the supply line from emergency water tank is automatically opened in order to supply enough cooling water for the units to come to a complete stop without overheating. The scheme for the same shall be submitted to the KSEBL for approval.

2.2.5.3 Oil Handling System

The insulating oil treatment plant of adequate capacity, complete with strainer, feed pump, thermostatically controlled heater, edge filter, vacuum chamber, ionic reactor column, vacuum pump, discharge pump, control panel instrumentation and all accessories capable of providing clean filtered oil after single pass having the following parameters shall be provided:

Gas contents	- less than 0.1% by volume.
Moisture content	- less than 5 ppm.
Suspended particles	- size less than 1 micron.

In addition to the above, common filter unit, online electrostatic filters have to be provided for each governor OPU system.

[Mobile insulating oil treatment plant of adequate capacity is acceptable. Transformer oil filter stands excluded in the scope of contract. The turbine oil capacity is as per the design of bidder. In addition to common LVDH filter, ESP filter shall be provided for each unit as per tender condition.]

2.2.5.4 Dewatering System

The dewatering system is not in the scope of this contract.

2.2.5.5 Fire Protection System

The scope includes and not limited to:

- a) Supply instrumentation and control system such as smoke detectors etc... of CO₂ and provide remote system controls at control room etc...
- b) Provide Portable Fire Extinguishers of various types (Clean Agent type & ABC type) of requisite capacity at appropriate locations in the powerhouse.

A suitable fire protection system shall be provided with valves, control unit nozzles etc... Conduit boxes and necessary wiring to a suitable junction box shall also be provided in the hot-air stream on the inlet side of the coolers and above the stator winding, to mount the fire detectors.

Fire fighting arrangements at the generator floor, control room, switchgear room etc... of the power house shall comprise of fire / heat / smoke detectors, portable fire extinguishers, fire buckets and hydrants as per the IS / relevant standards.

i. Fire / Heat / Smoke Detectors

The following locations shall be provided with fire / heat / smoke detectors which will be installed above the equipment / most suitable locations:

- Machine floor.
- Control room.
- L.T. and 11 kV switchgear areas.
- Any other location deemed necessary.

These fire / heat / smoke detectors shall initiate alarm and indication in the Fire Alarm Panel to be installed in the control room to identify the location of smoke / heat / fire to enable corrective actions. The central alarm & annunciation panel shall also have a connection from the detectors.

Manual call points shall be provided in all floors and a central fire alarm shall be provided in the control room.

ii. Portable Fire Extinguishers

Portable Fire Extinguishers of various types of requisite capacity shall be located at appropriate locations in the power house as below:

- a) Trolley mounted CO₂ type - 6 cylinders on Machine floor.
- b) CO₂ type fire extinguishers - 2 Nos. for Control room.

c) Clean Agent type	- 2 No. near DC batteries.
d) Foam type extinguishers	- 3 Nos. Near OPU.
e) Dry chemical type extinguishers	- 2 Nos. for Switchgear and Control room each
f) ABC type (Wall mounted type)	- 5 Nos. for General electrical installations.
g) Fire balls	- 10 Nos.

iii. Fire Buckets

Two sets of fire buckets, each set comprising 6 buckets filled with sand, shall be provided on covered steel stand at various places in the powerhouse area.

[Fire protection system for powerhouse and switchyard, except for the fire hydrant system, is included in the scope of the contract.]

2.2.5.6 Vibration Monitoring System

An online and continuous vibration and wobbling monitoring system complete with detector, proximeter, control unit and time delay relays shall be provided to measure the shaft relative displacement and bracket vibration at UGB, Thrust Bearing, LGB & TGB in both x and y directions. The detector shall be mounted in location best suited to detect excessive vibrations of the rotating and stationary parts.

2.2.5.7 Sanitary & Water Supply System

The sanitary & water supply system is not in the scope of this contract.

2.2.5.8 Station Compressed Air System

One centralized air compressor system complete with two compressors, receiver, air dryer, oil moisture trap, piping and fitting, loading and unloading valves shall be provided. Rated pressure of the compressor shall be sufficient for meeting the requirements of Braking, cleaning, operation of pneumatic equipment etc... All necessary oil level indicators, pressure switches / gauges etc... shall be provided.

The powerhouse shall be equipped with low-pressure air compressor system for hydraulically operated generator brakes, servomotor and other station services. The system shall comprise air compressor, air receiver accessories and other controls.

The system shall be suitably sized to meet the service air requirements for the:

- Operation of pneumatic tools during maintenance.
- Service air for cleaning and miscellaneous use.
- Generator braking system.

Two identical electrically driven compressor units complete with motor, starter, base plate air dryer, suction silencer, cleanable air filter, pressure gauges, check valves, un-loader valves, isolating valves, complete control system etc... shall be provided. Auto operation of Compressors shall be provided.

[As the design, engineering, procurement, erection and commissioning are in the scope of this contract, the bidders are advised to design the system suitable for the equipment supplied for the powerhouse.]

2.2.5.9 Ventilation & Air-conditioning System

Suitably rated Split type air condition system shall be provided in the Control room along with sufficient number of exhaust fans in the Power House.

2.2.5.10 Support Structure

The support structure shall be sized to maintain the connections under the different working conditions. Stresses caused by expansion and short-circuit in most unfavourable circumstances shall be considered for designing supports. The support structures and bolts shall be of hot dip galvanized steel. Earthing points shall be provided for connection to the main earthing system.

2.2.5.11 Dam Water Level Measurement

The dam water level measuring system is not in the scope of this contract.

2.2.5.12 General Clarifications

The Valve house renovation is not in the scope of this contract. The Optic Fibre Cable, if required, as per the engineering requirement of this tender both internal to powerhouse and external to switchyard, headrace measurement, tailrace measurement and butterfly valve status etc.. are in the scope of this contract. The Silt measurement system is not included in the scope of this tender. For Transport Limitations, Please refer clause 1.1.36.1. (Road / Culvert width limited to 3 metre - may be taken for reference only). Regarding the use of Generator Steel Barrel, alteration of the existing steel barrel to suit the renovated machine is acceptable. Regarding Civil Works & Hydro mechanical works, No major civil works are

envisaged. However modifications on account of mis-matching between existing and newly supplied equipment is to be carried out by the contractor. Modifications in Civil works required for the contractor supplied equipment are entirely under contractor's scope. Hydromechanical works in this tender is meant by MIV and its allied items. Regarding Existing generating unit assembly, dismantling, erection and commissioning tools, stator, rotor, LEB and UEB lifting tools and other required site tools, Special tools and tackles that are functional will be provided by KSEBL. Any other tools required shall be arranged by the bidder. The 11 kV cable is not in the scope of supply. The Thrust collar to rotor shaft fixing arrangement is presumed that it is thermal shrink fit. Bidder to ascertain during dismantling. The erection / dismantling procedure of the OEM is available at site and can be shared with the successful bidder. As Design and Engineering are included in the scope of tender, each bidder has to offer tools & tackles required for equipment offered by them.

2.2.6 Power Transformers & Switch-yard

All equipment related to switch-yard such as Generator Transformer, breakers, isolators, earthing system etc... are not included in this scope. The supply of all materials & equipment and works for the switch-yard will be carried out by KSEBL. The bidder/contractor has to collect all details related to the switch yard from KSEBL for the successful design, execution and commissioning of this project.

2.2.6.1 Power Evacuation Arrangement

The power generated by 3x27.5 MW (KHEP) + 1x50 MW (KES) are evacuated through 4 110kV feeders, namely Koduvally (KK-KD), Chevayur (KK-CH), Kuttiyadi (KK-KU) and Chakkittapara (KK-CK) from bus having a bus sectionaliser arrangement.

2.2.6.2 Power Transformers

Power transformers supply and installation is not covered in this scope. The contractor / bidder shall collect the details of power transformer from KSEBL for the successful design, implementation and commissioning of the project.

All the three old generator transformers of 28 MVA replaced with new 3 phase, 11/110 kV, Delta / Star Generator transformers of capacity 35 MVA each with water Cooling system departmentally to suit the uprated capacity of the units. (The Generator Transformer replacement is not in the scope of this contract). But, the protection, monitoring and control system for the Generator Transformer to be incorporated in SCADA system is included in the scope of this contract. Also, separate automatic firefighting system (including deluge

systems) for each generator transformers is included in the scope of this contract.

Terminal connectors including the segregated phase duct termination to the transformers are also included in the scope of this contract.

[Existing 28 MVA GTS have deluge system for fire protection. All the three old generator transformers of 28 MVA will be replaced by KSEBL before the commencement of works as per this contract. For the replaced 35 MVA GTs the firefighting system as specified shall be in the scope of this contract.]

2.2.6.3 110 kV Switch-yard Equipment

The switch yard equipment supply, installation and commissioning is not covered in this scope. The switch-yard equipment are not generally included in the scope of this contract. But the the control, protection and integration in SCADA of all switch-yard equipment including feeder control and metering is included in the scope of this contract. All control cabling for the switch-yard equipment including SCADA compatible cables forms the part of this contract. The contractor / bidder shall collect the details of Switch yard equipment from KSEBL for the successful design, implementation and commissioning of the project.

[The system consists of 4 No. of feeder bays, 3 No. GT bays & 2 No. transformer bays. The supplied SLD is only for First three machines.]

2.2.6.3.1 Switch-yard Monitoring, Control, Protection and Instrumentation

- Four (4) 110 kV feeder protection and metering panels.
- Two (2) 12.5 MVA, 110/11kV transformer control and relay panels.
- One (1) panel for bus bar protection relays with bus voltage / frequency indications.
- One (1) lot of cabling system for control, protection, metering and instrumentation.
- One (1) set of spares for five years of normal plant operation.
- Any other item, not specified here, but essential for the satisfactory system operation.

[The Switchyard bay Control panels are to be provided in central control room only. The 110kV Switchyard and that all protection, control panels are to be placed in the control room. Monitoring, Control, Protection & Instrumentation is required to be provided for Units - #1,#2,#3 and switchyard. For units #4,#5,#6 bays in 110kV switchyard SCADA integration to be provided for control and monitoring. The 11kV switchgear installation is not in the

scope of this contract. But control & indication including SCADA integration of 11 kV switchgear is in the scope of this contract.]

2.2.6.3.1.1 110kV Feeder Protection and Control Panels

The scope includes but not limited to:

a) Four (4) Feeder Vertical Panels

Supply and installation of feeder protection panels, Bay controller units, Annunciation panels etc... and install modern automatic computerized control, supervision and protection device working on microprocessor based data acquisition and control system.

b) Four (4) Import & Export Meters

Supply and installation of new Import & Export Trivector meters with AMR facility for all feeder panels.

Each 110kV feeder protection & control panels shall comprise of:

1. Circuit identification label	-	1 No.
2. Numerical distance protection scheme	-	1 No.
3. Directional IDMT over-current relay	-	3 Nos.
4. Directional IDMT Earth fault relay	-	1 No.
5. Local breaker backup relay	-	1 No.
6. Static backup impedance relay single zone capable of measuring Ph-Ph, Ph-N and 3-Ph faults with adjustable time setting and power swing blocking	-	1 No.
7. Timing unit for local breaker backup relay, as required	-	1 No.
8. Indicating lamps for PT voltage monitoring	-	3 Nos.
9. Test terminal block to facilitate secondary Injection test of protective relays (ABB make RTXP or equivalent)	-	1 set
10. High speed tripping relays	-	1 set
11. Trip circuit supervision relays	-	6 Nos.
12. High-speed single shot auto re-closing relay	-	1 No.
13. Auxiliary relays	-	As required

14. Control Relays (50V DC) for SCADA control	-	2 Nos.
15. MW, MVAR, A & V Transducers (4-20mA for Telemetry)	-	As required
16. DC supply monitoring relays	-	2 Nos.
17. Under voltage relay for earth switch interlock	-	1 No.
18. Indicating meters as follows:		
a) Ammeter of different scale range		
b) Megawatt meter (transducer type)		
c) MVAR meter (transducer type)		
d) Export MWH meter with reverse stop		
e) Export MVARH meter with reverse stop		
f) Import MWH meter with reverse stop		
g) Import MVARH meter with reverse stop		
h) Voltmeters		
19. Testing terminal block for the metering circuit	-	1 set
20. Internally mounted equipment	-	As required

In addition to the above 1 No frequency Transducer and sufficient quantity of Voltage transducers for measuring the voltage of each Bus shall be provided for Telemetry. The Voltage input to Frequency transducer shall be through a voltage selection scheme.

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SPECIFICATION NO. PE-TS-471-600-C001

SECTION - D
GENERAL TECHNICAL SPECIFICATION

Customer

KERALA STATE ELECTRICITY BOARD LTD.



BHARAT HEAVY ELECTRICALS LIMITED

NEW DELHI

SECTION – D comprises of sub-sections as mentioned below:

Sub-section D1: Earthwork in excavation and backfilling

Sub-section D2: Cement concrete (Plain and reinforced) and formwork

Sub-section D3: Carpentry and joinery

Sub-section D4: Roof and underground structures water proofing, insulation and allied works

Sub-section D5: Metal doors, windows, ventilators, louvers etc.

Sub-section D6: Glass and Glazing

Sub-section D7: Rolling Steel Shutter and Grills

Sub-section D8: Miscellaneous Metal

Sub-section D9: Masonry and allied works

Sub-section D10: Finish to masonry and concrete

Sub-section D11: Painting, Whitewashing, polishing

Sub-section D12: Floor finish and allied works

Sub-section D13: Sheet work in roof and siding

Sub-section D14: Suspended ceiling

Sub-section D15: Water supply, drainage & sanitation

Sub-section D16: Road & drainage

Sub-section D17: Fabrication of structural steelwork

Sub-section D18: Erection of structural steelwork



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SECTION - D

SUB-SECTION – D1

EARTHWORK IN EXCAVATION AND BACKFILLING

SPECIFICATION NO. PE-TS-999-600-C001



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



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**STANDARD TECHNICAL SPECIFICATION FOR EARTHWORK IN
EXCAVATION AND BACKFILLING**

1.0.0 SCOPE

This specification covers earth work excavation in all types of soil, soft rock and hard rock including setting out, clearing and grubbing, shoring, dewatering, back filling around foundations/pipelines to grade, watering, compaction of fills, testing, approaches, disposal of surplus earth, protective fencing, lighting etc relevant to the structures and locations covered under this contract.

2.0.0 GENERAL

2.1.0 Work to be provided for by the Contractor

The work to be provided for by the contractor unless specified otherwise shall include but not be limited to the following.

a) Supplying and providing all labour, supervision services, earth moving machineries, surveying instruments including facilities as required under statutory labour regulations, materials, scaffolds, equipment, tools and plants, transportation, etc. required for the work.

b) Preparation and submission of working drawings showing the approaches, slopes, berms, shoring, sumps for dewatering including drainage, space for temporary stacking of soils, disposal area, fencing etc and all other details as may be required by the engineer.

c) To carry tests and submit to the Engineer, test results of fill materials and degree of soil compaction of fill whenever required by the Engineer to assess the quality of fill.

d) Design, construction and maintenance of Magazine of proper capacity for storage of explosives for blasting work and removal of the same after completion of the work etc. including procurement of necessary licenses from proper authorities.

2.2.0 Work to be provided by others

No work under this specification will be provided by any agency other than the contractor unless specifically mentioned elsewhere in the contract.



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2.3.0 Codes and Standards

All works shall be carried out as per this specification and shall conform to the latest revision and/or replacements of the following or any other Indian Standard (IS) Codes unless specified otherwise.

IS-1200	Method of measurement of building and civil engineering works, Part-I: Earthwork
IS-2720	Method of test for soils (Relevant parts)
IS-3764	Excavation work - Code of safety
IS-4081	Safety code for blasting and related drilling operations
IS-4701	Indian Standard Code of Practice for earthwork on Canals
IS:6922	Criteria for safety and design of structures subject to underground blasts

IS: 3764 Excavation work – code of safety

In case of conflict between this specification and those (IS Codes) referred to herein, the former shall prevail. In case any particular aspect of work is not covered specifically by this specification/IS Codes, any other standard practice as may be specified by the engineer shall be followed.

2.4.0 Conformity with Designs

The contractor shall carry out the work as per the approved drawings, specification and as directed by the engineer.

2.5.0 Materials

2.5.1 General

All materials required for the work shall be of the best commercial variety and approved by the engineer.

2.5.2 Material for Excavation

For the purpose of identifying the various strata encountered during the course of excavation, refer clause no. 3.4.0 for the classification of earth strata.

2.5.3 Material for Filling

Material to be used for back filling shall be free from vegetations, roots, salts, rubbish, lumps, organic matter and any other harmful chemicals etc and shall be got approved by the engineer. Normally excavated earth shall be used for back filling. In case such earth contains deleterious salts, the same shall not be used. All clods of earth shall be broken or removed. Where the excavated material is mostly rock and if filling with the same is permitted by the engineer in writing, then the filling with rock shall be done in the following



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manner. The boulders shall be broken into pieces not exceeding 150mm size in any direction and mixed with fine materials consisting of decomposed rock, moorum or any approved earth to fill the voids as far as possible and the mixture shall then be used for filling.

In case the earth required for backfilling is over and above the earth available from the compulsory excavations within the project area, then borrow areas for obtaining suitable fill material shall be arranged by the contractor himself from outside the plant boundary limits and all expenses including royalties, taxes, duties etc shall be borne by him. The selected earth from the borrow areas shall be got approved by the engineer. The borrowed material shall be free from roots, vegetations, decayed organic matter, harmful salts and chemicals, free from lumps and clods etc. The contractor shall obtain and submit necessary clearances/permissions from the concerned authorities for the borrow areas/materials acquired to the engineer.

If specified, the back filling shall be done with clean well graded sand from approved quarries free from harmful and deleterious materials.

2.6.0 Quality Control

All works shall confirm to the lines, levels, grades, cross sections and dimensions shown on the approved drawings and/or as directed by the engineer. The contractor shall establish and maintain quality control for the various aspects of the work, method of construction, materials and equipments used etc. The quality control operation shall include but not be limited to the following.

Sl. No.	Activity	Check
1	Lines, levels & grades	a) By periodic surveys b) By establishing markers, boards etc
2	Back filling	(a) On quality of fill material (b) On moisture content of back fill (c) On degree of compaction achieved

2.7.0 Information regarding site conditions

Surface and Sub-surface data regarding the nature of soil, rock, sub-soil water etc. shown on drawing or otherwise furnished to the Contractor shall be taken as a guidance only and variation therefrom shall not affect the terms of the contract. The Contractor must satisfy himself regarding the character and volume of all work under this contract and expected surface, sub-surface and / or sub-soil water to be encountered. He must also satisfy himself about the general conditions of site and ascertain the existing and future construction likely to come up during the execution of the contract so that he may evolve a realistic programme of execution.



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3.0.0 EXECUTION

The contractor shall prepare and submit the detailed drawings/schemes for excavation and back filling works as proposed to be executed by him showing the dimensions as per the construction drawings and specification adding his proposal of slopes, shoring, approaches, dewatering, drainage, berms etc. for the approval of engineer.

3.1.0 Setting out

On receiving the approval from the engineer with modifications and corrections if any, the contractor shall set out the work from the control points furnished by the engineer and fix permanent points and markers for ease of periodic checking as the work proceeds. These permanent points and markers shall be fixed at the interval as prescribed by the engineer and shall be got checked and certified by the engineer after whom the contractor shall proceed with the work. It should be noted that this checking by the engineer prior to the start of the work will in no way relieve the contractor of his responsibility of carrying out the work to true lines, levels and grades as per the drawings and specification. If any errors are noticed in the contractor's work at any stage, the same shall be rectified by the contractor at his own risk and cost.

3.2.0 Initial Levels

Initial levels of the ground either in a definite grid pattern or as directed by the Engineer will be taken by the Contractor jointly with the Engineer over the original ground prior to starting actual excavation work and after setting out. These initial levels will be used for preparing cross-sections for volume measurement or for cross-checking the depths obtained from tape measurements. All records of levels, measurements etc. and also any drawing, cross-section etc. made therefrom, shall be jointly signed by the authorised representative of the contractor and the Engineer before the commencement of work and they shall form the basis of all payments in future.

3.3.0 Clearing and Grubbing

The area to be excavated shall be cleared out of fences, trees, logs, stumps, bushes, vegetation, rubbish, slush etc. Trees upto 300mm girth shall be uprooted. Trees above 300mm girth to be cut shall be approved by the engineer and marked. Cutting of trees shall include removing roots as well. After the tree is cut and roots taken out, the pot holes formed shall be filled with good earth in 250mm layers and compacted unless directed otherwise by the engineer. The trees shall be cut in to suitable pieces as instructed by the engineer. Before earthwork is started, all the spoils, unserviceable materials and rubbish shall be burnt or removed and disposed to the approved disposal



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area(s) as specified by the engineer. Useful materials, saleable timber, fire woods etc shall be the property of the owner and shall be stacked properly at the worksite in a manner as directed by the engineer.

3.4.0

Classification

All earthwork shall be classified under the following categories:

No distinction will be made whether the material is dry or wet.

a) Ordinary Soil

This shall comprise vegetable or organic soil, turf, sand, silt, loam, clay, mud, peat, black cotton soil, soft shale or loose moorum, a mixture of these and similar material which yields to the ordinary application of pick and shovel, rake or other ordinary digging implement. Removal of gravel or any other nodular material having diameter in any one direction not exceeding 75 mm occurring in such strata shall be deemed to be covered under this category.

b) Hard Soil

This shall include :

- i) stiff heavy clay, hard shale, or compact moorum requiring grafting tool or pick or both and shovel, closely applied ;
- ii) gravel and cobble stone having maximum diameter in any one direction between 75 and 300 mm ;
- iii) soling of roads, paths, etc., and hard core ;
- iv) macadam surfaces such as water bound, and bitumen/tar bound;
- v) lime concrete, stone masonry in lime mortar and brick work in lime/cement mortar, below ground level ;
- vi) soft conglomerate, where the stones may be detached from the matrix with picks ; and
- vii) generally any material which requires the close application of picks, or scarifiers to loosen and not affording resistance to digging greater than the hardest of any soil mentioned in (i) and (vi) above.

c) Soft and Decomposed Rock

This shall include :

- i) limestone, sandstone, laterite, hard conglomerate or other soft or disintegrated rock which may be quarried or split with crowbars ;
- ii) unreinforced cement concrete which may be broken up with crowbars or picks and stone masonry in cement mortar below ground level ;
- iii) boulders which do not require blasting having maximum diameter in any direction of more than 300 mm, found lying loose on the surface or embedded in river bed, soil, talus, slope wash and terrace material of dissimilar origin ; and
- iv) any rock which in dry state may be hard, requiring blasting, but which



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when wet becomes soft and manageable by means other than blasting.

d) Hard Rock (requiring blasting)

This shall include :

- i) any rock or cement concrete for the excavation of which the use of mechanical plant or blasting is required ;
- ii) reinforced cement concrete (reinforcement cut through but not separated from the concrete) below ground level; and
- iii) boulders requiring blasting.

e) Hard Rock (blasting prohibited)

Hard rock requiring blasting as described under (d) but where blasting is prohibited for any reason and excavation has to be carried out by chiselling, wedging or any other agreed method.

In case of any dispute regarding classification, the decision of the Engineer shall be final.

3.5.0 Excavation for Foundations and Trenches

3.5.1 General

All excavation shall be done to the minimum dimensions as required for the safety and working facility. In each individual case, the contractor shall obtain prior approval of the engineer for the method he proposes to adopt for the excavation including dimensions, side slopes, shoring, dewatering, drainage and disposal etc. This approval however shall not in any way make the engineer responsible for any consequent loss or damage. The excavation must be carried out in the most expeditious and efficient manner. All excavation in open cuts shall be made true to the line, slopes and grades as shown on the drawings and/or as directed by the engineer. No material shall project within the dimension of minimum excavation lines marked. Boulders (if any) projecting out of the excavated surfaces shall be removed if they are likely to be a hindrance to the work/workers in the opinion of the engineer.

Method of excavation shall in every case be subject to the approval of the engineer. The contractor shall ensure the stability and safety of the excavation, adjacent structures, services and works etc including the safety of the workmen. If any slip occurs, the contractor shall remove all the slipped materials from the excavated pit without any extra cost to the engineer/owner. All loose boulders and semi detached rocks which are not inside but so close to the area to be excavated and may liable to fall or otherwise endanger the workmen, equipment of the work etc during excavation in the opinion of the engineer shall be stripped off and removed away from the area of excavation. The method to be used for removal shall be such that it should not shatter or render unstable or unsafe the portion which was originally sound and safe. In



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case any material not required to be removed initially but later to become loose or unstable in the opinion of the engineer shall also be promptly and satisfactorily removed.

The rough excavation may be carried out upto a maximum depth of 150 mm above the final level. The balance shall be excavated with special care. If directed by the engineer, soft and undesirable spots shall be removed even below the final level. The extra excavation shall be filled up as instructed by the engineer. If the excavation (in all types of soil and rock) is done to a depth greater than that shown on the drawing or as directed by the engineer, the excess depth up to the required level shall be filled with cement concrete not leaner than 1:4:8 or richer as directed by the engineer at the own risk and cost of the contractor. In case where excavation in soil, soft rock (including weathered rock) and hard rock are involved, the excavation in each stratum shall be carried out separately with the approved methodology and as per the instructions of the engineer.

All excavated materials such as rock, boulders, bricks, dismantled concrete blocks etc shall be the property of the owner and shall be stacked separately as directed by the engineer. All gold, silver, oil, minerals, archeological and other findings of importance, trees cut or other materials of any description and all precious stones, coins, treasures, relics, antiquities and other similar things which may be found in or upon the site shall be the property of the owner and the contractor shall duly preserve the same to the satisfaction of the engineer/owner. The contractor shall deliver the same to such person or persons as may be authorized or appointed from time to time by the owner to receive the same.

Prior to starting the excavation, the ground level at the location shall be checked jointly with the engineer.

3.5.2

Excavation in All Type of Soil and in Soft Rock

The excavation in all type of soil, soft rock including decomposed rock etc shall be carried out as per the approved proposal and as directed by the engineer. The work shall be carried out in a workmanlike manner without endangering the safety of nearby structures/services or works and without causing hindrance to any other activities in the area. Foundation pits shall not be excavated to the full depth unless construction is imminent. The last 150mm depth shall be excavated once concreting work is imminent. At the discretion of the engineer, the full depth may be excavated and the bed be covered with lean concrete as specified after watering and compacting the bed. As the excavation reaches the required dimensions, lines, levels and grades etc, the work shall be got checked and approved by the engineer. In cases where deterioration of the ground, upheaval, slips etc are expected, the engineer may order to suspend the work at any stage and instruct the contractor to carry out the protection works before the excavation will be



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restarted.

3.5.3 Excavation in Hard Rock

Hard rocks shall normally be excavated by means of blasting. In case where blasting is prohibited for any reasons, the excavation shall be carried out by chiselling or any other approved method as directed by the engineer. Personnel deployed for rock excavation shall be protected from all hazards such as loose rock/boulder rolling down and from general slips of excavated surfaces. Where the excavated surface is not stable against sliding, necessary supports such as props, bracings or bulkheads shall be provided and maintained during the period of construction. Where the danger of falling loose rock/boulder from the excavated surfaces deeper than 2m exist, steel mesh anchored to the lower edge of the excavation and extending over and above the rock face adequate to retain the dislodged material shall be provided and maintained.

3.5.4 Blasting

Storage, handing and use of explosives shall be governed by the current explosive rules/regulations laid down by the Central and the State Governments. The contractor shall ensure that these rules/regulations are strictly adhere to. The following instructions are also to be strictly followed and the instructions wherever found in variance with the above said rules/regulations, the former (instructions) shall be superseded with the later (above said rules/regulations).

No child under the age of 16 and no person who is in a state of intoxication shall be allowed to enter the premises where explosives are stored nor they shall be allowed to handle the explosives. The contractor shall obtain licence from the District Authorities for undertaking the blasting work as well as for obtaining and storing the explosives as per Explosives Rules, 1940 corrected upto date. The contractor shall purchase the explosives, fuses, detonators etc only from a licensed dealer and shall be responsible for the safe custody and proper accounting of the explosive materials. The engineer or his authorized representative shall have the access to check the contractor's store of explosives and his accounts at any time. It is the full responsibility of the contractor to transport the explosives as and when required for the work in a safe manner to the work spot.

Further, the engineer may issue modifications, alterations and new instructions to the contractor from time to time. The contractor shall comply with the same without these being made a cause for any extra claim.

3.5.4.1 Materials

All materials such as explosives, detonators, fuses, tamping materials etc proposed to be used in the blasting operation shall have the prior approval of



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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.



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* 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



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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



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and other properties. Adequate safety precautions as per building byelaws, safety codes, statutory regulations etc shall be taken during blasting operations.

3.5.4.5 Restrictions in Blasting

- a) Blasting which may disturb or endanger the stability, safety or quality of the adjacent structures/foundations shall not be permitted.
- b) Blasting within 200m of a permanent structure or construction work in progress shall not be permitted.
- c) Progressive blasting shall be limited to two third of the total remaining depth of excavation.
- d) No large scale blasting operations will be resorted to when the excavation reaches the last one metre and only small charge preferably black powder may be allowed so as not to shatter the parent rock.
- e) The last blast shall not be more than 0.50 m in depth.
- f) In rocky formations, at locations where specifically indicated or ordered in writing by the engineer, the use of explosives shall be discontinued and excavation shall be completed by chiselling or any other suitable method as approved by the engineer.

3.5.5 Disposal

The excavated spoils shall be disposed of in any (or all) of the following manner as directed by the engineer.

- a) By using it straightway for backfilling.
- b) By stacking it temporarily to use for backfilling at a later date during execution of the contract.
- c) i) By either spreading
or
ii) By spreading and compacting at designated disposal areas.
- a) By selecting the useful material and stacking it neatly in designated areas as indicated by the engineer for use in backfilling by some other agency.

3.5.6 Disposal of Surplus Materials

All surplus material from excavation shall be removed and disposed of from the excavation site to the designated disposal area indicated by the engineer. All good and sound rocks obtained from excavations and all assorted materials of dismantled structures are the property of the owner and if the contractor wants to use it, he shall have to obtain it from the engineer at a mutually agreed rate. All sound rocks and other assorted materials like excavated bricks etc shall be stacked separately.



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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 practicable. 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



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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.



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3.7.0 Backfilling

3.7.1 General

The material to be used for backfilling shall be approved by the engineer which shall be obtained directly from the excavation, from the nearby areas where excavation work by the same agency is in progress, from the temporary stacks of excavated spoils or from the borrow pits as directed by the engineer. The material shall be free from lumps and clods, roots and vegetations, harmful salts and chemicals, organic materials etc.

In locations where sand filling is required, the sand used should be clean, well graded and be of the quality normally acceptable for use in concrete.

3.7.2 Filling and Compaction in Pits and Trenches all Around the Structures

As soon as the work in foundation has been accepted, the spaces around the foundation in pits and trenches shall be cleared of all debris, brick bats, mortar droppings etc and filled with approved earth in layers not exceeding 250mm (in loose thickness). Each layer(loose) shall be watered, rammed and properly compacted to the required degree to the satisfaction of the engineer. Earth shall be compacted with approved mechanized compaction machine. Usually, no manual compaction shall be allowed unless specifically permitted by the engineer. The moisture content of the fill material during compaction shall be controlled near to its optimum moisture content so as to obtain the required degree of compaction. The final surface shall be trimmed and levelled to proper profile as desired by the engineer.

3.7.3 Plinth Filling

The plinth shall be filled with earth in layers not exceeding 250mm (in loose thickness) and each layer shall be watered and compacted to the required degree with approved compaction machine or manually if specifically permitted by the engineer. When the filling reaches the finished level, the surface shall be flooded with water for at least 24 hours, allowed to dry and then rammed and compacted in order to avoid any settlement at a later stage. The finished surface of fill shall be trimmed to the slope intended to be provided for the floor.

3.7.4 Filling in Trenches for Water Pipes and Drains

Filling in trenches for pipes and drains shall be commenced as soon as the joints of pipes and drains have been tested and passed. Where the trenches are excavated in soil, the filling shall be done with earth on the sides and top of pipes in layers not exceeding 150mm, watered, rammed and compacted taking



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care that no damage is caused to the pipe below.

In case of trenches excavated in rock, the filling upto a height of 300mm or the diameter of the pipe whichever is more above the crown of the pipe or barrel shall be done with fine material such as earth, moorum, disintegrated rock or ash as per the availability at site and shall be filled in compacted layers not exceeding 150mm. The remaining filling shall be done in layers with the mixture of boulders (of size not exceeding 150mm) and fine material as specified elsewhere in the specification. Each layer shall be watered, rammed and compacted to the required degree and to the satisfaction of the engineer.

3.7.5 Filling in Disposal Area

Surplus materials from excavation which are not required for backfilling shall be disposed of in the designated disposal areas. The spoils shall not be dumped haphazardly but should be spread in layers approximately 250mm thick when loose, watered and compacted with the help of a compacting equipment as per the directions of the engineer. In wide areas, rollers shall be employed and compaction shall be done to the satisfaction of the engineer at the optimum moisture content which shall be checked and controlled by the contractor. In certain cases the engineer may direct the contractor to dispose the surplus materials without compaction which can be done by tipping the spoils from a high bench neatly maintaining a proper level and grade of the bench.

3.8.0 Approaches and Fencing

The contractor should provide and maintain proper approaches for the workmen and inspection. The roads and approaches around the excavation should be kept clear at all times so that there is no hindrance to the movement of men, material and equipment of various agencies connected with the project. Sturdy and elegant fencing is to be provided around the top edge of the excavation as well as around the bottom of the fill at the surplus disposal area where dumping from a high bench is in progress.

3.9.0 Lighting

Full scale area lighting is to be provided if night work is permitted or directed by the engineer. If no night work is in progress, red warning lights should be provided at the corners of the excavated pit and the edges of the fill.

4.0.0 TESTING AND ACCEPTANCE CRITERIA

4.1.0 Excavation

On completion of excavation, the dimension of the pits will be checked as per the drawings after the pits are completely dewatered. The work will be



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accepted after all undercuts have been set right and all over excavations are filled back to the required lines, levels and grades by placing ordinary cement concrete of 1:4:8 proportion and/or richer and/or by compacted earth as directed by the engineer. The choice of the grade of concrete will be a matter of unfettered discretion of the engineer. Over excavation of the sides shall be made good by the contractor while carrying out the backfilling. The excavation work will be accepted after the above requirements are fulfilled and all the temporary approaches encroaching inside the excavation have been removed.

4.2.0 Backfilling

The degree of compaction required will be as per the stipulation laid down in IS: 4701 and the actual method of measuring the degree of compaction will be as decided by the engineer. The work of back filling will be accepted after the engineer is satisfied with the degree of compaction achieved.

5.0.0 RATES AND MEASUREMENTS

5.1.0 Rates

a) The item of work in the schedule of quantities describe the work very briefly. The various items of the schedule of quantities shall be read in conjunction with the corresponding section in the technical specification including amendments and additions if any. For each item in the schedule of quantities, the bidder's rate shall include all the activities covered in the description of the items as well as for all necessary operations in detail as described in the technical specification.

b) No claims shall be entertained if the details shown on the released for construction drawings differ in any way from those shown on the tender drawings.

c) The unit rate quoted shall include minor details which are obviously and fairly intended and which may not have been included in these documents but are essential for the satisfactory completion of the work.

d) The bidder's quoted rate shall be inclusive of supplying and providing all labour, men, materials, equipments, tools and plants, supervision, services, approaches, schemes etc.

f) In case blasting in hard rock is envisaged, the unit rate quoted for earth work shall include the cost of storage and safety arrangements for the materials required for blasting. No separate payment will be made on this account.



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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, around 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, around 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.



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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.

6.0.0 INFORMATION TO BE SUBMITTED BY THE BIDDER

6.1.0 With Tender

Detail of equipments and machineries proposed to be used for excavation, backfilling and compaction shall be submitted along with the tender.

6.2.0 After Award

After award of the contract the successful bidder shall submit the following for approval.

a) Within 30 days of the award of contract, the contractor shall submit a detailed programme of the work as proposed to be executed giving completion dates of excavation for the various foundations and the time required for backfilling and compaction after completion of foundation for the structures. The earthwork programme shall be planned in accordance with the foundation programme. The programme should also show how the excavation and backfilling quantities will be balanced minimizing the temporary stacking of spoils. It is to be noted that the engineer even after initial approval of the programme may instruct the contractor to enhance or to retard the progress of work during the actual execution in order to match with the progress of foundations. The initial programme being submitted by the contractor should have sufficient flexibility to take care of such reasonable variations.

b) Within 15 days of the award of contract, the contractor shall submit the drawings for earth work in excavation and backfilling showing detail of slopes,



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shoring, approaches, sump pits, dewatering lines, fencing etc for the approval of the engineer.



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REINFORCED)**

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GENERAL TECHNICAL SPECIFICATION

CEMENT CONCRETE (PLAIN & REINFORCED)



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



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CEMENT CONCRETE (PLAIN &
REINFORCED)**

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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



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installation of various embedments like inserts, anchor bolts, pipe sleeves, frames, joint seals, frames, openings etc.

As decided by the Engineer some or all of the drawings & schedules prepared under item (b) to (e) above will have to be submitted for approval.

- f) Submit for approval detailed schemes of all operations required for executing the work, e.g. material handling, Concrete mixing, Placement of concrete, Compaction, curing, services, Approaches, etc.
- g) Design and submit for approval concrete mix designs required to be adopted on the job.

Furnish samples and submit for approval results of tests of various properties of the following:

- i) The various ingredients of concrete
- ii) Concrete
- iii) Embedments
- iv) Joint seals
- i) Provide all incidental items not shown or specified in particular but reasonably implied or necessary for successful completion of the work in accordance with the drawings and specifications.
- j) For supply of certain materials normally manufactured by specialist firms, the Contractor may have to produce, if directed by the Engineer, a guarantee in approved Performa for satisfactory performance for a reasonable period as may be specified, binding both the manufacturers and the Contractor, jointly and severally.

2.02.00 Work by others

No work under this specification will be provided by any agency other than the Contractor unless specifically mentioned elsewhere in the contract.

2.03.00 Information to be submitted by the Tenderer

2.03.01 With Tender

The following technical information's are required with the tender:

- a) Source and arrangement of processing of aggregates proposed to be adopted.



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- 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.



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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 Bending 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 Form, 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



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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.

- TG foundation top deck and sub structures including raft.
- Spring Supporting decks of all machine foundations.
- 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,



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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



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concrete and reinforcement. Super plasticizers conforming to IS: 9103 or ASTM C-494 shall only be used as admixture having the above properties either individually or in a combination as per the direction of the Engineer.

2.05.07 Reinforcement

Reinforcement shall be as per relevant IS Specification as mentioned in the Contract/Drawing/Instructions. All bars shall be of tested quality.

2.06.00 Storage of Materials

2.06.01 General

All materials shall be stored so as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work. Any material, which has deteriorated or has been damaged or is otherwise considered defective by the Engineer, shall not be used for concrete and shall be removed from site immediately, failing which, the Engineer shall be at liberty to get the materials removed and the cost incurred thereof shall be realised from the Contractor's dues. The Contractor shall maintain up-to-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



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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.



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- 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



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Washing and screening of coarse and fine aggregates to remove fines, dirt, or other deleterious materials shall be carried out by approved means as desired by the Engineer.

3.02.00 Admixture

All concrete shall be designed for normal rate of setting and hardening at normal temperature. Variations in temperature and humidity under different climatic conditions will affect the rate of setting and hardening, which will, in turn, affect the workability and quality of the concrete. Admixtures including plasticisers of approved make may be used with the Engineer's approval in accordance with IS-456 to modify the rate of hardening, to improve workability or as an aid to control concrete quality. The Engineer reserves the right to require laboratory test or use test data, or owner satisfactory reference before granting approval. The admixture shall be used strictly in accordance with the manufacturer's directions and/or as directed by the Engineer.

3.03.00 Grades of Concrete

Concrete shall be in one of the grades designated in IS: 456. Grade of concrete to be used in different parts of work shall be as shown on the drawing. In case of liquid retaining structures, IS: 3370 will be followed. Minimum cement content shall be as per IS: 456.

3.04.00 Proportioning and Works Control

3.04.01 General

“Design Mix Concrete” and “Nominal Mix Design” is defined as follows for use in this specification:

- Proportioning of ingredients of concrete made with preliminary tests by designing the concrete mix. Such concrete shall be called "Design Mix Concrete".
- Proportioning of ingredients of concrete made without preliminary tests adopting nominal concrete mix. Such concrete shall be called "Nominal Mix Concrete".

As far as possible, design mix concrete shall be used on all concrete works. Nominal mix concrete, in grades M-15 or lower only may be used if shown on drawings or approved by the Engineer. In all cases the Proportioning of ingredients and works control shall be in accordance with IS: 456 and shall be adopted for use after the Engineer is satisfied regarding its adequacy and after obtaining his approval in writing.

3.04.02 Mix Design Criteria



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Concrete mixes will be designed by the Contractor to achieve the strength, durability, and workability necessary for the job, by the most economical use of the various ingredients. In general, the design will keep in view the following considerations

- a) Consistent with the various other requirements of the mix, the quantity of water should be kept at the lowest possible level.
- b) The nominal maximum size of coarse aggregate shall be as large as possible within the limits specified.
- c) The various fractions of coarse and fine aggregates should be mixed in such a proportion as to produce the best possible combined internal grading giving the densest and most workable mix.
- d) The finished concrete should have adequate durability in all condition, to withstand satisfactorily the weather and other destruction agencies, which it is expected to be subjected to in actual service.
- e) The mix design shall have required workability and characteristic strength as per IS: 456. The quantity of cement, aggregates, and admixtures shall be determined by mass.

The requirement of adequate structural strength is catered for by the choice of proper grade of concrete in structural design. The Contractor will strictly abide by the same in his design of concrete mix installation. Various trials shall be given by the contractor with specific cement content on each trial. In some cases, plasticizers and other admixtures may be necessary to achieve the desired results.

3.05.00 Strength Requirements

The strength requirements of both design mix and nominal mix concrete where ordinary Portland Cement or Portland Blast furnace slag cement is used, shall be as per IS:456. All other relevant clauses of IS:456 shall also apply.

3.06.00 Minimum Cement Content

The minimum cement content for each grade of concrete shall be as per IS: 456. Contractor has to consider actual environmental exposure condition at site. Based on various tests results and as per Engineer, the environment condition shall be adopted for which minimum cement content shall be considered. No extra payment shall be made on account of any variation in environment condition.

- a) Sufficient number of trial mixes (to be decided by the Engineer) will be



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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.



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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 equipments, roads



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Low	25	50	Uncongested wide and shallow R.C.C. structures
Medium	50	100	Deep but wide R.C.C. structures with congestion of reinforcement and inserts
High	100	150	Very narrow and deep R.C.C. structures with congestion due to reinforcement and inserts.

Note: Notwithstanding anything mentioned above, the slump to be obtained for work in progress shall be as per direction of the Engineer.

With the permission of the Engineer, for any grade of concrete, if the water has to be increased in special cases, cement shall also be increased proportionately to keep the ratio of water to cement same as adopted in trial mix design for each grade of concrete. No extra payment will be made for this additional cement.

The workability of concrete shall be checked at frequent intervals by slump tests.

3.09.00 Size of coarse Aggregates

The maximum size of coarse aggregates for different locations shall be as follows unless otherwise directed by the Engineer

Very narrow space	- 12 mm
Reinforced concrete Except foundation	- 20 mm
Ordinary Plain concrete and Reinforced concrete foundations	- 40 mm
Mass concrete	- 80 mm
Lean concrete	- 40 mm

Grading of coarse aggregates for a particular size shall conform to relevant I.S. Codes and shall also be such as to produce a dense concrete of the specified proportions, strength and consistency that will work readily into position without segregation.



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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.



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Regular checks on mixer efficiency shall be carried out as directed by the Engineer as per IS: 4634 on all mixers employed at site only those mixers whose efficiencies are within the tolerances specified in IS: 1791 will be allowed to be employed.

Batching Plant shall conform to IS: 4925. The measuring gauges of batching plant shall be periodically calibrated for which the contractor shall provide standard weights. The accuracy of all gauges shall be within limits prescribed by the Engineer.

When hand mixing is permitted by the Engineer, for unimportant out of the way locations in small quantities, it shall be carried out on a water-tight platform and care shall be taken to ensure that mixing is continued until the mass is uniform in colour and consistency. In case of hand-mixing, 10% extra cement shall be added to each batch at no extra cost to the owner.

3.11.00 Conveying Concrete

Concrete shall be handled and conveyed from the place of mixing to the place of laying as rapidly as practicable by approved means and placed and compacted in the final position before the initial setting of the cement starts. Concrete should be conveyed in such a way as will prevent segregation or loss of any of the ingredients. For long distance haulage, agitator cars of approved design will be used. If, in spite of all precautions, segregations does occur during transport, the concrete shall be properly re-mixed before placement. During very hot or cold weather, if directed by the Engineer, concrete shall be transported in deep containers, which will reduce the rate of loss of water, by evaporation or loss of heat. If necessary, the container may have to be covered and insulated. Conveying equipments for concrete shall be well maintained and thoroughly cleaned before, commencement of concrete mixing. Such equipments shall be kept free from set concrete.

3.12.00 Placing and Compacting Concrete

Where specifically covered, the relevant I.S. Code will be followed for the procedure of surface preparation, placement, consolidation, curing, finishes, repairs and maintenance of concrete. If, however, there is no specific provision in relevant I.S. code for any particular aspect of work, any other standard code of practice, as may be specified by the Engineer, will be adopted. Concrete may have to be placed against the following types of surfaces:

- a) Earth foundation
- b) Rock foundation
- c) Formwork



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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



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placing & consolidation of concrete.

The rate of placement of concrete shall be such that no cold joint is formed and fresh concrete is placed always against green Concrete, which is still plastic and workable. No concrete shall be placed in open, during rains. During rainy season, no placement in the open is to be attempted unless sufficient tarpaulins or other similar protective arrangement for completely covering the still green concrete from rain is kept at the site of placement. If there has been any sign of washing of cement and sand, the entire affected concrete shall be removed immediately. Suitable precautions shall be taken in advance to guard against rains before leaving the fresh concrete unattended. No accumulation of water shall be permitted on or around freshly laid concrete.

Slabs, beams, and similar members shall be poured in one operation, unless otherwise instructed by the Engineer. Mouldings, throating, drip course, etc., shall be poured as shown on the drawings or as directed by the Engineer. Holes shall be provided and bolts, sleeves, anchors, fastenings, or other fixtures shall be embedded in concrete as shown on the drawings or as directed by the Engineer. Any deviation there from shall be set right by the Contractor at his own expense as instructed by the Engineer.

In case the forms or supports get displaced during or immediately after the placement and bring the concrete surface out of alignment beyond tolerance limits, the Engineer may direct to remove the portion and reconstruct or repair the same -at the Contractor's expense.

The Engineer shall decide upon the time interval between two placements of concrete of different ages coming in contact with each other, taking in consideration the degree of maturity of the older concrete, shrinkage, heat dissipation and the ability of the older concrete to withstand the load imposed upon it by the fresh placement.

Once the concrete is deposited, consolidated and finished in its final position, it shall not be distributed.

3.13.00 Construction Joints and Cold Joints

3.13.01 Construction Joints

It is always desirable to complete any concrete structure by continuous pouring in one operation. However, due to practical limitation of methods and equipment and certain design considerations, construction joints are formed by discontinuing concrete certain predetermined stages. These joints will be formed in a manner specified in the drawings/Instruction.

Vertical construction joints will be made with rigid stop-board forms having



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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



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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.



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- 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



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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



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satisfactory action is taken by the Contractor within 3 (three) hours of issuance of such instruction, the Engineer will be at liberty either to employ sufficient means through any agency to make good the deficiency and recover the cost thereof from the Contractor, or deduct certain amount from contractor's payment for the part where inadequate curing was noticed entirely at the discretion of the Engineer.

3.16.00 Reinforcement

Mild steel round bars, TMT bars, Hot rolled deformed bars or cold twisted deformed bars as medium tensile or high yield strength steel, plain hard drawn steel wire fabric etc, will be used as reinforcement as per drawings and directions. In an aggressive environment an anti-corrosive coating on the reinforcement may be provided as per IS: 9077, as shown on the drawing or as directed by the Engineer.

3.16.01 Bar Bending Schedules

The Contractor shall prepare **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



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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.



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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



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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



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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.



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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



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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.



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- 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



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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



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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.



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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



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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



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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



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depending on the type of formwork. The formwork shall be removed within 24 hours after concreting. Within 2 hours of striking of the formwork the retarder shall be washed off with strong water jet to make surface rough and clean. Then a rich cement mortar using cement, sand and aggregates (maximum size 8 mm) along with synthetic rubber emulsion type water resistant bonding agent shall be applied for a depth of 50 mm just before pouring the next stage of concreting. In case of walls, the above bonding agent will be mixed with water, which will be used for making the cement mortar. The proportion of mixing of this bonding agent with water shall be as per manufacturer's specification. In case of floor joint, however, after washing of retarder a solvent free two-component epoxy resin-bonding agent will be used at the joint before the next pour of concrete. The above bonding agent shall have the following properties after 28 days

Compressive strength	-	55 to 60 N/Sq.mm
Flexural strength	-	5 to 30 N/sq.mm
Tensile strength	-	15 N/Sq.mm (approx.)
Bonding strength to concrete	-	3 N/Sq.mm (approx.)
Bonding strength to steel	-	20 N/Sq.m (approx.)

The whole operation shall be done as per manufacturers specification. The contractor shall provide manufacturer's supervision at no extra cost to the owner.

Method 2: One row of threaded nozzles at regular intervals not exceeding 1.5 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



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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 plasticizer will be preferable.

- a) In concrete: The admixtures shall be procured from reliable and reputed manufacturers and approved by the Engineer. The method of application and other details shall conform to the manufacturer's specification and/or as instructed by the Engineer. The Contractor shall have the services of the manufacturer's supervisor at no extra cost to supervise the work, if desired by the Engineer.
- b) In Plaster: The concrete surface, to be plastered, shall be hacked to Engineer's satisfaction, cleaned thoroughly and kept wetted for 24 hours. The plaster shall be in cement sand mortar mixed in proportion varying from 1:1 to 1:4 by volume along with the approved waterproofing admixture and laid in appropriate thickness and in layers not exceeding 15 mm/layer or as per manufacturer's specification. The additive shall be of quality and type approved by the Engineer. If desired by the Engineer, the Contractor shall have the work supervised by the manufacturer's supervisor at no extra cost. On completion, the Plastered surface shall be cured continuously for a minimum period of 14 days like concrete.

3.26.04 Structural waterproofing

- a) Nozzles spaced as required after the concrete is completed shall be drilled into surfaces to be rendered watertight. Non-shrink cement grout with waterproofing compound as per manufacturers specifications shall be injected under pressure to seal all voids. Special care shall be taken at joints by providing additional nozzles. The pressure grouting shall be done on the internal surface.

- b) External Treatment

Two layers of (1:4) plaster of 12 mm thick each with waterproofing compound as per manufacturer's specification shall be provided on outer surface of concrete underground structures.

3.26.05 Protective coating on Inside Surface.

Two coats of cement based two components polymer modified flexible protective and waterproofing slurry having 1 mm thick for each coat shall be applied on the walls/floor after proper surface preparation as mentioned above. The slurry shall be applied by brush.



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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



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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), 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



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works unless satisfactory 3 (three) days and 7 (seven) days test results for compressive strength are known. The Engineer and Contractor will jointly associate themselves with the tests irrespective of whether they are carried out by the BHEL or the Contractor. These tests are of great importance, as their results will have a bearing on the acceptance of concrete or otherwise as per the terms and conditions of the Contract.

4.03.00 Aggregates

The contractor shall carry out any or all the tests on aggregates as may be required by the Engineer in accordance with IS: 2386 PARTS-I to VIII. The acceptance criteria of the samples tested shall be in accordance with the requirements of the relevant Indian Standards.

4.04.00 Water

Sampling and Testing of water being used for concrete works as per IS: 3550 will be carried out by the Contractor at regular intervals and whenever directed by the Engineer. The acceptance criteria will be as per IS: 456.

4.05.00 Admixture

4.05.01 Air Entraining Agents

Initially, before starting to use A.E.A., relationship between the percentage of air entrained and the cylinder cube crushing strength vis-a-vis quantity of A.E.A. used for all types of concrete will be established by the Contractor by carrying out sufficiently large number of tests. After that, at regular intervals and whenever directed by the Engineer, the Contractor will check up the actual percentages of air entrained and corresponding crushing strengths to correlate with the earlier test results.

4.05.02 Other Admixtures

Tests for establishing the various properties of any other admixtures, which may be required to be added, shall be carried out by the Contractor.

4.06.00 Concrete

The sampling of concrete, making the test specimens, curing and testing procedure etc. shall be in accordance with IS: 516 and IS: 1199, the size of specimen being 15 cm cubes. Normally, only compression tests shall be performed but under special circumstances the Engineer may require other tests to be performed in accordance with IS: 516. Sampling procedure, frequency of sampling and test specimen shall conform to IS: 456. To control the consistency of concrete from every mixing plant, slump tests shall be carried out by the Contractor every two hours or as directed by the Engineer.



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Slumps corresponding to the test specimens shall be recorded for reference. The acceptance criteria of concrete shall be in accordance with IS: 456. Concrete work found unsuitable for acceptance shall have to be dismantled and replacement is to be done as per specification by the Contractor at his own cost. In the course of dismantling, if any damage is done to the embedded items or adjacent structures, the same shall be made good, free of charge by the Contractor, to the satisfaction of the Engineer.

5.00.00 ACCEPTANCE CRITERIA

5.01.00 Standard Deviation

Standard deviation shall be based on test results and determination of Standard deviation shall conform to IS: 456.

5.02.00 Acceptance Criteria

The strength requirements and acceptance criteria shall conform to IS: 456.

5.03.00 Inspection and Core Tests

Inspection of concrete work immediately after stripping the formwork and core test of structures shall conform to IS: 456.

5.04.00 Load Test

Load tests of structural members as per IS:456 may be required by the Engineer, when the strength of test specimen results falls below the required strength.

If the member shows evident failure, the Contractor shall make the structure adequately strong free of cost to BHEL.

The entire cost of load testing shall be borne by the Contractor. If a portion of the structure is found to be unacceptable, it shall be dismantled and replaced by a new structure as per specification. The entire cost of dismantling and replacement and restoration of the site being borne by the Contractor.

If, in the course of dismantling, any damage is done to the embedded items and or other adjacent structures, the same will be made good, free of charge by the Contractor to the satisfaction of the Engineer.

6.00.00 RATES AND MEASUREMENTS

6.01.00 Cast-in-situ Concrete

6.01.01 Rates



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- a) The unit rates shall include the cost of labour, materials, equipment, handling, transporting, botching, mixing, placing in position, vibrating, compacting, finishing, curing, testing, etc. at all elevations. This shall include the cost of curing by regular wetting or by using curing compound.
- b) The unit rates shall include for all working conditions including at locations under water, liquid, mud, in or under foul positions and extreme weather conditions.
- c) The unit rates for exposed concrete works (including machine foundations) shall include all incidentals, rendering, smoothening with carborandum stone, finishing with a paste of cement sand mortar, curing, etc.
- d) The unit rates shall include all arrangement for maintaining stability of structure during execution.
- e) Nothing extra shall be payable for the handling/mixing of extra cement on account of any reason or pouring of second stage concrete.
- f) Nothing shall be payable to the Contractor on account of facilities and arrangement provided by him for conducting ultrasonic pulse velocity (UPV) tests or other relevant tests to ascertain grade and quality, etc. of the concrete in case the concrete quality is in doubt and contractor has to establish the quality by further tests. In case of any defects, the Contractor shall rectify the same by cement/epoxy grout at his own cost.

However, mandatory UPV test as specified in the drawings shall be carried out including arrangement of all its facilities, staging, etc. and shall be payable to the contractor as per BOQ item.
- g) The unit rates for controlling of the temperature of concrete shall include storing and mixing of ice, water, cooling of aggregate etc.
- h) The quoted rate shall include the cost of MIX design, making of all trial mixes using admixtures and mixing in concrete etc. complete.

6.01.02

Measurements

- a) Actual volume of concrete work as executed or as per drawings issued, whichever is less shall be measured in cubic metres to the nearest two decimals.
- b) No deductions shall be made for the following:
 - i) Ends of dissimilar materials embedded inside for example, beams, posts, girders, rafters, purlins, trusses, corbels and steps upto 500 sqcm



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in cross section;

ii) Opening upto 0.1 sq.m.

iii) Volume occupied by reinforcement, sleeves, anchor bolts, and similar items.

iv) Volume occupied by pipes, conduits, sheathing, etc. not exceeding 100 sq.cm. each in cross sectional area.

c) The concrete works of different grades; below and above ground floor finished level shall be measured separately, unless otherwise specified in the schedule of items. Accordingly rates shall be applied for concrete in foundation for concrete below ground floor finished level and concrete in superstructure for concrete above ground floor finished level.

d) For temperature control measures, measurement shall be done in terms of quantity of concrete in cum. in concreting of which the ice have been used or cooling of aggregates has been done to keep the temperature of freshly laid concrete to less than 23°C.

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.



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- 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 along with 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



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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.



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- b) Embedded steel parts supplied by Owner and installed by Contractor Measurement shall be done for the net weight of the embedments installed in tonnes correct to second place of decimal.
- c) For PVC pipes/conduits, measurements shall be in quintals correct to second place of decimal for the net weight.
- d) For mild steel pipes, measurement shall be in quintals, correct to second place of decimal, for the net weight of the steel pipe supplied, fabricated, and installed.
- e) The lugs shall be measured in Kg. correct to second place decimal for the net weight.
- f) The expansion fasteners shall be measured in number according to tension capacity.
- g) The rails shall not be treated as embedded steel part and the track shall be measured in running metres along the centre line and paid for under separate item of work as specified in schedule of items. Other related civil items associated with the laying of track shall be measured separately and paid under respective items of works.

6.05.00 Groutings

6.05.01 Rates

Rate shall include the cost of surface preparation, admixtures, and curing.

6.05.02 Measurements:

- a) Measurement shall be in cubic decimeters.
- b) Measurement for grouting shall be by volume of the block out, pockets or bolt hole upto the top surface of foundation concrete and shall be calculated from the dimensions shown on the drawings.
- c) Measurement for underpinning shall be by volume between the top surface of the foundation concrete and the underside of the base plate, the plan dimensions being as indicated on the drawings.
- d) No deduction shall be made for shims, bolts, shear keys and such other embedments.
- f) Pressure injection grouting with cement based grout if required as per drawing shall be applied at appropriate spacing to cover the desired



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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 tightness 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.



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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



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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



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- 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)



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- 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



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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.



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- 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 shotcreting.
- 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



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Reinforcement in RB and RCC Construction.

IS: 9103 - Indian Standard Specification for Admixtures for Concrete.

IS: 10262 - Recommended Guidelines for Concrete Mix Design.

IS: 13311 - Non-destructive testing of concrete.

SP: 34 - Handbook of concrete, reinforcement and detailing.



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



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CARPENTRY AND JOINERY

1.00.00 SCOPE

This section covers supply, fitting and fixing of timber frames to doors and windows with M S holdfasts, flush doors, windows, shutters, partitions, wall panelling, pelmets, shelves, furniture, etc. as shown in drawings, including a prime coat of approved paint, varnish, or fixing of decorative plastic laminate where called for. This shall also include the supply and fixing of all hardware and fixtures shown in drawing or specified.

2.00.00 INSTALLATION

2.00.01 Materials

a) Timber

Unless otherwise specified, all timber shall be best quality well seasoned CP teakwood free from large or loose knots, cracks or any other defects. All timber shall be treated with approved wood preservative before use, unless specified otherwise. The rough timber shall be approved by the Engineer before incorporating in the works and starting the carpenter's work.

b) Plywood

Plywood shall be of commercial quality or with decorative surface veneer. Unless specifically permitted otherwise, the adhesive used in plywood shall be phenol formaldehyde synthetic resin of BWP grade conforming to IS: 848.

c) Decorative Laminated Plastic Sheets

The colour, pattern, finish and texture shall be approved by the Engineer. The bulk supply shall be procured in full sheet sizes which will ensure the least number or joints in one surface.

d) Flush Doors

Flush doors shall be solid core doors with commercial or decorative faces and hardwood edges conforming to IS: 2202 (Part-1). The core for solid core doors shall be of block board or wood particle board. Manufacturer's literature and test certificates shall be submitted for the approval of the Engineer. The Contractor shall give a guarantee that the adhesive used is BWP grade phenol formaldehyde synthetic resin conforming to IS: 848. The thickness shall be as specified.



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e) Panel Doors

Panel door shall be of teakwood shutter frame, unless otherwise noted and panels with teakwood/commercial ply/teakwood particle board. Other considerations shall be as mentioned in item (d) above.

f) Windows, Ventilators

Windows and ventilators shall made of teakwood shutter frame, unless specified otherwise and glazing of specified thickness shall be fixed with wooden beadings.

g) Fixtures

Fixtures for doors, windows, furniture etc. shall be as shown on drawing or specified.

2.02.00 Workmanship

2.02.01 General

The work shall be done by skilled carpenters as per details shown on drawing or instructed by the Engineer.

Framing timber and other work shall be close - fitting with proper wood joinery, accurately set to required lines or levels and rigidly secured in place. The surface of frames etc., which will come in contact with masonry after fixing, shall be given two coats of approved paint before fixing. Mastic caulking shall be done after fixing external door and window frames. Special care shall be taken to match the grain of timber or plywood, which will be subsequently polished. Screwing or nailing will not be permitted to the edge of plywood and particle board. The edge of all plywood, blackboard and particle board shall be finished with teakwood lipping unless otherwise shown on drawings.

Fixing to frames and partitions shall generally be with 40 mm x 6 mm x 300 mm long M S holdfasts bifurcated at end and grouted with 1:2:4 cement concrete. The gap between masonry and external door and window frame shall be caulked with polysulphide mastic. M.S. grills or guard bars shall be provided to windows where called for in the drawings.



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2.02.02 Finish

All carpentry work after finishing shall be sand papered smooth. A prime coat paint shall be given after inspection of the Engineer to all surfaces other than those, which shall be subsequently polished or covered with laminated plastic sheet.

2.02.03 Surface Treatment

When shown on drawings or called for, decorative ply or laminated plastic sheets shall be bonded under pressure to the surface to be finished. The adhesive used shall be of brand and brought to site in sealed containers. The rate of application and the length of time for which the pressure is to be applied shall be as per the manufacturer's instructions. The edge of sheets shall be protected by teak lipping or bevelled as shown on drawings.

3.00.00 ACCEPTANCE CRITERIA

3.00.01 Door and Window Frames

All frames shall be square and flat at the time of delivery and shall be checked for dimensions and corner angles. After fixing they shall be on a fine vertical plane. All external door and window frames shall be caulked with mastic.

3.02.00 Door and Window Shutters

All doors and window shutters shall be of proper size, shape, and design and free of warp. When fixed to frames, these shall operate smoothly without jamming and all latching or locking devices shall engage properly without undue pressure.

3.03.00 Partitions, Paneling, Pelmet, Furniture, etc.

3.03.01 General

These shall conform to drawings in all details. No unsightly nail marks etc. shall be permitted. Plywood grains shall be matched to give a uniform and pleasing appearance.

3.03.02 Partition

Shall be checked for rigidity of fixing, plumb and horizontal as well as vertical alignment.



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3.03.03 Pelmets

Shall be checked for rigidity of fixing and adequate clearance of fixture.

3.03.04 Cupboard Shutters

Shall operate smoothly without jamming and locks, bolts and double ball catches shall engage securely. Single ball catches shall not be used.

3.03.05 Drawers

Shall operate smoothly and have backstops to prevent them from being pushed too far. Locks shall engage securely.

3.03.06 Loose Furniture

When placed on a level surface, tables tops etc. shall be horizontal and the pieces stand stably on legs or supports.

4.00.00 IS CODES

All work shall be carried out as per this specification and shall conform to the latest revision and/or replacements of the following or any other Indian Standard (IS) Codes, unless specified otherwise. In case any particular aspect of work is not specifically covered by Indian Standard Codes, any other standard practice, as may be specified by the Engineer, shall be followed.

IS: 848 - Synthetic resin adhesives for plywood (Phenolic and Aminoplastic)

IS: 1003 - Timber panelled and glazed shutters.

IS: 2191 - Wooden flush door shutter (Cellular and hollow core type).

IS: 2202 - Wooden flush door shutters (solid core type).

IS: 4021 - Timber door, window, and ventilator frames.

5.00.00 RATES AND MEASUREMENT

5.01.00 Rates

Rates shall include of all activities mentioned in "Schedule of Item" for completion of the work. No separate payment shall be made for fixing, caulking, application of primer coat, polishing, providing of butt hinges,



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holdfasts, sliding/tower bolts, door stoppers, door closers and other fittings and fixtures.

5.02.00

Measurement

Measurement shall be done in Sqm for doors, windows, ventilators, shutters, partitions etc.

Measurement for wooden frame shall be in CuM.

Pelmets shall be measured in RM.



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ROOF AND UNDERGROUND
STRUCTURES WATER PROOFING,
INSULATION AND ALLIED WORKS**

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**ROOF AND UNDERGROUND STRUCTURES WATER
PROOFING, INSULATION AND ALLIED WORKS**

SPECIFICATION NO. PE-TS-999-600-C004



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



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INSULATION AND ALLIED WORKS**

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**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



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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 Expanded 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



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approved specification. Only specifically experienced workers shall be used for this work. If the Engineer is not satisfied about the efficiency of the workers the Contractor shall secure manufacturers supervision at no extra cost to the Owner.

2.03.00 Fillets

Fillets at Junction of roofs and vertical walls shall be provided with the same insulating material as provided for the main roof insulation. The fillets shall be 150 mm x 150 mm in size unless otherwise shown on drawings or instructed by the Engineer.

Where there is no insulation over roof slab, fillets shall be cast-in-situ cement concrete (1:2:4) nominal mix volume.

2.04.00 Waterproofing Treatment

2.04.01 Bitumen Felt Treatment

Waterproofing treatment shall be laid by a specialist firm with long experience in the particular trade.

The waterproofing treatment for roofs with bitumen felts shall be done following relevant IS: 1346. Bitumen felt shall conform to IS: 1322 and Bitumen primer to IS: 3384.

The bonding materials shall consist of blown type conforming to IS: 702 or residual bitumen conforming to IS: 73 or a mixture of the two to withstand local conditions of prevailing temperature or gradient of roof surface. The Contractor shall convince the Engineer that the bonding material proposed to be used is suitable for the particular job.

The Contractor shall state the source from where he proposed to procure the materials. Samples of the self-finished felt shall be submitted in advance to the Engineer along with test certificates for his review. Test certificates for the bonding materials shall also be submitted and samples, if desired by the Engineer, shall be provided for confirmatory tests. Samples shall be submitted if instructed by the Engineer.

Minimum overlaps of 100 and 75 mm shall be given at the end and sides of strips of felt and properly bonded with bitumen. Joints in successive layers of felt shall be staggered.

Normal treatment with one layer of felt, heavy treatment with two layers of felt or Extra Heavy treatment with three layers of felt shall be indicated. Brief details of the various treatments shall be as follows:



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a) Normal Treatment - Five courses

- 1) Primer coat conforming to IS:3384 applied at the rate 0.27lits/sqm min.
- 2) Hot applied bitumen at the rate of 1.2 kg/sq.m. (min.)
- 3) Hessian base self finished felt, type 3, grade 1.
- 4) Hot applied bitumen at the rate of 1.2 kg/sq.m. (min.)
- 5) 20 mm thick pressed precast concrete tiles with 15 mm, thick 1:4 cement-sand mortar underbed.

b) Heavy Treatment - Seven Courses

With Hessian base felt

- 1) Primer coat conforming to IS:3384 applied at the rate 0.27lits/sqm min.
- 2) Hot applied bitumen at the rate of 1.2 kg/sq.m (Min.)
- 3) Hessian base self-finished felt, type 3, grade 1.
- 4) Hot applied bitumen at the rate of 1.2 kg/sq.m (Min.)
- 5) Hessian base self-finished felt, type 3, grade I.
- 6) Hot applied bitumen at the rate of 1.2 kg/sq.m (Min.)
- 7) 20 mm thick pressed precast concrete tiles with 15 mm thick 1:4 cement: sand mortar underbed.

or

With 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.)



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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.



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- 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 ASTM C836-89a 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°C 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



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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 (using 12.5mm 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



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and the epoxy resin based material to be applied as directed by the manufacturer. The material shall not have any adverse effect on the surface on which it is applied and must stick to it uniformly to make a strong durable bond. It shall not be affected by short duration fire, sun exposure, and light duty traffic. The application shall be resistant to growth of fungus and proof against saltpetre action. If desired by the Engineer, a sample shall be prepared in advance and tested for waterproofness for 48 hours under 300 mm depth of standing water. The Contractor shall arrange the demonstration by providing free the materials and labour for the application as free of cost to Owner. This item shall carry a guarantee as specified.

2.04.02 Flashing

Unless otherwise stated flashing shall be done in the same way as the waterproofing except that the last layer shall be finished with two coats of bituminous primer. The flashing shall be extended up the vertical surfaces as shown on drawing. The flashing shall end in grooves in vertical walls. The grooves shall be at least 65 mm deep and caulked with waterproof mastic cement. The minimum overlap with horizontal roofing felt shall be 100 mm.

Where specified or directed by the Engineer, metal flashing shall be provided. The materials shall be 18 Gage or 22 G G.I. sheets, as specified or as directed by the Engineer.

2.05.00 WATER-PROOFING OF UNDERGROUND STRUCTURES

Basements, ducts, pits, tunnels (excluding tanks) etc below the ground water table and in contact with soil are covered under this. Bonding material shall be blown bitumen of 65/25 grade conforming to IS: 702.

Waterproofing shall be provided on the outside of walls and top of RCC slab and shall be carried out upto 150mm above ground level. The number of layers of bitumen felt to be used for walls and floor unless otherwise shown in the drawing shall be:

- a) 2 layers - for depths up to 5m below ground level
- b) 3 layers - for depths beyond 5m below ground level

2.05.01 Method of laying the bitumen felts and workmanship shall be as per IS: 1609 and IS: 3067. Water proofing work shall be taken in hand only when the sub-soil water level is at its lowest; the site shall be kept dry by adequate arrangements for pumping out water till the work has been completed.

For this purpose drains shall be formed along the edges of the excavation but beyond the building line, with suitable collecting sumps.



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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



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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



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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.



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Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
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METAL DOORS, WINDOWS, VENTILATORS, LOUVERS ETC.**1.00.00 SCOPE**

This section covers supplying and/or erecting and installing of all metal doors, windows, ventilators, louvers, glazed partitions, etc. The scope of work shall also include the assembly and erection of all doors, windows, louvers, glazed partitions, etc. Supplying and/or fixing of all door and window accessories and hardware are also included in the scope.

2.00.00 INSTALLATION**2.01.00 Materials**

Steel sections used for fabrication of doors, windows etc. shall be standard rolled steel sections specified in IS: 1038 and IS: 1361 or as specified.

Steel sheets for frames, shutters, louver blades etc. shall be of gauge mentioned in drawings and schedules.

Aluminium sections for fabricating doors, windows, partitions etc. shall be extruded sections conforming to IS:733 or IS:1285 or as manufactured by Indian Aluminium Company Limited or approved equivalent. Aluminium door, windows and ventilator shall be fabricated as per IS:1948 and IS:1949. The alloy used shall conform to IS Designation HE 9-WP of IS: 733.

Hardware and fixtures shall be as specified and the best quality from approved manufacturers shall only be used. The tenderer shall specifically state the particular manufacturer's materials he proposes to use. Improper alignment or faulty operation due to inadequate strength of hardware or fixture shall entirely be the Contractor's responsibility.

All hardware and fixtures shall be able to withstand repeated use. Door closures shall conform to IS: 3564 and shall be suitable for doors weighing 61-80 Kg. unless otherwise stated. Each closer shall be guaranteed against manufacturing defect for one year and any defect found within this period shall be rectified or shall be replaced free of charge. Concealed door closers shall be either floor mounted or transom mounted, suitable for installation with metal doors. It shall conform to the performance Requirements and endurance test stated in IS: 3564 - Appendix-A. The Contractor shall submit samples of each type of hardware to the Engineer. The approved samples shall be retained by the Engineer for comparison of bulk supply. The samples shall be returned to the Contractor towards end for incorporation in the job. The mastic for caulking shall be of best quality from a manufacturer approved by, the Engineer. In general, mastic for fixing of metals frames shall be as per IS: 1081 or as approved by the Engineer.



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2.02.00 Fabrication**2.02.01 Steel Doors, Windows, Ventilators, louvers etc.****a) Door Frames**

Frames shall be fabricated from 16 gage(G) sheets. They shall, be mortised, reinforced, drilled, and tapped for hinge lock and bolt strikes. Where necessary, frames shall be reinforced for door closers. Welded construction with mitered Corners shall be used. Rubber door silencers shall be furnished for the striking jamb. Loose “T” masonry anchors shall be provided. Frames shall finish flush with floor and adjustable floor anchors shall be installed. Frames shall be brought to site with floor ties/weather bars installed in, place.

b) Double Plate Flush Door Shutters

Door shutters shall be 45 mm thick, completely flush design and shall comprise of the outer sheets or 18 G steel sheets, rigidly connected and reinforced inside with continuous vertical 20 G stiffeners, spot welded in position at not more than 150 mm on centres.

Both edges of doors shall be joined and reinforced full height by steel channels placed immediately inside and welded to the door faces. Top and bottom of doors shall be reinforced horizontally as shown on drawing by steel channels running full width of door. Doors shall not have more than 2.5 mm clearance at jambs and heads, shall have proper level on lock stiles and rails to operate without binding, and shall be reinforced at corners to prevent sagging or twisting. Pairs or double doors shall have meeting-stile edges bevelled or rebated. Where shown on drawing, or called for in the schedule of items, the doors shall be sound deadened by filling the inside voids with mineral wool or other suitable approved materials.

Doors shall be mortised, reinforced, drilled, and tapped in shop for hinges, locks, and bolts. They shall also be reinforced for closers, push-plates, and other surface hardware where necessary. Any drilling and tapping required for surface hardware shall be done at site. Where shown drawing, provision shall be made for fixing glazing, vision panels, louvers etc. glazing mouldings shall be of 18 G steel or extruded aluminium sections and suitable for fixing 6 mm. glass. Louvers blades shall be V or Z shaped and made out of 16 G sheets.



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c) Single Sheet Door Shutters

Single sheet doors shall be made from best quality 18 G mild steel sheets, and shall present a flush surface on the outside. The inside shall be stiffened with semi tubular edge and central stiffening rail, which shall convey the lock and other fixture. The frames shall be made from best quality, 16 G mild steel sheets.

Wherever required, provisions for fixing glass panes, louvers etc. shall be made.

The manufacturing shall be done as specified in 2.02.01 (b) “Double Plate Flush Door Shutters.”

d) Sliding Door

Sliding doors shall be either double plate or single plate Construction made out of 18 gauge steel sheets with adequate stiffeners. The contractor shall specify the weight of the door in his shop and submit the manufacturer's catalogue of the sliding gear he proposes to use. Where called for the Contractor shall make provision for openings to the door for monorail beams. Doors shall close positively to exclude rainwater from seeping in. When called for, sliding doors shall withstand specified wind loads without buckling or jamming. The door shall slide freely under all ambient conditions.

e) Door Threshold

Door threshold shall be provided. Doors without threshold shall have bottom tie of approved type.

f) Steel Windows, Sashes, and Ventilators etc.

These shall conform in all respects to IS: 1038 and IS: 1361 latest editions. The details as called for in the above codes shall be applicable for coupling mullions, transoms, weather bars, and pivot arrangements for ventilators, etc. or as called for. All welds shall be dressed flush on all exposed and contact surfaces. Where composite unit openings are required the individual window units shall be joined together with requisite transoms and mullions. All windows shall be outside glazed, fixed with putty or metal glazing beads as specified. Where aluminium glazing beads are specified, they shall be extruded aluminium channel 9.5 mm x 9.5 mm x 1.6 mm (Indal Section No. 2209) unless otherwise shown on drawings. Aluminium beads shall be given one coat of zinc chromate primer before fixing to windows.



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2.02.02 Aluminium Door, Windows, and Frames

Extruded sections shall have a minimum 3 mm wall thickness. All sections shall be approved by the Engineer before fabrication is taken up. Doors frames, mullions, transom etc. shall be anodized in a bath of sulphuric acid to provide a clear coating of minimum 15 micron thickness. The anodized materials shall then be sealed by immersing in boiling water for 15 minutes. A protective transparent Coating shall be applied to the sections before shipment from the factory.

All work shall be fitted and shop assembled to a first class job, and ready for erection. Shop joints shall be made to hair lines and then welded or braced by such method as will produce an uniform colour throughout the work. Work on the above, other than described, shall be carefully fitted and assembled with neat joints with concealed fasteners. Wherever possible, joints shall be made in concealed locations and on edges of doors. Field connections of all work may be made with concealed screws or other approved type of fasteners. Glazing beads shall be snap fit type without visible screws and shall be of sizes to accommodate 6 mm thick glazing. All work shall be adequately braced and reinforced as necessary for strength and rigidity.

2.03.00 Shop Coat or Paint

The shop Paint for steel doors, windows etc. shall be best lead or zinc chromate primer paint from, approved manufacturer. All surfaces shall be thoroughly cleaned of rust, grease, loose mill scales etc. and given one coat of shop paint. Portions like mullions, transoms etc. that will be inaccessible after assembly of units shall be given an extra coat of paint before assembly.

Where called for, all steel doors, windows, etc. shall be hot dip galvanized to give a coating weight of 1½ - 2 oz. per sqft. One coat zinc chromate primer coat shall then be applied as shop paint.

Portions of aluminium frame, which come in contact with masonry construction shall be (before shipment from workshop) protected with a heavy coat of alkali resistant paint. Aluminium coming in contact with other incompatible metals shall be coated with zinc chromate primer.

2.04.00 Handling & Storage of Fabricated Material

All metal doors, windows, etc. shall be packed and crated properly before dispatch, to ensure that there will be no damage to the fabricated materials. Loading into wagons and trucks shall be done with all care to ensure safe arrival of materials at site in undamaged condition.

When taking delivery of items supplied by Owner, the Contractor shall satisfy



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himself that the items supplied are up to the specified standard. Any defect detected shall promptly be brought to the notice of the Engineer.

All metal doors, windows etc. shall be stored under cover in a way to prevent damage or distortion. Special care shall be taken to prevent staining of aluminium products by rust, mortar etc.

2.05.00**Assembly & Erection at Site**

In general, the fixing of steel doors, windows, ventilators, louvers, etc. shall conform to IS: 1081. The Contractor shall assemble and install all steel doors, windows, sashes, fixed metal louvers, etc. including transoms and mullions for composite units in respective places, keening proper “Lines and levels”, and in approved workmanlike manner, to give trouble free and leak-proof installations. Installation shall be done according to instructions of the manufacturer, and/or as approved by the Engineer. If required by the Engineer, the installation shall have to be carried out under the supervision of the manufacturer's staff. The Contractor shall take all precaution against damage of the components during installation. Necessary holes, chases, etc. required for fixing shall be made by the Contractor and made good again as per original, after installation, without any extra charge.

After installation of steel doors, windows, etc. all abrasions to shop-coat of paint shall be retouched and made good the same quality of paint used in shop coat.

All coupling mullions, transoms, frames, etc. in contact with adjacent steel and other members, shall be well bedded in mastic. The Contractor shall bring to the site the cement in original sealed containers of manufacturer and shall apply it as per the instruction. For all frames supplied by either the owner or the Contractor, mastic shall be supplied by the Contractor and caulking done properly as per drawings, specifications and as per instructions of the Engineer.

Door shutters, partitions hardware fixtures etc. shall be fixed only after major equipments have been installed in rooms.

Wherever required, nylon cords of approved quality shall be supplied along with pivoted sashes and shall be of adequate length to terminate one metres from the floor. Loose ends of cords shall end in metal or plastic pull as approved by the Engineer.

2.06.0**Fire proof Door**

Fire proof doors shall be provided at all fire exit points as specified and also to restrict the spread of fire within buildings whether from internal fire or from external fire. The construction details of door shall conform to the



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requirements stipulated in IS:3614(Part-1). Doors shall comply with the testing requirement mentioned in IS:3614 (Part-2). The doors shall be approved by Tariff Advisory Committee and shall have minimum 2 hrs. fire rating.

Metal covered (on both sides) Doors having insulating core filled up with mineral wool shall be used at all fire exit points and shall open out side.

All necessary accessories and hardware shall also be supplied along with doors. Fire proof door shall be provided with zinc silicate primer (minimum DFT 75 micron) after blast cleaning the surface to near white metal surface and shall be finished painted with epoxy based painting.

3.00.00 ACCEPTANCE CRITERIA**3.01.00 For fabricated Items**

- a) Overall dimensions shall be within ± 1.5 mm of the size shown on drawings.
- b) Mullions, transoms etc. shall be in one length and permissible deviations from straightness shall be limited to ± 1.5 mm from the axis of the member.
- c) Door and window shutters shall operate without jamming. The clearance at head and jamb for door shutters shall not exceed 1.5 mm for double leaf doors; the gap at the meeting stiles shall not be more than 1.5 mm.
- d) Door leaves shall be undercut where shown on drawings.
- e) Doors, windows, frames, etc. shall be on a true planes, free from warp or buckle.
- f) All welds shall be dressed flush on exposed and contact surfaces.
- g) Correctness of location and smoothness of operations of all shop installed hardware and fixtures
- h) Provision for hardware and fixtures to be installed at site.
- i) Glazing beads shall be cut with mitered corners.
- j) Glazing clips, fixing devices etc. shall be supplied in adequate numbers.
- k) Shop coats shall be properly applied.
- l) Exposed aluminum surfaces shall be free from scratches, stains, and discoloration. Anodized surfaces shall present a uniform and pleasing look.

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3.02.00

For installed Items

a)

Installations shall be at correct location, elevation and in general, on a true vertical plane.

b)

Fixing details shall be strictly as shown on drawings.

c)

Assembly of composite units shall be strictly, as per drawings with mastic caulking of transoms and mullions, gaskets, weather strips etc. complete.

d)

All frames on external walls shall be mastic caulked to prevent leakage through joint between frames and masonry.

e)

All openable section shall operate smoothly without jamming.

f)

Locks, fasteners etc. shall be engage positively. Key shall, be non-interchangeable.

g)

Cutting to concrete or masonry shall be made good and all abrasions to shop paint shall be touched up with paint of same quality as shop paint.

h)

Aluminium doors, windows, etc. shall be free from scratches stain or discoloration.

4.00.00

INFORMATION TO BE SUBMITTED

4.01.00

With Tender

a)

Names of manufacturers for Doors, windows etc.

b)

Manufacturer's catalogue for all hardware and fixtures proposed to be used.

4.02.00

After Award

a)

Before starting fabrication of all metal doors, windows, etc. the Contractor shall submit detailed fabrication drawings to the Engineer for approval. The fabrication shall be started only after approval of drawings.

b)

He shall submit a programme of work to be done for the approval of the Engineer.

c)

Before bulk supply, he shall submit for the approval of the Engineer samples of all bought out items and samples of each type of fabricated items. The samples shall by retained by the Engineer for comparison of bulk supply and returned to the Contractor towards the end for final incorporation in the job.



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5.00.00 IS CODES

All work shall be carried out as per this specification and shall conform to the latest revision and/or replacements of the following or any other Indian Standard (IS) Codes, unless specified otherwise. In case any particular aspect of work is not specifically covered by Indian Standard Codes, any other standard practice, as may be specified by the Engineer, shall be followed.

Specification for Wrought Aluminium and Aluminium Alloy bars, rods and sections (for general engineering purpose) - IS: 733

Specification for Wrought Aluminium and Aluminium Alloy, extruded round tube, hollow section (for general engineering purpose) - IS: 1285

Steel doors, windows, and ventilators - IS: 1038

Steel windows for industrial, building - IS: 1361

Aluminium doors windows, and ventilators - IS: 1948

Aluminium windows for industrial buildings - IS: 1949

Steel doorframes - IS: 4351

Code of practice for fixing and glazing of Metal (steel and aluminium) doors, windows and Ventilators. - IS: 1081

Specification for Fire-check Doors – Part 1: Plate, Metal covered and Rolling type - IS: 3614

Hot Rolled Steel Sections for Doors, Windows and Ventilators – Specification - IS: 7452

6.00.00 RATES AND MEASUREMENT**6.01.00 Rates**

Rates shall be applicable of all elevation. Rates shall include preparation of working drawings (if required), supply of material, fixtures, gaskets, erection of unit, caulking and jamming of frames, including cutting/drilling/welding, grouting, grinding, making good of the structure for installing the unit etc. complete as per “Schedule of Items”.



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Rates shall also include cost of surface preparation, application of primer, enamel painting or anodizing as applicable.

Rate for fire proof door is inclusive of providing insulation core, primer, shop painting (epoxy based), all hardware as specified in Schedule of items.

6.02.00**Measurement**

Supply and installation of doors, windows, and ventilators shall be measured in Sqm or Kg as per BOQ item. If measured in sqm, it shall be for net outer to outer (excluding frame) area of doors, windows, and ventilators of each type used as described in “Schedule of Items”. Frame for steel or aluminium shall be measured in Kgs. Wooden frames shall be measured in Cum. Measurement for aluminium partition frames shall be in Kg. Panelling and glazing shall be paid separately if not covered in BOQ item description.

Measurement for fire proof door shall be in SqM in net area outer to outer of the door.



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ANNEXURE-A

SCHEDULE OF FIXTURES

A. TIMBER DOORS

1. For single leaf panel/flush doors

i) 100 mm brass butt hinges with screws	-	3 Nos.
ii) 150 mm brass tower bolts with screws	-	1 No.
iii) 100 mm x 225 mm clear plastic push Plate with counter sunk brass screws	-	1 No.
iv) 30 mm brass ring pull handle with Plates and screws	-	1 No.
v) 150 mm brass coat hook with screws	-	1 No.
vi) Heavy duty, cylinder looks on active leaf - for flush door. For door- closure, see "Door Schedule".		

B. ALUMINIUM DOORS

1. For double leaf door

- | |
|--|
| i) Concealed hanging arrangement for door leaves. |
| ii) Concealed two points bolt encasing simultaneously at head and threshold
on inactive leaf, operable from inside. |
| iii) Heavy duty, cylinder look on active leaf. |
| iv) Pull handle of approved design on both leaves. |
| v) Doors stops for both leaves. |
| vi) Overhead door closure for both leaves. |



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ANNEXURE-A

C. STEEL DOORS AND WINDOWS**1. Doors****a) Double leaf doors**

- i) 100 mm butt hinges - 3 Nos. on each leaf.
- ii) 300 mm aluminum tower bolt - 2 Nos. (top and bottom)
On inside of inactive
Leaf. 1. No. (Top only)
On inside active leaf.
- iii) 200 mm anodized aluminum
pull handle - 1 No. of each leaf.
- iv) Door stop of approved design - 1 No. of each leaf.

NOTE: For locks, door closure and threshold, see "Door Schedule".

b) Single leaf doors

- i) 100 mm butt hinges - 3 Nos.
- ii) 300 mm aluminum tower bolt - 2 Nos. top & bottom of Inside
face
- iii) 200mm anodised aluminum
Pull handle - 1 No.
- iv) Door stop of approved design - 1 No.

NOTE: For locks, door closures and threshold, see "Door Schedule".

2. Windows, Ventilators, etc.**a) Side Hung Windows**

- i) Hinges - As per standard Practice of the
Manufacturer, but minimum two
hinges Per leaf.
- ii) 12" peg stays - 1 No. per leaf

ANNEXURE-A



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iii) 2 point handles - 1 No. per leaf

b) Top Hung Ventilators (Projecting Out)

i) Hinges - As per standard Practice of the Manufacturer, but minimum two hinges Per leaf.

ii) Adjustable sliding fabrication
assembles - 2 Nos. per leaf.

iii) 2 point handles - 1 No. per leaf.

c) Bottom Hung Ventilators (Projecting in)

i) Hinges - As per standard Practice of the Manufacturer, but minimum two hinges Per leaf.

ii) Concealed side arms for
opening adjustment. - 2 Nos. per leaf.

iii) Spring Catch - 1 No. per leaf.



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ANNEXURE-A

D. ALUMINIUM WINDOW, VENTILATORS, ETC.

(As per IS-1948 latest editions)

a) Side Hung Windows

- i) Hinges - As per standard Practice of the Manufacturer, but minimum two hinges Per leaf.
- ii) 300 mm peg stays - 1 No per leaf
- iii) 2 point handles - 1 No per leaf

b) Top Hung Ventilators (Projecting out)

- i) Hinges - As per standard Practice of the Manufacturer, but minimum two hinges Per leaf.
- ii) Adjustable sliding fabrication assemblies - 2 Nos. per leaf
- iii) 2 Point handles - 1 No. per leaf

c) Bottom Hung Ventilation & (Projecting In)

- i) Hinges - As per standard Practice of the Manufacturer, but minimum two hinges Per leaf.
- ii) Concealed side arms for opening adjustment - 2 Nos. per leaf
- iii) Spring Catch - 1 No. per leaf



TITLE:

**TECHNICAL SPECIFICATION
FOR GLASS AND GLAZING**

SPECIFICATION NO. PE-TS-999-600-C006

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GLASS AND GLAZING

SPECIFICATION NO. PE-TS-999-600-C006



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



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<u>GLASS AND GLAZING</u> 1.00.00 SCOPE This section covers supplying and fixing of all glass and glazing including all clips, putty, mastic cement etc. wherever required as per specifications. 2.00.00 INSTALLATION 2.01.00 General The Contractor shall supply and install all glass and glazing as required for various doors, windows, sashes, ventilators and fixed louvers, miscellaneous glazing and partitions, from approved manufacturer like Hindustan Pilkinton or equivalent, having uniform refractive index and free from flaws, specks, and bubbles. The glass shall be brought to site in the original packing from the manufacturer and cut to size at site. Materials a) Glare reducing or heat absorbing glass shall be "Calorex" of Hindustan Pilkinton or approved equivalent and special care shall be taken to grind smooth and round off the edges before fixing. b) Clear glass shall be flat draw sheet glass and shall be at least 4 mm thick. Sheet glass for doors shall be minimum 5.5 mm thick. c) Wired glass shall be thick- rolled glass with centrally embedded 42g wire mesh of Georgian type. This may be of clear or coloured glass, as required. d) Obscure glasses shall have a cast surface in one side. e) Coloured and figured glass shall be as per approved sample. f) In general, the putty shall conform to IS: 400 and be of best quality from approved manufacturer. It shall be brought to site in the manufacturer's original packing. g) Neoprene gaskets with snap-fit glazing beads shall be fixed as per manufacturer's instructions and shall sit snugly against glass to give a leak proof installation. 2.03.00 Glazing, Setting, and Finish All glazing clips, bolts, nuts, putty, mastic cement etc. as required shall be supplied by the Contractor. All glass shall be thoroughly cleaned before putting in position. Each glass		

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	pane shall be held in place by special glazing clips of approved type. As specified in relevant I.S. Codes, four glazing chips shall be provided per glass pane, except for large panes where six or more clips shall be used as per engineer's instructions. All holes that may be necessary for holding the clips glazing heads and all other attachments shall be drilled by, the Contractor. Glass panes shall be set without springing, and shall be bedded in putty and back puttied, except where mouldings or gasket are specified, putty, mastic cement etc. shall be smoothly finished to the even line and figured glass shall be set with smooth side out. Where owner will supply glass, the Contractor shall cut it to size and fix them in the same as specified above. The Contractor shall supply necessary glazing clips, putty, mastic cement etc. After completion of glazing, the Contractor shall remove all dirt stains, excess putty etc. clean glass panes and leave the work in perfectly acceptable condition. All broken cracked or damaged glass shall be replaced by new ones at the contractor's own cost. 3.00.00 ACCEPTANCE CRITERIA a) All installation shall be free from cracked, broken, or damaged glass. Edges of large panes of thicker glass and heat absorbing glass shall be inspected carefully for chipped, cracked, or underground edges. b) Glazing shall be carefully done to avoid direct contact with metal frames. c) All glass shall be embedded in mastic or fixed by neoprene gaskets to give a leak proof installation. d) At completion, the panes shall be free from dirt, stains, excess putty etc. to the complete satisfaction of the Engineer. 4.00.00 I.S. CODES Following are some of the important I.S.Codes relevant to this Section: IS: 3548 - Code of practice for glazing in building. IS: 1081 - Code of practice' for fixing and glazing metal doors, windows ventilators.	

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5.00.00	RATES Rates of glass and glazing if not included in respective items for supply and installation of window, ventilator, and partitions shall be paid separately as per BOQ items provided. No separate payment shall be made for glazing clips, mastic cement, putty, screws; rails, etc. nor for drilling holes in frames for inserting glazing clips.				



TITLE:

**TECHNICAL SPECIFICATION FOR
ROLLING STEEL SHUTTERS AND
GRILLS**

SPECIFICATION NO. PE-TS-999-600-C007

VOLUME - II B

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ROLLING STEEL SHUTTERS AND GRILLS

SPECIFICATION NO. PE-TS-999-600-C007



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



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ROLLING STEEL SHUTTERS AND GRILLS

1.00.00 SCOPE

This Section covers the design and supply of materials, fabrication, delivery and erection of Rolling Shutters/Grills with motor drive and/or manual operation including all accessories as hereinafter specified.

2.00.00 INSTALLATION

2.01.00 Components

- a) Slats for rolling shutters shall be made from tested bright cold rolled, annealed M.S. strips, not less than 0.9 mm thick for shutters upto 4.5 M wide and not less than 1.25 mm thick for shutters having width more than 4.5 M, wide and above, machine rolled at 75 mm rolling centers, interlocking with each other. The profile will be such as to prevent excessive deflection under specified wind load.
- b) Rolling grills shall be constructed out of 6mm rods at 35 mm on centers running horizontally flexible connected with vertical links spaced not more than 200 centers. Alternatively, rolling grills shall be made from perforated slats of approved design reinforced with 6mm dia rods.
- c) End locks shall be heavy type M.C.I./C.I. and shall be provided at each end of alternate slats unless specified otherwise.
- d) Bottom bars shall be finished with two angles not less than 6 mm thick for external shutters. When shown on drawings, a flexible weather strip shall be applied to make tight contact with the floor.
- e) Guides shall be of such depth as to retain the shutter under a wind pressure of 100 Kg/Sq.m.
- f) Shafts shall be of steel pipe of sufficient size to carry the tensional load with a maximum deflection of 1/360th of span. Grease packed ball bearings or bushings shall be provided for smooth trouble free operation.
- g) Hoods shall be formed of not less than 20 gauge steel, suitable reinforced to prevent sag.
- h) Locks shall be slide bolt and hasp, or cylinder lock operable from one or both sides. Provision securing hand chain with pad-lock, provision for removable handle for hand cranks etc. shall be made as prescribed by the Engineer.



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GRILLS**

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- i) Power unit shall be suitable for 3 phase, 50 cycles, 400-volt A.C. power supply and be either floor or wall mounted unit. The motor shall be of sufficient capacity, to move the shutter in either direction at a speed of 0.3 metres per second. In addition to the gear motor each standard power unit shall include a magnetic brake, a reversing starter with built-in overload protection, a geared limit switch and one push button station located inside the building unless otherwise stated in drawing.

It is desirable that the bottom bar of motor operated doors shall be provided with a sensitive edge, electrically connected to stop the travel of the door on meeting an obstruction.

- j) Operating chains shall be of tested quality, heavily galvanized and with all ends rounded to assure smooth operation and hand protection.
- k) Reduction gears shall be high strength grey cast iron, machine moulded from machine out patterns.

2.02.00 Manually Operated Shutters/Grills

Manually operated shutters shall be easily operable by one person. The speed of operation shall be about 1.3 metres per second. In general, manually operated shutters shall be push pull type for opening up to 9 Sq. metre in area. Larger shutters shall, be either chain and gear operated or crank and gear operated. The crank handle shall be removable. All shutters shall be lockable from one or both sides as desired by the Engineer.

2.03.00 Power operated Shutters/Grills

These shall be operable from a push button station conveniently located beside the door. One emergency hand chain/crank operation shall also be provided for use in case of failure of the electric system. Where called for, externally mounted shutters shall be operated by control mechanism located inside the building.

2.04.00 Shop Coat

Shutters shall be painted with one coat of red lead or zinc chromate primer. Where specified, doors shall be galvanized and subsequently painted one coat of zinc chromate for adhesion of field coat.

2.05.00 Erection

Door shall be installed by the manufacturer or his authorized representative and all work shall be as per manufacturer's instructions. Any drilling or cutting to concrete, masonry etc. shall be made good after erection of shutters and all abrasion to shop coat shall be touched up. All electrical work shall be

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in strict accordance with the latest Indian Electricity Rules.					
3.00.00	ACCEPTANCE CRITERIA AND GUARANTEE				
3.01.00	Shop Inspection				
After completing the manufacture of the different components of the rolling shutter, an arrangement for shop inspection by the Engineer shall be made to check the conformity with approved shop drawings.					
3.02.00	Field Inspection				
After installing the shutters, the Contractor shall test the performance of the shutter in the presence of the Engineer. The doors shall be smoothly operable under all ambient conditions. All control and locking devices shall give fault free performance.					
3.03.00	Guarantee				
The Contractor shall give one year's guarantee for the successful operation of the shutters. This shall be supported by a separate and unilateral guarantee from the manufacturer of the shutters.					
4.00.00	I.S. CODE				
IS: 6248 - Metal rolling shutters and rolling grills.					
5.00.00	RATES AND MEASUREMENT				
5.01.00	Rates				
Rates for rolling shutters and grill shall include the cost of the locks, guide channels, cost of drive as specified. In case of electrically operated rolling shutters, the rate shall also include the mounting of controls, wire and wiring from the nearest junction box, conduit and other electrical connections and cost of electric motor.					
5.02.00	Measurement				
Supply and installation of rolling shutter and grill shall be measured in Sqm in net outer to outer (including frame) area of each type used as described in “Schedule of Items”.					



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MISCELLANEOUS METAL

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Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
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MISCELLANEOUS METAL

1.00.00 SCOPE

This section covers supply, fabrication and erection of miscellaneous metal items of light nature in gates, balcony and stair hand rails, structural works, ladders, hangers, masonry anchors, anchor bolts, fasteners, chain link fencing, barbed wire fencing etc. as specified or shown on drawing or as instructed by the Engineer. The above items shall be of fabricated or cast of mild steel, aluminium, brass, cast iron, M.S.& galvanized M.S. sheets, aluminium sheets, expanded metal, wire mesh as shown on drawings or specified.

2.00.00 INSTALLATION

2.01.00 Fabrication/casting

2.01.01 General

All work shall be done according to approved shop drawings. All workmanship shall be equal to the best practice in modern structural or foundry shop.

2.01.02 Shop Connections

- a) All shop connections shall be riveted or welded except when noted otherwise on drawings.
- b) Welding of steel shall be done in accordance with IS: 816.
- c) Welding of aluminium shall be done accordance with IS: 2812, "Arc welding of Aluminium and Alloys." Special care shall be taken to grind smooth all welded surface that shall remain exposed to view. Welds shall be electrically continuous if so required by the Engineer.

2.01.03 Shop Coat

Before leaving the shop, all metal work shall be thoroughly cleaned by effective means of all loose mill seals, rust and foreign matter. Except where encased in concrete, all steelwork shall be given one coat of approved metal protective paint, applied by 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.



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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 of reaming and slight



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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 manufacturers 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



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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 than ± 0.05 mm. 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



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sufficiently threaded and fitted with a nut and washer. Two-way eye bolt strainer shall have suitable ring nuts fitted after the wires have been strained on one side. Stretcher bar shall consist of mild steel flats 25 x 4.75 mm. They shall be secured to the cleats by steel bolts.

The chain link fencing shall be strained between each pair of straining posts and secured to each straining posts by means of a stretcher bar. One of top line wire shall be threaded through appropriate adjacent row of mesh, care being taken that no meshes in the row are bypassed by the line wire except where deviation is necessary at the straining posts. The second top line wire shall be strained in front of the fencing. The fencing shall be attached to the top and bottom line wire by wire ties spaced at 150mm apart and to the other middle line wire by wire ties spaced at 450mm apart.

The bottom of fencing shall be treated as follows:

Continuous concrete sill 125mm wide x 225mm high for full length between posts shall be cast with the top 25mm above GL and 25mm below the chain link fencing. Hair pin staples shall be threaded through the bottom row of mesh at 750mm c/c and set in the sill to a depth of 150mm.

2.03.02

Barbed Wire Fencing

The barbed wire shall be conform to IS:278 latest edition. The barbed wire shall be galvanised and galvanising shall conform to the requirement laid down for 'light-coated wire' of IS:4826 and it shall be smooth and relatively free of lumps etc. Wire with excessive roughness blisters, salammoniac spots shall be rejected. The barbed wire shall be made from two line wire and two point wire of 2.5 mm thickness each. The barbs shall have four point and shall be formed by twisting two point wires, each two turns, tightly around both or one line wire (Type A - around both line wire, Type B - around one line wire) making altogether four complete turns. The barbs shall be so finished that four points are set and located or locked as far as possible at right angle to each other. The barbs shall have a length of not less than 13mm and not more than 18mm. The distance between two barbs shall be 75 ± 12 mm.

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



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wire shall be of mild steel of not less than 25 x 4.75 mm thick with 38 x 4.85 mm half round staples for fastening the barbed wire to them. Bracing for the rows of barbed wire shall be approved by the Engineer.

3.00.00

ACCEPTANCE CRITERIA

- a) All items shall be correct shape, size, weight etc. shown on drawings and schedule of items.
- b) For installed items, the tolerances shall be as follows
 - i) Permissible deviation from, straightness – 1 in 1000.
 - ii) Seats, stiffener connections etc. shall be as per approved drawings and shall not interfere with architectural clearances.
- c) All castings shall be free from blowholes, cracks, and other blemishes.
- d) All MS wire fencing shall be in true vertical plain, and shall not bulge.

4.00.00

IS CODES

- IS:278 Specification for Galvanised Steel Barbed wire for fencing.
- IS:816 Code of practice for use of Metal Arc welding for general construction in mild steel.
- IS:1367 Industrial Fasteners – Threaded steel fasteners - Technical supply condition.
- IS:2721 Specification for Galvanised Steel Chain Link fence fabric.
- IS:2812 Arc welding of Aluminum and Alloy

5.00.00

RATES AND MEASUREMENTS

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



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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.



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Project Engineering Management
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MASONRY AND ALLIED WORKS

1.00.00 SCOPE

This section covers furnishing, installation including handling, transporting, batching, mixing, laying scaffolding, centering, shuttering, finishing, curing, protection, maintenance and repair of common building materials till handing over of masonry and allied works for use in structures and locations covered under the scope of this package.

2.00.00 MATERIALS

a) Brick

Bricks for general masonry work shall be of class designation 7.5 of nominal dimensions as per standard specification under IS: 1077, well burnt, of uniform size, shape and colour, free from cracks, flaws or modules of free lime and emit clear ringing sound when struck. Fractured surface shall show uniform texture free from grits, lumps holes etc. Water absorption after 24 hours immersion shall not exceed 20% by weight for bricks. Dimensional tolerance shall not exceed 8% of the size shown in drawings for bricks. All bricks shall have rectangular faces and sharp straight edges. The bricks shall show no efflorescence after soaking in water and drying in shade.

Each brick shall have the manufacturer's identification marks clearly marked on the frog. Representative samples shall be submitted and approved samples shall be retained by the Engineer for further comparisons and reference. Any brick not found up to the specification shall be removed immediately from site at the Contractor's own cost.

Bricks shall not be dumped at site. They shall be stacked in regular tiers, even as they are unloaded; to minimize breakage and defacement of bricks. Bricks selected for different situation of use in the work shall be stacked separately.

b) Stone

All stones shall be obtained from approved quarries, hard, tough, durable compact grained, uniform in texture and colour and free from decay, flaws, veins, cracks and sand holes. The surface of a freshly broken stone shall be bright, clean, and sharp and shall show uniformity of texture, without loose grains and free from any dull, chalky, or earthly appearance. Stone



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showing mottled colours shall not be used for face work. A stone shall not absorb more than 5 per cent of its weight of water after 24 hours immersion. The type of stone shall be as specified on drawings and/or instructed by the Engineer. Samples shall be submitted by the Contractor and approved samples shall be retained by the Engineer for comparison of bulk supply.

c) Cement

Cement used shall be Ordinarily Portland Cement or Portland Slag Cement or Portland Pozzolana Cement conforming to IS Codes and shall be fresh when delivered. In special cases, Rapid Hardening Portland Cement, Low Heat Cement etc. may be permitted or directed to be used by the Engineer. The Contractor shall submit the manufacturer's certificate for each consignment of cement procured to the Engineer. If at any time, the Engineer feels that the cement being used by the Contractor is not up to specification, he may stop the work and send the samples of the cement to a testing laboratory for standard tests and all expenses incurred thus shall be borne by the Contractor. The Contractor shall also have no claim for this type of suspension of work.

The cement shall be stored above the ground level in perfectly dry and watertight sheds. The bags shall be stacked in a manner so as to facilitate removal or first in first out basis. Any material considered defective by the Engineer shall not be used by the Contractor and shall be removed from the site immediately.

d) Coarse Aggregate

Coarse aggregates shall be as per IS: 383 latest editions, consisting of hard, strong and durable pieces of crushed stone and shall be free from organic or clay coatings and other impurities like disintegrated stones, soft flaky particles etc. and any other material liable to affect the strength, durability or appearance of concrete.

Aggregates other than crushed stone conforming to the provisions of specification may be used if permitted by the Engineer.

Washing of aggregates by approved means shall be carried out, if desired by the Engineer.

Grading of coarse aggregates shall generally conform to IS: 383 and shall be such as to produce a dense concrete or the specified proportions and strength and of consistence that will work readily into position without segregation.



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Aggregates shall be stored on brick soling or an equivalent platform so that they do not come in contact with dirt, clay, grass, or any other injurious substances at any stage.

Aggregate of different size shall be kept in separate stacks. If so desired by the Engineer aggregate from different sources shall be stacked separately with proper care to prevent intermixing.

e) Sand

Sand shall be hard, durable, clean, and free from adherent coatings or organic matter and shall not contain clay balls or pellets. The sand shall be free from impurities such as iron pyrites, alkalis, salts, coal, mica, shale or other laminated materials in such forms or quantities as to affect adversely the hardening, strength, durability or appearance of mortar, plaster or concrete or to cause corrosion to any metal in contact with such mortar, plaster or concrete. All sand shall be properly graded and shall be as per relevant IS Code. Sand for concrete shall conform to IS: 383.

f) Water

Water shall be clean, fresh and free from organic matters, acids or soluble salts and other deleterious substances which may cause corrosion, discoloration, efflorescence etc.

g) Reinforcement

Reinforcement steel shall be clean and free from loose mill scales, dust, loose rust, oil and grease or other coatings, which may impair proper bond. Structural steel shall conform to IS: 2062. Mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement shall conform to IS: 432. Cold twisted steel bars shall conform to IS: 1786. Hand drawn steel wire fabric shall conform to IS: 1566. Hexagonal wire netting shall conform to IS: 3150. All steel bars including and above 10 mm diameter shall be of tested quality. All wire netting shall be galvanized.

Reinforcement bars shall be stored off the ground and under cover if so desired by the Engineer. If necessary, a coat of cement wash shall be given to the bars to guard against rusting.

3.00.00 INSTALLATION

3:01.00 Soling

3.01.01 Brick Soling

The ground shall be dressed, consolidated by ramming, or by light rolling and a 12 mm thick cushion of sand laid. On the sand cushion the bricks shall be



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laid with fine joints and placed firmly in position by hammering with wooden mallet. The surface shall be free from undulations. The 'frog' side shall be on the underside. The joints shall be broken the in all direction and bricks cut as required. The pattern of laying and number of layers shall be as per Schedule of item. Orientation shall be as desired by the Engineer. After laying of each layer of bricks sand shall be spread over and worked into the joints to pack the bricks tight.

3.01.02 Stone Soling

The stones for soling shall be selected on the basis of thickness of soling specified in the Schedule of Items. The larger stones shall be laid and the gaps filled by smaller stones. The interstices shall then be firmly packed with sand by flooding with water.

3.02.00 Brick-on-Edge

Excavation shall be done close to the brick dimensions and in perfect alignment. Bricks shall be firmly placed by hammering with wooden mallets and sides and joints packed firmly with earth so that the edging is not disturbed easily. Alignment and level shall be acceptable to the Engineer.

3.03.00 Masonry

3.03.01 General

All masonry work shall be true to lines and levels as shown on drawings. All masonry shall be tightly built against structural members and bonded with dowels, inserts etc. as shown on drawings.

3.03.02 Cement Mortar

Cement mortar shall be prepared with materials specified in clause 2.00.00. Sand for masonry mortar shall conform to IS: 2116. Cement and sand in the specified proportion shall be mixed dry thoroughly and minimum water added to attain required workability.

Surplus mortar droppings from masonry, if received on surface free from dirt may be mixed with fresh mortar if permitted by the Engineer who may direct addition of additional cement without any extra payment. No mortar, which has stood for more than half an hour, shall be used.

3.03.03 Brick Masonry

Bricks shall be soaked by submergence in clean water for at least two hours in



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approved vats before use. Bricks shall be laid in English bond unless specified otherwise. Broken bricks shall not be used. Cut bricks shall be used if necessary to complete bond or as closers. Bricks shall be laid with frogs upwards over full mortar beds. Bricks shall be pressed into mortar and tapped into final position so as to embed fully in mortar. Inside faces shall be buttered with mortar before the next bricks is placed and pressed against it. Thus all joints between bricks shall be fully filled with mortar.

Mortar joints shall be kept uniformly 10 mm thick. All joints on face shall be raked to minimum 10 mm depth using raking tool while the mortar is still green to provide bond for plaster or pointing.

Where plaster or pointing is not provided, the joints shall be struck flush and finished immediately. Brickworks two bricks thick or more shall have both faces in true plane. Brickwork of lesser thickness shall have one selected face in true plane.

3.03.04 Exposed Brickwork

Brickwork in superstructures, which is not covered by plaster, shall be as shown on drawing and executed by specially skilled mason. Courses shall be truly horizontal and vertical joints truly vertical. Wooden straight edges with brick course graduations and position of window sills and lintels shall be used to control uniformity of brick courses. Masons must check workmanship frequently with plumb, spirit level, rule, and string. All brickwork shall be cleaned at the end of days work. If face bricks are specified, the brickwork shall be in composite bricks, with face bricks on the exposed face and balance in routine bricks, but maintaining the bond fully. Where face bricks are not specified, bricks for the exposed face shall be specially selected from routine bricks. All exposed brickwork on completion of work shall be rubbed down, washed clean, and pointed as specified. Where face bricks are used carborandum stone shall be used for rubbing down.

3.03.05 Reinforced Brickworks

Reinforcements shall be as specified. All reinforcements shall be thoroughly cleaned and fully embedded in mortar. Where M.S. bars are used as reinforcement, these shall be lapped with dowels if left in R.C. columns or welded to steel stanchions.

3.03.06 Stone Masonry

Stones shall be thoroughly soaked before laying. Stones shall be laid on their natural quarry beds. Individual stones shall be fitted with mallet and properly wedged to reduce thickness of mortar joints. Thickness of joint shall be not less than 8 mm and not greater than 25 mm. At least two stones shall run the



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full width of the wall for every square meter of surface area.

3.03.07 Exposed Stone work

Stonework, which is to be kept exposed, shall be as shown on approved drawing. It shall be executed by specially skilled mason. Stones used for exposed face shall be specially selected. All exposed stone faces shall be kept clean and free from mortar and pointed up neatly as the work proceeds in a manner called for in the drawings or instructions. A sample wall, 10 Sq.M. area shall be built and approved by the Engineer and all works shall match with this sample.

3.03.08 Composite Masonry

Where stonework facing with brick masonry backing is specified the bond between them shall be achieved by bond stones of dimensions and frequency as desired by the Engineer.

3.03.09 Expansion & Separation Joints

Location of joints shall strictly be as shown on drawings or as instructed by the Engineer. Expansion joints shall be as shown on drawings and specified. Expansion joint filler boards and sealing strips shall have minimum transverse joints. Transverse joints shall meet the approval of the Engineer.

Separation joints shall be with standard waterproof paper or with alkathene sheets about 1 mm in thickness. Length and sealing of laps shall be to the satisfaction of the Engineer.

3.03.10 Mouldings, Cornices, Drip Course

These shall be made as shown in drawings. Bricks or stone shall be cut and dressed as required. If no subsequent finish is envisaged, these shall be rubbed to correct profile with Carborundum stone.

3.03.11 Curing

Masonry shall be cured by keeping it wet for seven days from the date of laying. In dry weather at the end of days work top surface of masonry shall be



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kept wet by ponding.

3.03.12 Embedding of fixtures

All fixtures shall generally be embedded in mortar and masonry units shall be cut as required.

3.03.13 Encasing of Structural Steel

This shall be done by building masonry work round flanges, webs etc., and filling the gap between steel and masonry by minimum 12 mm thick mortar. Encased members shall be wrapped with chicken wire mesh when shown on drawings or instructed by the Engineer. The minimum lap in chicken wire mesh shall be 50 mm.

3.04.00 Damp Proof Course (DPC)

Unless otherwise specified Damp-proof course shall be 40 mm thick 'artificial stone' in proportion 1:1½:3 cement sand stone-chips (10 mm down) with admixture of a waterproofing compound as approved by the Engineer. The percentage of admixture shall be as per manufacturer's specifications but not less than 2% by weight of cement. The top surface shall be double chequered and cured by ponding for seven days.

3.05.00 Damp Proof Membrane

Damp proof treatment using fibre or hessian base bitumen felt shall be 6, 8 or 10 course treatment as specified in IS: 1609. The number of courses shall be as shown as drawings or as specified. Sequence of work shall be as directed by the Engineer. Extreme care shall be taken to prevent damage to felt during and after laying. The Contractor shall be obliged, at his own expense, to rectify any leakage appearing within 5 years of installation by removing and renewing the coats at the point of leakage.

Where shown on drawing, damp proof membrane with one layer bitumen paper or one layer alkathene sheet shall be laid with minimum 150 mm lap under slabs on grade.

3.05.00 Plinth Protection

Plinth of buildings shall be protected with brick-on-edge paving of minimum 750mm width unless otherwise shown on the drawings. The treatment shall consist of laying bricks in cement mortar 1:6 (1 cement: 6 sand) over a 75mm thick bed of dry graded brick aggregate, 40mm nominal size, grouted with sand. The top shall be finished with 1:2 cement mortar pointing (1 cement: 2 sand). Plinth protection shall be laid with a minimum outward slope of 1 in 50.



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The brick aggregate shall be well graded, broken from well burnt or slightly overburnt and dense brickbats. It shall be homogeneous in texture, roughly cubical in shape, clean and free from dirt or any other foreign matter.

The ground shall first be prepared to the required slope around the building. The high portions of the ground should be cut down; hollows and depressions filled up to the required level from the excavated earth and rammed so as to give uniform outward slope. The bed shall be watered and rammed with heavy iron square rammers. Surplus earth, if any, shall be disposed off beyond a lead of 50m or as directed by the Engineer.

Over this, 75mm thick bed of aggregate of 40mm nominal size, shall be laid with a minimum outward slope of 1 in 50. Aggregates shall be carefully laid and packed, bigger sized being placed at the bottom. The brick aggregates shall be consolidated dry with heavy iron rammers.

The aggregates shall then be grouted evenly with sand at the rate of 0.6 cubic metre per square metre area, adequately watered to ensure filling of voids by sand and again rammed with heavy iron rammers. The finished surface shall give uniform appearance. After the subgrade has been compacted thoroughly, brick flooring with bricks of specified strength in cement mortar 1:6 (1 cement: 6 sand) shall be laid.

The bricks shall be laid on edge in Diagonal/Herring Bone Bond or other pattern as specified or as directed by the Engineer. Bricks shall be laid on 12mm thick mortar bed and each brick shall be properly bedded and set home by gentle tapping with handle of trowel or wooden mallet. Its inside face shall be buttered with mortar before the next brick is laid and pressed against it. On completion of the portion of flooring, the vertical joints shall be fully filled from the top with mortar. The surface shall present a true plain surface with the required slope.

The pointing shall be done in cement mortar 1:2 (1 cement: 2 sand). The mortar shall be pressed into the joints and shall be finished off flush and level with the edges of the bricks so as to give a smooth appearance. The edges shall be neatly trimmed with a trowel and a straight edge. The mortar shall not spread over surface of the masonry.

Brick flooring & pointing shall be kept wet for a minimum period of seven days. These shall be protected from rain by suitable covering when the mortar is green.

4.00.00

I.S. CODES

Some of the important relevant codes for this section are:

IS: 1127: Recommendations for dimensions and workmanship of natural building stones for masonry work.



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IS: 1597: Code of Practice for Construction of stone Masonry.

IS: 1609: Code of Practice for laying Damp proof treatment using bitumen felts.

IS: 2212: Code of Practice for Brickwork.

IS: 2250: Code of Practice for preparation and use of masonry Mortar.

IS: 5134: Bitumen Impregnated Paper & Board.

5.00.00 RATES AND MEASUREMENTS

5.01.00 Rates

Unit rate for masonry work shall include the following:

- Raking out joints for plastering or pointing or finishing the joint flush as the work proceeds.
- Preparing top sand sides of existing wall for joining old with new work.
- Providing, dismantling and removing the scaffolding.

Unit rate for DPC shall be inclusive of formwork and bitumen painting.

5.02.00 Measurement

Brickwork in wall of half brick thickness shall be measured separately in Sqm stating the wall thickness and more than half brick thickness shall be measured by volume. Plaster thickness shall not be considered for computation of volume.

Masonry work in sub structure and super structure shall be measured separately, unless otherwise specified in the Schedule of items.

No deductions shall be made and no extra payment shall be made for following:

- Opening upto 0.1 Sqm each in area. In calculating the area of the opening lintels or sills shall be included along with the size of the opening.
- Drainage holes and recesses for cement blocks to embed holdfasts for doors, windows etc.
- Pipe and fixtures upto 300mm dia. and nothing extra shall be paid for the mortar used for fixing.



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- d) Ends of dissimilar materials (i.e. joists, beams, lintels, posts, girders, rafters, purlins, trusses, corbels, steps, etc); up to 0.1 sqm in section;
- e) Chases of section not exceeding 50 cm in girth;
- f) Iron fixtures, such as wall ties and hold fasts for doors and windows;
- g) Cement concrete blocks as for hold fasts and holding down bolts;
- h) Wall plates, bed plates, and bearing of slabs, CHAJJAS and the like, where thickness does not exceed 10 cm and bearing does not extend over the full thickness of wall;

Reinforcement in masonry work shall be paid separately under respective items.

Damp proof course shall be measured in Sqm. No deduction shall be made and no extra shall be paid for opening upto 0.1 Sqm in area.

Plinth protection shall be measured under respective item of works executed required for completion of the work as specified.



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



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FINISH TO MASONRY AND CONCRETE

1.00.00 SCOPE

This Section covers finishing, installation, repairing, finishing, curing, testing, protection, maintenance till handing over of finishing items for masonry and concrete. This shall also include the work to be done to make the surface suitable for receiving the finishing treatment.

Before commencing finishing items the Contractor shall obtain the approval of the Engineer regarding the scheduling of work to minimize damage by other trades. He shall also undertake normal precaution to prevent damage or disfiguration to work of other trades or other installation.

2.00.01 INSTALLATION

2.01.00 Preparation of Surface

All joints in masonry walls shall be raked out to a depth of at least 10 mm with a hooked tool made for the purpose while the mortar is still green. Walls shall be rushed down with stiff wire brush to remove all loose dust from joints and thoroughly, washed with water. All laitance shall be removed from concrete to be plastered.

For all types of flooring, skirting and dado work, the base cement concrete slab or masonry surface shall be roughened by chipping and cleaned of all dirt, grease or loose particles by hard brush and water. The surface shall be thoroughly moist to prevent absorption of water from the base course. Any excess of water shall be mopped up.

At any point, the level of base shall be lower than the theoretical finished floor level by the thickness of floor finish. Any chipping or filling to be done to bring the base in the required level shall be brought to the notice of the Engineer and his approval shall be taken regarding the method and extent of rectification work required.

Prior to commencement of actual finishing work, the approval of the Engineer shall be taken as to the acceptability of the base.

2.02.00 PLASTERING

2.02.01 Mortar

Mortar for plastering shall be as specified.

For sand cement plaster, sand and cement in the specified proportion shall be mixed dry, on a watertight platform and minimum water added to achieve



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working consistency. The sand for plaster shall conform to IS: 1542.

No plaster, which has stood for more than half an hour, shall be used; plaster that shows tendency to become dry before this time shall have water added to it.

2.02.02 Application of Plaster

Plaster, when more than 12 mm thick, shall be applied in two coats a base coat followed by the finishing coat. Thickness of the base coat shall be sufficient to fill up all unevenness in the surface; no single coat, however, shall exceed 12 mm in thickness. The lower coat shall be thicker than the upper coat; the overall thickness of the coats shall not be less than the minimum thickness shown on the drawings. The undercoat shall be allowed to dry and shrink before applying the second coat of plaster. The undercoat shall be scratched or roughened before it is fully hardened to form a mechanical key. The method of application shall be 'thrown on' rather than 'applied by trowel'.

To ensure even thickness and true surface, patches of plaster about 100 mm to 150 mm square or wooden screed 75 mm wide and of the thickness of the plaster, shall be fixed vertically about 2000 mm to 3000 mm apart, to act as gauges. The finished wall surface shall be true to plumb, and the Contractor shall, without any extra cost to the Owner, make up any irregularity in the brickwork with plaster.

All vertical edges of brick pillars, doorjambs etc. shall be chamfered or rounded off as directed by the Engineer. All drips, grooves, mouldings and cornices as shown on drawing or instructed by the Engineer shall be done with special care to maintain true lines, levels and profiles. After the plastering work is completed, all debris shall be removed and the area left clean. Any plastering that is damaged shall be repaired and left in good condition at the completion of the job.

2.02.03 Finish

Generally, the standard finish shall be used unless otherwise Shown on drawing or directed by the engineer. Wherever any special treatment to the plastered surface is indicated, the work shall be done exactly as shown on the drawings, to the entire satisfaction of the engineer regarding the texture, color and finish.

a) Standard Finish

Wherever punning is indicated, the interior plaster shall be finished rough; otherwise the interior plaster shall generally be finished to a smooth surface. The exterior surface shall generally be finished with a wooden float.



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b) Neat Cement Finish

Immediately after achieving a true plastered surface with the help of a wooden straight edge, the entire area shall be uniformly treated with a paste of neat cement at the rate of one (1) kg. per Sq.M. and rubbed smooth with a trowel.

c) Coloured Plaster Finish

This shall be done in the same way as specified in Clause 2.02.02 but using Coloured cement in place of ordinary cement. When coloured plastering is specified in more than one coat, the topcoat only shall be made with coloured cement.

Coloured cement shall be either ready mixed material or may be obtained by mixing pigments and cement at site, as approved by the Engineer. The pigments to be mixed with cement shall conform to Appendix-A of IS: 2114 latest editions.

Samples of colouring material shall be submitted to the engineer for approval and material procured, shall conform in all respects to the approved samples, which shall remain with the Engineer. All coloured cement and/or pigments shall be stored in an approved manner in order to prevent deteriorations.

d) Pebble-dash Finish

Mortar of required thickness consisting of 1 part cement and 4 parts sand by volume shall be applied in the usual manner as described under plastering Clause 2.02.02. While the mortar is still plastic small pebbles or crushed stone of size generally from 10mm to 20mm as approved by the Engineer shall be thrown on the plastered surface. The aggregate shall be lightly tapped into the mortar with a wood float or the flat end of oil a trowel, in order to ensure satisfactory bond between the dashing and the mortar.

e) Rough-cast Finish

A wet plastic mix of 3 parts coloured cement 6 parts sand and 4 parts aggregate by volume (gravel or crushed stone of size from 6 mm to 12 as approved by the Engineer) shall be thrown on to the wall by means of a plaster's trowel and left in the rough condition.

f) Scraped Finish

Ordinary plaster as described under Clause 2.02.02 after being leveled and allowed to stiffen for a few hours, shall be scraped with a steel straight edge to remove the surface skin. The pattern shall be as approved by the



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g) Textured Finish

Mortar consisting of 1 part cement and 3 parts sand by volume shall be applied in a manner as specified under “Plastering” Clause 2.2.2 Ornamental treatments in the form of horizontal or vertical rib texture fan texture etc. shall be applied by means of suitable tools to the freshly applied plastered surface, as approved by the Engineer.

h) Sand Faced Plaster

The plaster shall be applied in 2 coats. The first coat or the scratch coat should be approximately 14mm and shall be continuously carried out without break to the full length of wall or natural breaking points such as doors, windows, etc. The scratch coat shall be dashed on the prepared surface with heavy pressure, brought to true and even surface and then lightly roughened by cross scratch lines, to provide bond for the finishing coat. The mortar proportion for this scratch coat shall be as specified in the respective item or work. The scratch coat shall be cured for at least 7 days & then allowed to dry. The second coat shall be 6mm thick and it shall not be applied until at least 10 days have elapsed after the application of scratch coat. Before application of the second coat, the scratch coat shall be evenly damped. This coat shall be applied from top to bottom in one operation & without joints; finish shall be straight, true, & even. The mortar of this coat shall be as specified under the respective item of work. White sand for finish shall be used for the second coat & for finishing work. Sand for finish shall be of even coarse size & shall be dashed on the surface & sponged.

2.02.04

Curing

All plastered surfaces after laying shall be watered, for a minimum period of seven days, by an approved method, and shall be protected from excessive heat and sunlight by suitable approved means. Moistening shall commence, as soon as the plaster has hardened sufficiently and not susceptible to damage. Each individual coat of plaster shall be kept damp continuously, for at least two days, and then dried thoroughly, before applying the next coat.

2.03.00

Pointing to masonry

All Joints of brickwork shall be raked out to a depth of 10 mm with a hooked tool made for the purpose while the mortar is still green. The brickwork shall then be brushed down with a stiff wire brush, so as to remove all loose dust from the joints and thoroughly washed with water. Mortar consisting of 1 part cement and 3 parts clean, sharp, well graded sand by volume shall be pressed carefully into the joints and finishes with suitably tools to shape as shown on



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the drawings. Any surplus mortar shall be scalped off the wall face leaving the surface clean.

The pointed surface shall be kept wet for at least three days for curing.

2.04.00 Plaster with Metal Lath

The supports, hangers, brackets, cleats etc. shall be as shown on drawings and/or as approved by the Engineer. These shall have a coat of prime paint before and another coat of approved paint after erection.

The metal lath shall be expanded metal, with 12 mm x 38 mm mesh, 16 thick and 3 mm wide strands. Side laps shall be minimum 12 mm and end laps 25 mm minimum. The plastering shall be minimum 20 mm thick measured from the back of lath and applied in two-layers. The mortar for plastering shall consist of 1 part cement and 4 parts sand by volume mixed as specified in plastering, Clause 2.02.01. The application, finish etc. shall be as specified under relevant clause above. Where called for a 2 mm Plaster of Paris punting shall be applied over plaster as a finishing coat to give perfectly smooth and even finish.

2.05.00 Lime Punning

For plastered surfaces, where an even smooth surface is specified, lime punning with 5 parts of shell lime properly slaked, strained and aged, mixed with 1 part clean, washed, sieved, fine sand by volume shall be done. The thickness of lime punning shall be not less than 2 mm and more than 3 mm. The plastered surface shall be saturated with water before application of the lime punning. The punning shall be applied by skilled workman and given a smooth and even finish free from undulations, cracks etc. and to the satisfaction of the Engineer.

2.06.00 Plaster of Paris Punning

Plastered surfaces, where specified shall be finished with Plaster-of-Paris punning. The material shall be from approved manufacturers and approved by the Engineer. The thickness of the punning shall be 2 mm and shall be applied by skilled workmen. The finish shall be smooth, even and free from undulation, cracks etc.

Before bulk work is taken in hand, a sample of punning shall be done on roughly 10 Sq.M. areas and approval of the Engineer taken. The work shall then be taken in hand as per approved sample.

2.07.00 Stone Facing

Stone facing where specified shall be done as shown on design drawings and



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approved shop drawings. The stone shall be as specified on drawings. Samples of stone shall be submitted to the Engineer for approval and then bulk purchase made. The Contractor shall submit three copies of shop drawings for the Engineer's approval before commencing the work.

The thickness of facing stone shall be not less than 25 mm unless otherwise specified on drawings.

The stone slabs shall be cut and finished to sizes as per pattern shown on drawings. They shall be fastened to wall with suitable non-corrodible anchorage as approved by the Engineer. Where mild steel clamps, stays etc. are used for anchorage, they shall be galvanized (weight of zinc coating shall not be less than 700 gms per square meter of surface) to prevent rust stains developing on the finished surface. There shall be at least 12 mm gap between the stone and masonry, which shall be filled up and packed by a mortar of 1 part cement and 3 parts of sand by volume. After the mortar is set and cured for at least four days, the exposed surface shall be rubbed and polished as approved by the Engineer.

The completed surface shall be neat, or uniform texture and acceptable to the Engineer.

Where pointing is specified on drawings it shall be done by mortar as specified on drawings.

3.00.00 ACCEPTANCE CRITERIA

Finish to masonry and concrete shall fully comply with the Specifications, approved samples and instructions of the Engineer with respect to lines, levels, thickness, colour, texture, pattern and any other special criteria as mentioned in the body of the specification or as shown on drawings.

4.00.00 I.S. CODE

All work shall be carried out as per this specification and shall conform to the latest revision and/or replacements of the following or any other Indian Standard (IS) Codes, unless specified otherwise. In case any particular aspect of work is not specifically covered by Indian Standard Codes, any other standard practice, as may be specified by the Engineer, shall be followed.

IS: 1661: Code practice for cement and cement-lime plaster finish on wall & ceilings.

IS: 4101: code of practice for external facings and veneers.



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5.00.00 RATES AND MEASUREMENT

5.01.00 Rates

Rates shall also include providing, dismantling and removing of scaffolding, surface preparation, curing and all type of surface, shapes/ profiles and at all elevations.

5.02.00 Measurement

All plastering shall be measured net (on surface area on which it is applied) in Sqm. Plaster work shall be classified according to the type used and shall be measured separately. Plaster on ceiling and walls shall be measured separately. Soffits of stairs shall measured as plastering on ceiling.

No deduction shall be made for opening not exceeding 0.5 Sqm and for ends of beams, joints, etc. also no payment shall be made for reveals, jams, soffits, sills of these openings.

50% deduction shall be made for opening exceeding 0.5 Sqm but not exceeding 3.0 Sqm each and no addition shall be made for reveals, jams, soffits, sills etc.

In case of opening exceeding 3.0 Sqm each, deduction shall be made for opening but jams, soffits, and reveals shall be measured and paid for.



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PAINTING, WHITEWASHING,
POLISHING

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SPECIFICATION NO. PE-TS-999-600-C011



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



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PAINTING, WHITE WASHING, POLISHING, ETC.

1.00.00 SCOPE

This section covers painting, white washing, varnishing, polishing etc. of both interior and exterior surfaces of wood work, masonry, concrete plastering, plaster of paris, false ceiling, structural and other miscellaneous steel items, rain water down comer, floor and roof drains, soil, waste and service water pipes, and other ferrous and non-ferrous metal items.

Copper, bronze, chromium plate, Nickel, stainless steel and aluminium shall generally not be painted or finished except if otherwise specified.

Before commencing painting, the Contractor shall obtain the approval of the Engineer in writing regarding the schedule of work to minimize damage; disfiguration or staining to work of other trades or other installations.

2.00.00 INSTALLATION

2.00.01 Materials

Materials shall be highest grade products or well-known approved manufacture and shall be delivered to the site in original sealed containers, bearing brand name, manufacturer's name and colour shade, with labels intact and seals unbroken. All materials shall be subject to inspection, analysis and approved by the Engineer. It is desired that materials of one manufacturer only shall be used as far as possible and paint of one shade is obtained from the same manufacturing batch. Each and every supply of primer, finish paint etc. shall be accompanied by manufacturer's test certificate. All paint shall be subject to analysis from random samples taken at site from 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.



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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 shall conform to IS: 427. 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.

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



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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.



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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.

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2.02.00	Application
2.02.01	General
	The method of application shall be as recommended by the manufacturer. In case of selection of special shades and colour (not available in standard shades) the Contractor shall mix different shades and prepare test panels of minimum size 1 meter square as per instruction of the Engineer and obtain his approval prior of application of finishing paints. Proper tools and implements shall be used. Scaffoldings used shall be independent of the surface to be painted to avoid shade differences of the freshly repaired anchor notes. Painting shall be done by skilled labours in a workmanlike manner. All materials shall be evenly applied so as to free of sags, runs, crawls, or other defects. All coats shall be of proper consistency. In case of application by brush, no brush marks shall be visible. The brushes shall be clean and in good condition before application of paint. All priming undercoat for painting shall be applied by brush only, and rollers spray equipments etc. shall not be used. No work shall be done under conditions that are unsuitable production of good results. No painting shall be done when plastering is in progress or is drying. Application of paint, which seals the surfaces to moisture shall only be done after the moisture on and below the surface has dried out. All coats shall be thoroughly dry before succeeding coat is applied. Coats of painting as specified are intended to cover surfaces perfectly. In case the surface is not covered property by applying the specified number of coats, further coats shall be applied by the Contractor when so desired by the Engineer. All primers and undercoats shall be tinted to approximate the colour of the finishing coats. Finished coats shall be of exact colour and shade as per approved samples and all finish shall be uniform in colour and texture. All parts of mouldings and ornaments shall be left clean and true to finish. Painting on ferrous metal surface shall, be done as per IS: 1477 (Part I & 2). The total dry thickness of film should not be less than 120 Micron.
2.02.02	White Washing
	The surface where white washing is to be applied shall be cleared of all loose materials and dirt. All holes and irregularities of the surface shall be filled up with lime putty and shall be allowed to dry up before white washing.



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One coat of whitewash shall consist of one stroke from top downwards, another from bottom upwards over the first stroke and another from left to right before the previous one dries up. Second coat shall be applied and in case the Engineer feels that one or more coats are required the Contractor shall do so without any extra cost to the Owner. No brush marks shall show on the finished surface.

2.02.03 Dry Distemper

New plastered surface shall be allowed to dry for at least two months. New lime or lime cement plastered surface shall be washed with a solution of 1 part Vinegar to 12 parts water or 1:50 sulphuric acid solution and for 24 hours after which the wall shall be thoroughly washed with clean water. For cement-plastered surface, the surface shall be washed with solution of 100 gms. of zinc sulphate to 1 litre of water and allowed to dry.

Dry distempering shall be done as per manufacturers instruction. In applying the distempers the brush, should first be applied horizontally and immediately crossed off perpendicularly. Brushing shall not be continued too long, otherwise brush marks may result.

2.02.04 Oil bound washable distemper

The distemper shall be applied after surface is primed with an alkali resistant primer, and followed by minimum two coats of oil bound washable distemper all as per manufacturer's instruction.

2.02.05 Waterproof Cement Paint

Surface to be coated with cement paint shall be washed and brushed down. As soon as the moisture has disappeared, the surface shall be given one coat of paint. Care shall be taken so that the paint does not dry out too rapidly. After 4 to 6 hours, the water shall be sprinkled over the surface to assist curing and prevent cracking. After the first coat has dried (24 to 48 hours) the second coat shall be applied in a similar manner. The finished surface shall be kept moist by occasional sprinkling with water for seven days after painting.

2.02.06 Acrylic Emulsion Paint

Paint shall be applied after providing one coat of cement primer solvent of approved quality and primer shall be 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.



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2.02.07 Synthetic Enamel Paint

Shall be applied on properly primed surface. Subsequential 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 flattening 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.



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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

- All painted surfaces shall be uniform and pleasing in appearance.
- All varnished surfaces shall be of uniform texture and high glossy finish.
- The colour, texture etc. shall match exactly with those of approved samples.
- All stains, splashes, and splatters of paints and varnishes shall be removed from surrounding surfaces.



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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 be removed and replaced by the Contractor. The work shall be redone as per Specification of the contract and direction of the Engineer without extra cost to owner.

4.00.00

I.S. CODE

All work shall be carried out as per this specification and shall conform to the latest revision and/or replacements of the following or any other Indian Standard (IS) Codes, unless specified otherwise. In case any particular aspect of work is not specifically covered by Indian Standard Codes, any other standard practice, as may be specified by the Engineer, shall be followed.

- IS: 348 Specification for French polish
- IS: 427 Specification for Distemper, dry colour as required.
- IS: 428 Specification for Distemper oil emulsion, colour as required.
- IS: 1477
(I & II) Code of Practice for painting of ferrous metal in buildings.

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	IS: 2338 (I & II)	Code of Practice for finishing of wood and wood based materials.
	IS: 2339	Specification for Aluminium, Paints for general purposes in dual containers.
	IS: 2395	Code of Practice for painting concrete, masonry, and Plaster surface.
	IS: 2932	Specification for enamel, exterior type-1.
	IS: 5410	Specification for cement paint, colour as required.
5.00.00	RATES AND MEASUREMENT	
5.01.00	Rates	
	Rates shall be unit rates for complete items described in the “Schedule of Items”.	
	Rate shall include cleaning, preparation of surface, supply and application of primer, painting and providing all protection and scaffolding required at site.	
5.02.00	Measurements	
	Painting over the concrete/masonry/wooden surface shall be measured net (on the surface area on which it is applied) in Sqm.	
	No deduction shall be made for opening not exceeding 0.5 Sqm and ends of beams, joints, etc. also no payment shall be made for reveals, jams, soffits, sill of these openings.	
	50% deduction shall be made for opening exceeding 0.5 Sqm but not exceeding 3.0 Sqm each and no addition shall be made for reveals, jams, soffits, sills etc.	
	In case of opening exceeding 3.0 Sqm each, deduction shall be made for opening but jams, soffits, and reveals shall be measured and paid for.	
	Corrugated surfaces shall be measured flat and measured area shall be increased by 15%.	
	Painting of structural steel works shall be measured in M.T. of fabricated steel (as per section D-17 clause 6.02.00 i.e Mode of measurement of technical specification for fabrication of structural steel works) unless specified otherwise.	



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



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FLOOR FINISH AND ALLIED WORKS

1.00.0

SCOPE

This section covers furnishing, installation, finishing, curing, testing, protection, maintenance till handing over various types of floor finishes, and allied items of work as listed below

a) In Situ Finishes

- i) Integral finish to concrete base
- ii) Terrazzo finish
- iii) Granolithic finishes
- iv) Patent Stone
- v) Metallic Hardener like “Ironte”/Hardonate Finish
- vi) Mastic Asphalt finishes
- vii) Chemical Resistant finish

b) Tiled Finishes

- i) Terrazzo tile
- ii) Chequered tile
- iii) Glazed tile
- iv) Tesse rae (Mosaic etc.)
- v) Chemical Resistant
- vi) Rubber, Vinyl etc.
- vii) Stone Slab including Kota Stone.

1.01.00

Base

The base to receive the finish is covered under other relevant specifications.

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1.01.01	Sequence Commencement, scheduling and sequence of the finishing works shall be planned in detail and must be specifically approved by the Engineer in view the activities of other agencies working in that area. However, the Contractor for the finishing items shall remain fully responsible for all normal precautions and vigilance to prevent any damages whatsoever till handing over.	
2.00.00	INSTALLATION	
2.00.01	Special Materials Basic materials are covered elsewhere under the Specification. In general, all such materials shall be as per relevant Codes where available. In all cases these materials shall be of the best quality available indigenously unless specified otherwise. The materials for finishing items must be procured from well-reputed specialized manufacturers and on the basis of approval of samples by the Engineer. The materials shall be ordered, procured and stored well in advance to avoid compulsion to use substandard items to maintain in the construction schedule.	
2.00.02	Workmanship Only workers specially experienced in particular items of finishing work shall be engaged, where such workers are not readily available, with the Engineer's permission, experienced supervisors recommended by the manufacturer shall be engaged. In particular cases where the Engineer so desires the Contractor shall get the finishing items installed by the manufacturer.	
2.00.03	Preparation of the Base Surface The surface to be treated shall be thoroughly examined by the Contractor. Any rectification necessary shall be brought to the notice of the Engineer and his approval shall be taken regarding method and extent of such rectification work. For all types of flooring, skirting, dado and similar locations, the base to receive the finish shall be adequately roughened by chipping, raking out joints and cleaning thoroughly all dirts, grease etc. with water and hard brush and detergent if required, unless otherwise directed by the manufacturer of any special finishing materials or specifically indicated in this specification. To prevent of water from the finishing treatment the base shall be thoroughly soaked with water and all excess water mopped up. The surface shall be bone dry where adhesives are used for fixing the finishes.	



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Prior to commencement of actual finishing work the approval of the Engineer shall be taken as per the acceptability of the surface.

2.01.00 In Situ Finishes**2.01.01 Integral Finish To Concrete Base**

While the surface of the concrete laid as per specification for 'Cement Concrete' has been fully compacted and levelled but the concrete is still 'green' thick slurry, made with neat cement shall be applied evenly and worked in with iron floats. When the slurry starts to set it shall be pressed with iron floats to have a firm compact smooth surface without trowel mark or undulations. This finish shall be as thin as possible by using 2.2 kg. of cement per Sq.M. of area.

The surface shall be kept in shade for 24 hours and then cured for at least 7 days continuously by flooding with water. The surface shall not be subjected to any load or abrasion till 21 days after lying.

As desired by the Engineer the surface, while still 'green' shall be indented by pressing strings, the marking shall be of even depth, in straight lines and the panels shall be of uniform and symmetrical patterns.

2.01.02 Terrazzo Finish in Situ

It shall consist of an underbed and a topping laid over an already laid and matured concrete base.

a) Thickness

Unless otherwise specified the total thickness of the 'finish shall be minimum 40 mm for horizontal and 25 mm for vertical surface of which the topping shall be not less than 10 mm. While the topping shall be of uniform thickness the underbed may vary in thickness to provide necessary slopes. The vertical surface shall project out 6 mm from the adjacent plaster or other finish. Necessary cutting into the surface receiving the finish shall be done to acc ate the specified thickness. All junctions of vertical with horizontal shall be rounded neatly to uniform radius of 25 mm.

b) Mix**i) Underbed**

The underbed for floors and similar horizontal surfaces shall consist of a mix of 1 parts cement, 1½ parts sand and 3 parts stone chips by volume. For vertical surfaces the mix shall consist of 1 part cement to 3 parts sand by volume. The sand shall be coarse. The stone chips



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shall be 10 mm down well graded. Only sufficient water to be added to give a workable consistency.

ii) Topping

The mix for the topping shall be composed of cement, colour Pigment, marble dust and marble chips. Proportions of the ingredients shall be such as to produce the terrazzo of colour texture and pattern approved by the Engineer. The cement shall be white or gray or a mixture of the two to which pigment shall be added to achieve the desired colour. To 3 parts of this mixture 1 part marble powder by volume shall be added and thoroughly mixed dry. To 1 part of this mix 1 to 1½ parts of marble chips by volume shall be added and thoroughly mixed dry again.

The pigment must be stable and nonfading. It must be very finely ground. The marble powder shall be from White marble and shall be finer than IS Sieve No.: 30. The size of marble chips shall be between 1 mm to 20 mm. Sufficient quantity to cover each visible area shall be prepared in one lot to ensure uniform colour. Water to make it just workable shall be added to a quantity that can be used up immediately before it starts to set.

c) Laying

The underbed shall be laid in panels. The panels shall not be more than 5 Sq.M. in area of which no side shall be more than 2.5 M. long. For exposed locations the maximum area of a panel shall be 2.0 Sq.M. The panel shall be laid in alternate bays or chequered board pattern. No panel shall be cast in contact with another already laid until the latter has contracted to the full extent.

Dividing strips made of aluminium or glass shall be used for forming the panels. The strips shall exactly match the total depth of underbeds plus topping.

After laying, the underbed shall be levelled compacted and brought to proper grade with a screed or float. The topping shall be laid after about 24 hours while the underbed is still somewhat “green” but firm enough to receive the topping. A slurry of the mixture of cement and pigment already made shall be spread evenly and brushed in just before laying the topping. The topping shall be rolled for horizontal areas and thrown and pressed for vertical areas to extract all superfluous cement and water and to achieve a compact dense mass fully bonded with the underbed. The surface of the topping shall be trowelled over, pressed and brought to a smooth dense surface showing a minimum 75% area covered by marble chips in an even pattern of distribution.



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d) Curing

The surface shall be left for curing for about 12 to 18 hours and then cured by allowing water to stand on the surface or by covering with wet sack for four days.

e) Grinding and Polish

When the surface has sufficiently hardened it shall be watered and ground evenly with rapid cutting coarse grade (no.80) grit blocks, till the marble chips are exposed and the surface is smooth. Then the surface shall be thoroughly washed and cleaned. A grout with already prepared mixture of cement and pigment shall be applied to fill up all pinholes. The surface shall be cured for 7 days by keeping it moist and then ground with fine grit blocks (no.: 120). It shall again be cleaned with water, the slurry applied again to fill up any pinholes that might have appeared and allowed to be cured again for 5 days. Finally, the surface is ground a third time with very fine grit blocks (no.: 320) to get smooth surface without any pinhole. A suitable machine shall do the grinding. Where grinding machine can not be used hand grinding may be allowed when the first rubbing shall be with carborundum stone of coarse grade (no.:60), second rubbing with medium grade (no.: 80) and final rubbing and polishing with fine grade (no.: 120). The surface shall be cleaned with water, dried, and covered with soil free, clean sawdust if directed by the Engineer. The final polishing shall be postponed till before handing over if desired by the Engineer. Just before handing over the surface shall be dusted with oxalic acid at the rate of 0.33 gm. per. Sq.M., water sprinkled on to it and finished by buffing with felt or hessian bobs. The floor shall be cleaned with soft moist rag and dried. However, all excess wax polish to be wiped off and the surface to be left glossy, but not slippery.

2.01.03

Granolithic Finish

Granolithic finish shall either be laid monolithically over base concrete or separately over hardened base concrete.

a) Thickness

The finish shall be average 20 mm and minimum 12 mm thick, unless specified otherwise.

b) Mix

The mix shall consist of 1 part cement: 1 part coarse sand 2 parts coarse aggregate by volume. The coarse aggregate shall be very hard like granite and well graded between 6 mm and 12 mm. Minimum quantity of water to get workability shall be added.



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c) Laying of Monolithic Topping

The concrete base shall be laid as per specification “Cement Concrete” and levelled upto the required grade. The form shall remain sufficiently protruding to take the finish.

Within about 3 hours of laying the base while it is still fully -green- the topping shall be laid evenly to proper thickness and grade. If considered necessary the surface ‘ of the base shall roughened by wire brushing. Unless manual operation is permitted by the Engineer, mechanical vibrators of suitable design shall be used to press the topping firmly and work vigorously and quickly secure full bond with concrete base.

The laitance brought to the surface during compression shall be removed carefully without disturbing the stone chips. The surface shall then the lightly trowelled to remove all, marks. When sufficiently set, hand trowelling shall be done to secure a smooth surface without disturbing the stone chips.

For large areas the laying shall be in panels of maximum 25 Sq.M. area. The panels shall be laid in chequered board pattern.

d) Laying of Topping Separately on Hardened Base

The base concrete shall be prepared as stated in clause 2.00.03 and a slurry of neat cement applied just prior to laying the granolithic concrete mix (1:1:2). The method of compaction etc. shall be same as for monolithic topping.

Curing

Immediately after laying, the finish shall be protected against rapid drying. As soon as the surface had hardened sufficiently, it shall be kept continuously moist for at least 10 days by means of wet gunny bags or pounding of water on the surface. The floor shall not be exposed to heavy traffic during this period.

f) Grinding

If grinding is specified, it shall start only after the finish has fully set. Clause 2.01.02 (e) shall be followed. However, the Engineer shall decide upon the ultimate polish required.

g) Finishing

Where specified, sodium, silicate or magnesium or zinc silico fluoride treatment shall be done. The number of coats to be applied shall be as per approved drawings or as instructed. The concentration and method of application of the solutions shall be as specified in IS: 5491.



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It shall consist of an underbed and a topping laid on an already laid and matured concrete base.

a) Thickness

The patent stone finish shall have thickness as stipulated under clause 2.01.02 (a) except that the topping shall be 12 mm thick.

b) Mix

i) Underbed

The mix shall be as stipulated under clause 2.01.02 (b).

ii) Topping

The mix for the topping shall consist of 1 part cement and 2 part stone aggregate 6mm nominal size by volume.

c) Laying

The Patent Stone finish including the underbed shall be laid in alternate bays or in Chequered board pattern. No panel shall be cast in contact with another already laid till the contraction of the latter has already taken place.

The maximum area of each panel shall be 3 Sq.M. of which no side shall be more than 2 M. long.

A cement grout shall be applied and worked into the surface to receive the finish; the underbed then laid, compacted, and leveled to proper grade with a screed or float. The topping shall be applied evenly on the underbed while it is not fully set but firm enough and rolled and pressed to get full bond. The topping shall be trowelled to a dense finish to the satisfaction of the Engineer. All trowel marks shall be mopped out with a soft cloth to give a clean smooth surface.

After the surface is sufficiently set, the finished floor shall be kept moist for 7 days for curing. If desired the finish shall be polished as directed by the Engineer.

2.01.05

Metallic Hardener Like 'Ironite'/'Hardonate' Finish



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This will consist of a topping (incorporating iron particles) to bond with concrete base while the latter is 'green'.

a) Thickness

Unless otherwise specified the metallic hardener finish shall be of 12 mm depth.

b) Material

The hardening compound shall be uniformly graded iron particles free from non-ferrous metal impurities, oil, grease, sand soluble alkaline compounds or other injurious materials when desired by the engineer, actual samples shall be tested.

c) Mix

Proportion of the metallic hardener shall be as specified or as indicated by the manufacturer. However, in absence of any such direction 1 part metallic hardener shall be mixed dry, with 4 parts cement, by weight. To this mixture 6 mm nominal size stone chips shall be added in proportion of 1 part cement (mixed with hardener) to 2 parts of stone chips by volume and uniformly mixed. Minimum quantity of water shall be added to make it workable.

d) Laying

The concrete floor shall be laid as per specification 'Cement Concrete' and levelled upto required grade. The forms, if any, shall remain sufficiently projecting to make the finish. The surface shall be roughened by wire brush as soon as possible.

The finish shall be laid while the concrete underbed is still very 'green' within about 3 hours of laying of the latter. The finish shall be of uniform thickness and even dense surface without trowel marks, pin holes etc. This topping layer shall be pressed firmly and worked vigorously and quickly to secure full bond with the concrete base. Just when the initial set starts the surface shall be finished smoothened with steel trowel.

The finished floor shall be cured for 7 days by keeping it wet.

2.01.06

Mastic Asphalt Finish



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This is a one-layer treatment on concrete or brick base.

a) Thickness

The thickness shall be as specified in the drawing.

b) Materials

Bitumen shall be industrial Bitumen of the grade 90/15 and 75/15 conforming to IS: 702.

Mineral filler shall be dry stone dust passing through 75 micron IS Sieve.

Fine aggregate shall be crushed and graded natural limestone or other hard work.

Coarse aggregate shall be crushed siliceous stone or other approved aggregate 6 mm stone chips shall be used for finish upto 20 mm thick & 10 mm chips for thicker finish.

c) Composition

Bitumen mastic shall conform IS: 1195 and shall be either brought to site in blocks weighing about 25 Kg or prepared at site. If brought in blocks, these shall be remelted in mechanically agitated mastic cookers and coarse aggregate, preferably preheated fed in successive portions until the complete change is thoroughly, incorporated. At no stage during the remelting and mixing process, shall the temperature exceed 205°C.

d) Laying

The hot mastic shall be laid on dry base surface cleaned thoroughly by wire brushing and sweeping. The mastic shall be leveled and when cooled to some extent shall be finished with a wooden float with addition of small quantity of fine sand if required. No load shall be allowed till the finish has cooled to normal temperature.

The mastic shall be laid in suitable panels of about 1.5 Sq.M. in area each formed by formers. Succeeding panels shall be laid overlapping the finish panel so as to melt its edges and form a continuous finish without joint.

2.01.07

Chemical Resistant in Situ Finish



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Chemical resistant in situ finish shall be as epoxy resin with suitable filler material over a primer. The minimum thickness shall be 6 mm. About its performance the Engineer shall have to be fully satisfied by test results and examination of similar treatment already in existence. The contractor shall get it done by a specialized Manufacturer and get guarantee of performance from the organization and pass it on to the Owner in addition to his own guarantee.

2.02.00 Tiled Finish

These shall include finish tiles, stone slabs, and similar manufactured or natural items over already laid and matured base of concrete or masonry by means of an underbed or an adhesive layer.

2.02.01 Terrazzo Tile Finish

The finish will consist of manufacture terrazzo and an underbed.

a) Thickness

The total thickness including the underbed shall be minimum 40 mm for floors 30 mm for walls unless otherwise specified.

The skirting, dado and similar vertical surfaces shall project out 6 mm uniformly from the adjacent plaster or other wall finishes. The necessary cutting into the surface receiving the tiled finish, to accommodate the specified thickness shall be done.

b) Tiles: Terrazzo

The tiles shall, unless specifically permitted in special cases be machine made under quality control in a shop. The tile shall be pressed hydraulically to a minimum of 140 Kg. per Sq.cm.

Each tile shall bear on its back permanent and legible trademark of the manufacturer. All angles of the tiles shall be right angles all arises sharp and true, colour and texture of the wearing face uniform throughout. Maximum tolerance allowance length and breadth shall be ± 1 mm and the thickness ± 3 mm. Face of the tile shall be plane, free from pinholes and other blemishes.

The tiles shall be composed of a backing and topping. The topping shall be of uniform thickness not less than 10 mm.

The total thickness including the topping shall be as specified but not less than 20 mm in any case.



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The backing shall be composed of 1 part ordinary gray cement and 3 parts of stone chips by weight mixed with water.

The topping shall be as specified under clause 2.01.02 (b).

The tile shall be cured at the shop for at least 14 days before delivery to the site. First grinding shall be given to the tiles at the shop before delivery. Tiles shall be packed properly to prevent damage during transit and storage. The tiles must be carefully stored to prevent staining by damp, rust, oil, and grease or other chemicals.

Tiles made in each batch shall be kept and used separately so that colour of each area of the floor may remain uniform.

The manufacturer shall supply along with the tiles the grout mix containing cement and pigment in exact proportions as used in topping of the tiles. The containers for the grout mix shall be suitably marked to relate it to the particular type and batch of tiles.

c) Mix: Underbed

The underbed for floor and similar horizontal surfaces shall be 1 part lime putty: 1 part surkhi: 2 parts coarse sand by weight mixed with sufficient water to form a stiff workable mass. For skirting and dado and all vertical surfaces it shall be about 12 mm thick and composed of 1 part cement and 3 parts coarse sand by weight.

d) Laying

The underbed mortar shall be evenly spread and brought to proper grade and consolidated to a smooth surface. The surface shall be roughened for better bond. Before the underbed had time to set and while it is still fairly moist but firm, cement shall be hand dusted over it or a cement slurry applied and the tiles shall immediately be placed upon and firmly pressed by wooden mallet on to the underbed until it achieves the desired level. The tiles shall be kept soaked for about 10 minutes just before laying. The joints between tiles shall be as close as possible and not more than 1.5 mm wide.

Special care shall be taken to check the level of the surface and the lines of the joints frequently so that they are perfect.

When tiles are required to be cut to match the dimensions these shall be sawn and edges rubbed smooth. The location of cut tiles shall be planned in advance and approval of the Engineer taken.

At the junction of horizontal surface with vertical surface the tiles on the



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former shall enter at least 12 mm under the latter.

After fixing, the floor shall be kept moist and allowed to mature undisturbed for 7 days. Heavy traffic shall not be allowed.

If desired dividing strips as specified under Clause 2.01.02(c) may be used for dividing the work into suitable panels.

e) Grinding and Polishing

Procedure shall be same as Clause 2.01.02(e). Grinding shall not commence earlier than 14 days after laying of tiles.

2.02.02

Chequered Tile Finish

The finish shall consist of manufactured gray or coloured cement tiles or terrazzo tiles with chequered face and an underbed laid over concrete or brick surface.

a) Thickness

Thickness shall be same as in clause 2.02.01 (a).

b) Tiles: Chequered

The tiles shall have chequers not less than 2.5 cm. c/c and not more than 5 cm. c/c. Depth of grooves shall be not less than 5 mm. The grooves shall be uniform and straight.

The tiles shall conform to clause 2.02.01 (b) except that these may have the topping in terrazzo or plain gray cement or colour pigment added to cement.

c) Under-bed

As per clause 2.02.01 (c).

d) Laying

As per clause 2.02.01 (d).

e) Grinding and Polishing

As per clause 2.02.01 (e) except that the tiles shall be ground and polished by hand and after laying taking special care in polishing the grooves properly and uniformly.

2.02.03

Glazed Tiles Finish



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This finish shall be composed of glazed earthenware tiles with an underbed laid over a concrete or masonry base.

a) Thickness

The total thickness shall be between 20mm and 25mm including the underbed.

The tile finish on vertical surface shall project out 6 mm uniformly from the adjacent plaster or other wall finishes. The necessary cutting into the surface receiving the finish, to accommodate the specified thickness shall be done.

b) Tiles: Glazed

The tiles shall be of earthenware, covered with glaze white or coloured, plain or with designs, of 150 mm x 150 mm nominal sizes and 5.5 mm to 6 mm on thick unless otherwise specified. The tolerance shall be ± 1.5 mm for length and breadth and ± 0.5 mm for thickness specials like internal and external angles; beads, covers, cornices, corner pieces etc. shall match. The top surface of the tiles shall be glazed with a gloss or matt, unfading stable finish as desired by the Engineer. The tiles shall be flat and true to shape. The colour shall be uniform and fractured section shall be fine grained in textures, dense and homogeneous. The tiles shall be strong and free from flaws like cracks, craze, specks, crawlings, etc. and other imperfections. The edge and the underside of the tiles shall be completely free from glaze and the underside shall have ribs or indentations for better anchorage with the fixing mortar.

The coloured tiles, when supplied, shall preferably come from one batch to avoid difference in colour.

c) Mix: Underbed

The mix for the underbed shall consist of 1 part cement and 3 parts coarse sand by weight mixed with sufficient water or any other mix if specified.

c) Laying

Same as clause 2.02.01 (d).

e) Finishing

The joints shall be cleaned and flush pointed with white cement and cured for 7 days by keeping it wet. The surface shall be cleaned with soap or suitable detergent, washed fully, and wiped with soft cloth to prevent scratching before handing over.



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2.02.04

Tesserae Finish (Mosaic etc.)

This finish consists of manufactured vitreous, glass, ceramic or similar hard small pieces set in an underbed over a concrete or masonry surface, already laid.

a) Thickness

The total thickness including the underbed shall be between 16 mm & 25 mm.

b) Tesserae Finish

These shall usually be 6 mm thick small piece of ceramic vitreous china, tinted glass, or similar hard wearing, strong, and durable material in desired shapes and sizes and patterns.

The supply shall come in the desired pattern in full or sections conveniently for handling, stuck to pieces of strong thick paper on the surface to be exposed. The gum used for this purpose must be water soluble and non-staining. The sections shall be properly marked to avoid mistakes and master drawing shall be available at the site for guidance.

c) Mix: Underbed

Same as clause 2.02.03 (c)

d) Laying

The specification for laying if given by the manufacturer of the item shall be followed provided it is approved by the Engineer. Otherwise clause 2.02.03 (d) shall generally be followed. However, instead of gray cement the slurry shall be made with white cement to fix the panels. The paper-mounted patterns in sections shall be carefully placed and pressed in position true to lines and levels. Earliest possible the paper shall be peeled off and surface examined and cleaned, joints flush pointed with white cement and cured for 7 days by keeping it wet.



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2.02.05 Chemical Resistant Tiled Finish

This shall include all varieties of special tiles used for specific chemical resistance function and an underbed over already laid concrete or masonry.

a) Tiles

The chemical resistant tiles shall be of the best indigenous Manufacture unless otherwise specified and shall be resistant to the chemical (both acid and alkali). The tiles shall have straight edges, uniform thickness, plain surface, uniform nonfading colour, and textures.

Usually the chemical resistant tiles shall not absorb water more than 2% by weight. The tiles shall have at least compression strength of 700 Kg/cm². The surface shall be abrasion resistant and durable.

b) Laying

The mortar used for setting or for underbed these tiles shall be durable, strong and chemical resistant epoxy mortar. The grout, which shall be to the full depth of tile, shall have equal chemical resistant properties. Joints shall be pointed if so desired. The setting and fixing shall be according to the manufacturer's specification approved by the Engineer.

2.02.06 Rubber, Vinyl, or Vinyl Asbestos Tiles Finish

This shall include various types of tiles manufactured from rubber, vinyl etc. set with an adhesive on concrete or masonry base. An underbed may be required to secure desirable surface and grade.

a) Thickness

The thickness of the tiles shall be as incorporated in drawing.

b) Tiles

Unless otherwise desired the tiles shall be squares of approved dimensions. The tolerance in dimensions shall be ± 1.5 mm.

The face of the tiles shall be free from porosity, blisters, cracks, embedded foreign matters or either physical defects which affect appearance or serviceability. All edges shall be cut true and square. The colour shall be nonfading and uniform in appearance, insoluble in water and resistant to alkalies, cleaning agents and usual floor polishes.

Each tile shall be marked on the back legibly and indelibly with manufacturer's trademark, the thickness, sizes, batch number, and date of



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manufacturer.

Tiles shall be delivered securely packed and stored in clean, dry well ventilated place at a temperature near about to that the tiles shall be called upon to stand ultimately.

Adhesive to be used for sticking the tiles shall be approved by the tile manufacturer. The adhesive shall have a short drying time and long life in addition to toughness.

c) Mix: Underbed

The underbed where required to make up the specified thickness or to give the required grade or to get the right type of surface shall be composed of 1 part like putty:1 part cement: 3 parts coarse sand mixed with just sufficient water to make it workable.

d) Laying

The tiles shall be kept in the room to be tiled for at least 24 hours to bring them to the same temperature as the room. For air-conditioned space, the air-conditioning shall be completed before tiling is taken up.

The surface to receive this finish shall be firm even textured but not too smooth, without undulations and other deficiencies. If an underbed is laid the same shall be cured for at least 7 days by keeping it moist and then fully dried.

The surface shall be thoroughly cleaned. All loose dust particles shall be removed. Oil and grease if any shall be completely cleaned by use of detergent.

The adhesive shall be applied to fully dry surface in desired thickness uniformly. The adhesive shall also be applied to the backs and edges of the tiles and allowed to surface dry. The tiles shall be placed neatly on the surface exactly to the approved pattern and set with a suitable tool. If the edges tend to curl, weights are to be used to keep the edges down. Special care shall be taken to avoid formation of air pockets under the tiles. The joints shall be very fine. Any adhesive squeezed out through the joints shall be removed immediately.

e) Finishing

If any adhesive mark is there on the surface a soft cloth soaked in solvent shall be used to wipe it off. The surface shall be cleaned with soft soap, dried, and polished with an approved type of polish just before handing over.



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2.02.07

Stone Slab Finish: Marble, Stone, and Similar Fine Grained Stone including Kota stone

a) Thickness

The underbed shall be minimum 12 mm and average 20 mm thick. The slabs will be 20 mm thick.

b) Stone Slab

The stone slabs shall be made from selected stock, which is hard, sound, homogeneous and dense in texture and free from flaws. Angles and edges shall be true, square, and free from chipping and surface shall be plane. The slabs shall preferably be machine cut to the required dimensions. Tolerance of ± 5 mm in dimensions and ± 2 mm in thickness will be allowed. Unless specified the slabs shall be minimum 300 mm x 300 mm.

The stone slabs shall come from specific regions and in specified quality with top surface fine chisel dressed. All sides shall also be fine chisel dressed to the full depth to allow finest possible joints.

The slabs shall be delivered to the site well protected against damages and stored in dry place under cover.

c) Mix: Underbed

Same as clause 2.02.01 (c).

d) Laying

The sides and top surface of the slabs shall be machine rubbed or table rubbed with coarse sand stone and washed before laying.

The underbed mortar shall be evenly spread and brought to proper level on the area under each slab. The slab shall be laid over the underbed, pressed, and tapped down with wooden mallet to the proper level. The slab shall then be lifted and the underbed corrected as necessary and allowed to stiffen a little. Next, thick cement slurry shall be spread over the surface. The edges of the slab shall be buttered with slurry of cement, gray / white / mixed with pigment matching the colour of the stone slabs. The slab shall be gently laid and tapped with wooden mallet to bed properly to a very fine joint and to the required level. All surplus cement slurry shall be removed and the surface mopped clean with wet soft cloth. The laid finish shall be cured for 7 days by keeping it wet.



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e) Polishing, Finishing

Fine chiselling shall be done to remove the slight undulations that usually exist at the joints. The polishing and finishing shall be done as specified under clause 2.02.01 (e). However, the joints shall be so fine in the case of stone slabs that grouting shall not be called for.

2.02.08

Stone Slab Finish: Sand Stone and Similar Coarse Grained Stone Finish

Generally clause 2.02.07 shall be followed except that the workmanship and finish shall not be fine as which are explained hereunder.

The slabs shall be rough chiselled or fine chiselled as specified. Tolerance may be allowed upto ± 6 mm for rough finish, but no sharp unevenness and shall be allowed. For fine chiselling the unevenness shall be limited to ± 2 mm. The sides shall be chisel dressed at least to half slab depth so that the maximum deviation from straight line shall be within 25 mm. Beyond this depth the edge may be slightly splayed.

The joint thickness shall be kept limited to 5 mm in case of rough finish and 3 mm in case of fine finish unless wider joints are specified. The joints shall be grouted with white or coloured cement. If fine joints in the flooring are specified, the edges of slabs shall be cut in such a way that it shall form a inverted 'Y'.

3.00.00

ACCEPTANCE CRITERIA

The finish shall be checked specially for:

- a) Level, Slope, Plumb as the case may be
- b) Pattern and Symmetry
- c) Alignment of joints, dividing strip etc.
- d) Colour, texture
- e) Surface finish
- f) Thickness of joints
- g) Details at edges, junctions etc.
- h) Performance
- i) Precautions specified for durability

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4.00.00	I.S. CODES All work shall be carried out as per this specification and shall conform to the latest revision and/or replacements of the following or any other Indian Standard (IS) Codes, unless specified otherwise. In case any particular aspect of work is not specifically covered by Indian Standard Codes, any other standard practice, as may be specified by the Engineer, shall be followed. IS: 777 : Glazed earthenware tiles IS: 1196 : Code of practice for laying bitumen mastic flooring. IS: 1197 : Code of practice for laying of rubber floors IS: 1237 : Cement concrete flooring tiles IS: 1443 : Code of practice for laying and finishing of cement concrete flooring tiles. IS: 2114 : Code of practice for laying in situ terrazzo floor. IS: 3461 : PVC asbestos floor tiles IS: 4860 : Specification for acid resistant bricks IS: 5518 : Code of practice for laying of flexible PVC Sheet and tile flooring. IS: 5491 : Code of practice for laying in situ granolithic floor topping. 5.00.00 RATES AND MEASUREMENT 5.01.00 Rates Rates shall be for the complete work (including dividing strips, ironite, metals, tiles etc. if any) as per the schedule of items. Rates shall be applicable for application on horizontal and vertical surfaces at all elevations and for all types of work including stairs tread and riser, laying in desired pattern and panels, cost of specials (if any) rounding of corners, mouldings etc. Rates shall be including provision of side shuttering (if required) for casting of floor in alternate panels and or without dividing strips.	



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5.02.00

Measurement

The finished surface shall be measured in Sqm for area unless otherwise specified. Deduction shall not be made for opening or embedded articles having area not exceeding 0.1 Sqm.



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SHEET WORK IN ROOF AND SIDING

SPECIFICATION NO. PE-TS-999-600-C013



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



TITLE:

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2.00.00	INSTALLATION	3
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<u>SHEET WORK IN ROOF AND SIDING</u> 1.00.00 SCOPE This section covers supply, cutting & fabrication and erection of corrugated/plain asbestos, corrugated galvanized iron, aluminum, permanently colour coated troughed zinc-aluminium alloy coated M.S. sheet or other sheet for covering to roof and sides at various elevations as specified. 2.00.00 INSTALLATION 2.01.00 Storage of Materials All materials shall be stored by the Contractor in proper way to prevent all damage. 2.02.00 Workmanship The workmanship shall be according to best construction practice to give a watertight finish to the satisfaction of the Engineer. Fixing of gutters and down pipes shall be according to IS: 2527. 2.02.01 Asbestos Sheeting Asbestos sheets of profiles as specified shall be fixed with minimum 150 mm end lap and side laps as per manufacturer's specification. Hook bolts or J-bolts shall be 8 mm dia. at 305 mm centres. Six (6) mm dia. galvanized iron seam bolt and nut with G.I. flat washers and bitumen washers shall be used for stitching ridge cappings, corner pieces, ventilators, north light curves etc. 2.02.02 C.G.I. Sheeting and Aluminium Sheeting Side laps shall be 2 corrugations for roof and one corrugation for side sheeting. End laps shall be minimum 150 mm for roof and 100 mm for side sheeting. In ridges and hips where plain sheets are used, the end laps shall be minimum 100 mm. Holes in C.G.I. sheets shall preferably be made on the ground. The sheets should be placed on purlins/trestles and holes punched in the ridge of the corrugation from the outside inward for obtaining proper seating of limpet washers. Sheets shall be secured to sheet framing by 8 mm dia. galvanised iron hooks or J-bolts and maximum spacing of the bolts shall be 305 mm. The length of the hook or J-bolts shall be to suit the sections of the bearers. Sheets shall also be bolted at the ends at every third corrugation with 6 mm dia. galvanized iron seam bolts and G.I. flat washers and bituminous washers.		

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2.02.03	Fibre Glass Reinforced Plastic Sheeting This shall be of thickness and profile as specified. Colour and light transmittance shall be as mentioned. Where used in conjunction with C.G.I. or asbestos sheeting, the end and side laps and fixing device shall be same as used for general sheeting. Where used in lieu of glass, the fixing shall be by means of timber or metal glazing beads. In all cases, the installation shall be completely watertight and able to withstand the designed wind-pressure.	
2.02.04	PERMANENT COLOUR COATED (SANDWICHED INSULATED) METAL CLADDING SYSTEM i. Troughed zinc-aluminium alloy coated (both sides) M.S. sheet having 0.6mm minimum thickness (or high tensile steel sheet having minimum yield strength of 350 Mpa of 0.5mm minimum thickness) shall be used on external face (outer face) of cladding system. Weight of coating shall not be less than 150 gm/sq.m. The outer side (exposed face) shall be permanently colour coated with Polyfluro Vinyl Coating (PVF₂) of Dry Film Thickness (DFT) 20 microns (minimum) over primer. Inner side of external sheet shall be provided with suitable pre-coating of minimum 7 microns. ii. Galvanised M.S. sheets of minimum 0.6mm thickness shall be used as inner liner (internal face) of cladding system. The exposed face shall be permanently colour coated with silicon modified polyester paint of DFT 20 microns (minimum) over primer. Inner face of external sheet shall be provided with suitable pre-coating of minimum 7 microns. The rate of galvanization shall not be less than 275 gm/sqm. iii. The permanent colour coated sheet shall meet the general requirements of IS:14246 and shall conform to class 3 for the durability. iv. Inner sheet shall be fixed directly to side runners and Z spacers made out of at least 2 mm thick galvanized steel sheet of grade 375 as per IS:277. Inner sheet shall be fixed at the rate not more than 1.50M centre to centre to hold the insulation and external sheeting. The fasteners shall be of high quality corrosion resistant grade of self tapping / self drilling type provided with suitable cap. v. The insulation shall be of bonded mineral wool of minimum thickness 50mm conforming to IS:8183, having a density of 32 Kg/cu.m. for glass wool & 48 Kg/cu.m. for rock wool.	
2.02.05	PERMANENT COLOUR COATED (NON-INSULATED) METAL CLADDING SYSTEM i. Troughed zinc-aluminium alloy coated not less than 150 gm/sq.m M.S. sheets having 0.6 mm minimum thickness (or High tensile steel sheet having minimum yield strength of 350 Mpa of 0.5mm minimum thickness) shall be	

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	used for the cladding system. The outer side (exposed face) shall be permanently colour coated with PVF₂ paint of minimum DFT 20 microns over primer and the inner side (internal face) shall be coated with same paint of minimum DFT 12 microns over primer. These shall be fixed directly to runners. The sheets shall meet the general requirement of IS:14246 and shall conform to class 3 for the durability. ii. FLASHING, CAPS, TRIM CLOSURES ETC. All flashings, trim closures caps etc. required for the metal cladding system shall be made out of plain sheets having same material and coating specification as mentioned above for the outer face of the sandwiched metal cladding. 3.00.00 ACCEPTANCE CRITERIA The installations shall present a neat appearance and shall be checked for water tightness. The following shall be checked: a) Side and end laps b) Absence of cracks, holes or damages in sheet c) Spacing of bolts d) Provision of double washers (G.I. and asbestos or bituminous washers) e) Proper installation of flashing. 4.00.00 I.S. CODE All work shall be carried out as per this specification and shall conform to the latest revision and/or replacements of the following or any other Indian Standard (IS) Codes, unless specified otherwise. In case any particular aspect of work is not specifically covered by Indian Standard Codes, any other standard practice, as may be specified by the Engineer, shall be followed. - IS: 3007 : Code of practice for laying of asbestos cement sheets. - IS: 2527 : Code of practice for fixing rainwater gutters and down pipes for roof drainage. - IS: 1626 : Specification for asbestos cement building pipes, gutters and fittings. - IS: 277 : Specification for galvanized steel sheets (plain and corrugated).	

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5.00.00	RATES AND MEASUREMENT	
5.01.00	Rates	
	Rates shall be unit rate for complete item described in “Schedule of Items” and shall include all wastage.	
5.02.00	Measurement	
	Sheeting work in roof & sides shall be measured in Sq.M. for net area of the work done. Profiled sheeting shall be measured flat and not girthed. Opening less than 0.40 Sqm shall not be deducted. No extra shall be paid for extra labour in cutting and for wastage etc. No payment shall be made for laps, flashings, sealing, fasteners etc. in sheeting works.	



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**TECHNICAL SPECIFICATION FOR
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SUSPENDED CEILING

SPECIFICATION NO. PE-TS-999-600-C014



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



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SUSPENDED CEILING**1.00.00 SCOPE**

This section covers supply and installation of suspended ceiling together with the suspension system as shown on drawing or specified in schedule of item with all materials, labour and equipments. The work shall also include providing of openings in the ceiling for lighting, air-conditioning diffusers etc. as shown on drawings or as instructed by the Engineer.

2.00.00 INSTALLATION**2.01.00 Suspension System****2.01.01 General**

Suspension system shall consist of the grid supporting the ceiling panels, intermediate runner supports for the grid if any and hangers, wall angles etc. required to suspend the grid or the runners from structural works, slabs and beams.

All members of the suspension system shall be of sufficient strength and rigidity to carry, the ceiling boards or sheets in a true and level plane without exceeding a deflection of 1/360th of their span. All joints in ceiling panels shall run straight and cross joint shall be at perfect right angles. Angle moulds where shown on drawings shall be securely fixed to walls. All drillings of structural concrete and installation of suitable anchoring device for installation including welding of the suspension system shall be included in the rate. All M.S. sections used for supports etc. shall be given one coat of synthetic enamel paint over a coat of red lead primer.

2.01.02 Metal Grid Suspension System

Aluminium grid ceiling system shall be “Bead lock” as manufactured by W A Beard shell and Co. Pvt. Ltd. or Ajit India Limited or approved equal. Steel grid ceiling system shall be 'Jolly Snap Grid' as manufactured by Jolly Board Limited or approved equal.

Steel tees as intermediate members and steel channels, as end pieces will be assembled in the form of grid. Size of tees and channels shall be as required.

The cross-tees shall intersect main tee runners in pattern shown on drawing and positively locked together with intersection members. All perimeter areas shall have tee runners fixed to vertical wall surfaces and end channels shall be fixed to runners leaving return air space between vertical wall and channels,



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unless otherwise shown on drawings. Angle cleats or other suitable fixing device shall be fixed to the structural beams above for fixing of hangers. Main runners shall be hung by M.S. flats, angles, rods or 12G or heavier galvanized tie wire hangers at maximum 1.2 metre centres. Extra hangers shall be provided at light fixtures that are supported from the ceiling system. The spacing of main and cross runners shall be as shown on drawings. Turnbuckles shall be provided in M.S. rods for adjustment in levels.

2.02.00 Ceiling Panels

2.02.01 Material

Ceiling panels shall be best quality material in thickness and properties called for in the “Schedule of items”. The Contractor shall submit test certificates to the Engineer for approval before bulk supply. The ceiling panels may be of following type:

- a) Plaster of Paris board (decorative)
- b) Expanded polystyrene insulation board with plastic fascia.
- c) Fibre Insulation board.
- d) Bonded wooden particle board (Plain and decorative)
- e) Glass fibre reinforced polystyrene sheets.
- f) Flat asbestos sheets (with plastic fascia).

2.02.02 Installation of Ceiling Panels

Installation of Ceiling panels shall be strictly as per manufacturer’s instruction.

For concealed grid system, tiles shall be fixed to the supporting grid in manner shown on drawing or as specified by the manufacturer. Where V joints in tiles are called for in drawings, these shall be in true lines. Where flush surface is required, the joints shall be filled with approved filler material and finished to give a neat uniform surface. Special care shall be taken to neatly finish the ceiling at junctions with walls, light fixtures, diffusers etc.

2.02.03 Aluminium Lineal Ceiling System

Aluminium lineal ceiling system shall be “Luxalon 84C ” or approved equal and the installation shall be strictly as per manufacturer’s instruction/ specification subject to approval of the Engineer.



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Aluminium lineal ceiling shall comprise of plain panels, 84 mm wide and 12.5 mm deep with a 23.9 mm recessed flange, roll formed out of 0.5 mm thick aluminium alloy panels stove enamelled on both sides, fixed on roll-formed carriers made of enamelled 0.95 mm thick aluminium, 32 mm wide and 39 mm deep with prongs to hold panels in the module of 100mm, at maximum spacing 1.2 M centre to centre. The carriers shall be suspended from roof by 4 mm dia galvanised steel wire hangers with special height adjustment clips made out of spring steel at maximum spacing of 1.2 M c/c. Hangers shall be fixed to roof by 'J' hooks and nylon inserts. 25 mm thick resin bonded mineral wool (spintex 300 or equivalent) insulation bound in polythene shall be laid on top of panels. Lineal ceiling shall be fixed in pattern as per detailed drawings.

3.00.00 SAMPLES

Samples of Ceiling panels and metal suspension system components as noted below shall be submitted for Engineer's approval:

Panels : 3 samples approximately 300 mm square/long each

Suspension System : 3 samples of short length : each of main and secondary system

4.00.00 SHOP DRAWINGS

Shop drawings shall be submitted for approval as required and approval shall be obtained prior to delivery of suspended ceiling components. Shop drawings shall be co-coordinated with all related work and shall show the following information:

- a) A reflected ceiling plan of areas indicated to receive the ceiling showing electrical and mechanical features.
- b) Typical Intermediate framing for support where required.
- c) Hanger fastening details.
- d) Panels - unit support at ceiling penetrations.
- e) Details of splicing method for main and cross runners.
- f) A table indicating load bearing capacity of main and cross runner
- g) A note stating that the suspension system member furnished will not deflect more than 1/360 of the span under the indicated loading.

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5.00.00	ACCEPTANCE CRITERIA Finished ceiling shall be at the correct plane and present a pleasing and uniform appearance, free from, sags, warps, disfigured, or damaged board. Cutouts for light fixtures, diffusers etc. shall be of exact dimensions and in exact locations.	
6.00.00	RATES AND MEASUREMENT	
6.01.00	Rates Rates shall be for the complete item called for in the “Schedule of Items”. No extra payment will be made for alignment and adjustment of lighting fixtures, air-conditioning diffusers, access panels etc. The rate shall include all cutting and wastage from standard size sheets, runners/carries etc.	
6.02.00	Measurement Actual area of work shall be measured in Sqm correct to second place of decimal. However, no deduction will be made for opening upto 0.25 Sqm. each in area.	



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**WATER SUPPLY, DRAINAGE
AND SANITATION**

SPECIFICATION NO. PE-TS-999-600-C015



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



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WATER SUPPLY, DRAINAGE AND SANITATION**1.00.00****SCOPE**

This section covers supply of all materials labour and incidentals required for supply, laying and installation of under/over ground pipes for water supply, drainage and sanitation with all fittings, fixtures and jointing, construction of ancillary works like manholes, drop connections, gully chambers, septic tank, soak pits, surface drain etc.

The supply and installation of water supply/sanitation fixtures and accessories like water closets, urinals, wash basins, sinks, mirrors, shelves, towel rail, soap container etc. with all fittings, fixtures, water supply/sanitation pipes and water storage tanks etc.

2.00.00**MATERIAL**

All materials, fittings, fixtures, and appliances shall be of the best quality conforming to relevant Indian Standard and shall be procured from approved manufacturers. Unless specifically allowed by the Engineer, the Contractor shall submit samples of fittings and fixtures, which will be retained by him for comparison when bulk supplies are received at the site. Ultimate choice of type, model, and manufacturer lies completely with the Engineer.

It shall be the responsibility of the Contractor to procure the materials selected by the Engineer. Hence orders are to be placed with the manufacturers in time, so that the materials are available at the site well ahead of their requirement.

The materials brought to the site, shall be stored in a separate secured enclosure away from the building materials. Pipe threads, sockets, and similar items shall be specially protected till final installation. Brass and other expansive items shall be kept under lock and key. Fragile items shall be checked thoroughly when received at the site and items found damaged shall not be retained at the site.

2.01.01**Pipes and Pipe Fittings**

For water supply, galvanised mild steel pipe of medium grade confirming to IS: 1239 shall be used. The galvanising shall not be less than 400gm/sqm of pipe surface area. Galvanising shall be smooth and shall be subjected to testing as per IS: 2633 for uniformity of coating. The zinc coating shall be free from defects.

For Roof drainage and building sanitation works following type of pipe are coved in this Section:



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- a) Cast Iron pipe
- b) Steel pipe (lined, coated with bituminous composition, out coated with cement concrete or mortar or galvanized)
- c) Concrete pipe
- d) Asbestos cement pipe
- e) PVC pipe
- f) Stoneware pipe
- g) Vitrified pipe
- h) Lead pipe (not to be used for portable water)

2.02.01**Fixtures**

All material, fittings, fixtures, appliances, accessories shall be of approved quality and shall be procured from reputed brands like Hindustan/Pasriware/Cera or equivalent or as approved by Engineer. The bidder shall procure the fixtures from the above named reputed manufacturers and shall mention in his bid the type & make of the fixtures he intends to use.

All items brought to the site must bear the manufacturer's identification mark. Procurements shall be made well in advance and should get inspected & approved immediately by the Engineer. All fixtures shall be adequately protected, covered, and plugged till handing over.

All fittings, gratings, fasteners, unless specified otherwise, shall be chromium plated. The chromium plating shall be of grade-2 (10micron thickness) confirming to IS: 4827. Powder coating shall be of approved colour and shall have minimum thickness (DFT) of 20micron. Stainless steel accessories shall be of grade SS-304 and from reputed manufacturer (like Salem Steel) and shall be polished bright finish.

Unless specified in the contract the fixtures shall be as specified hereinafter.

Water closet**a) European type**

It shall consist of European type glazed vitreous china basin (confirming to IS: 2556, part-II), with siphon open front solid plastic seat and plastic cover, low level glazed stoneware flushing cistern with valve less fittings, supply connections and necessary fittings. All fittings shall be chromium



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plated. Colour of basin, cistern, seat and cover shall be as approved by the Engineer.

b) Squatting type

It shall consist of Orissa pattern glazed vitreous china squatting pan with integral foot rests (confirming to IS:2556, part-III) and high level cast iron flushing cistern with valve less fittings, supply connections and necessary fittings. All fittings shall be chromium plated. The flushing cistern shall be painted as specified by the Engineer.

Urinals

It shall consist of wall type glazed vitreous china urinals (conforming to IS:2556), cast iron automatic flushing cistern complete with supply connections, flush pipe, lead pipes, gratings, traps and all other necessary fittings. Frequency of automatic flushing shall be approximately once every five minutes. For every four urinals (maximum) located together may be served by one cistern of adequately capacity. All fittings shall be chromium plated.

Wash Basin

It shall be made of glazed vitreous china conforming to IS:2556, part-IV. The basin shall be flat back, wall hung by painted cast-iron brackets and complete with hot and cold CP brass faucets with nylon washers, PVC connection pipe with CP brass nuts, CP brass chain with rubber plug, 32mm dia. Chromium plated brass waste of standard pattern, 32mm dia. CP brass trap union complete with necessary fittings.

Sink

It shall be made of glazed vitreous china conforming to IS:2556, part-V. It shall be wall hung by painted cast iron brackets and complete with one CP brass faucet with nylon washers, PVC connection pipe with CP brass nuts, CP brass chain with rubber plug, 40mm dia. chromium plated brass waste of standard pattern, 40mm dia. CP brass trap union complete with necessary fittings.

Bathroom mirror

It shall be made of the best quality 6 mm thick glass and produced by a reputed mirror manufacturer. It shall be wall mounted with adjustable revolving brackets. The brackets, screws, and other fittings shall be chromium plated.



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Glass shelves

Class shelves shall consist of 6 mm thick clear glass with guardrails and shall be wall mounted with brackets. All brackets, guardrails, and screws shall be chromium plated.

Towel rail

Towel rails shall be 20 mm dia chromium plated MS pipes wall mounted with steel brackets. The brackets, screws etc. shall also be chromium plated.

Soap holder

It shall be made of chromium plated strong members. The holders shall be wall mounted with chromium-plated screws.

Liquid Soap Dispenser

It shall be round and easily revolving with removable threaded nozzle. The body, bracket for wall mounting and screws shall be chromium plated.

Toilet roll holder

It shall be made of glazed vitreous china with suitable cover cum cutter. Wall mounting screw shall be chromium plated.

Valve, cocks, Taps

All valves, stop cocks, taps etc. shall conform to relevant Indian standard specification and shall be of best quality from approved manufacturers. These shall be suitable for normal working pressures. Nominal size and material shall be as required / specified.

2.03.00**Water Storage Tank**

Water storage tank shall be PVC of approved brand and make (Syntex or equivalent). Reservoirs made of concrete masonry or fabricated steel shall be covered by respective work specifications.

3.00.00**INSTALLATION****3.01.00****General**

Basic layouts may be available in the drawings provided, the details might have to be supplemented by the Contractor and get the approval of the Engineer before installation. Special attention shall be given to economise the layout. Symmetry of layout is very important. Fittings meant for operation



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shall be located and oriented to allow easy reach and operation. Maintenance, repairs, and replacements of pipes, fittings, and fixtures must be conveniently possible. All pipe lines, locations of fittings and fixtures, etc. shall be as per drawings or as directed by the Engineer. Correctness of lines, plumb, orientation, symmetry, and levels shall be strictly ensured. All items shall be fully secured against movement in any direction and so located as to allow easy maintenance.

All pipelines, fittings, and fixtures shall be installed leak proof. When the works under scope of this specification linked up with works executed by others, the connections shall be such as to prevent any splashing or spilling or emission of foul odour and gases.

3.02.00 Portable water supply Pipe Lines**3.02.01 Laying**

In addition to fulfilling the functional requirements all pipelines shall be laid true to line, plumb and level and shall run on the surface of the walls, ceiling or in chases. Any deviation shall need approval of the Engineer. Meticulous care shall be taken to avoid chances of airlock and water hammer.

Pipes shall be laid on continuous unyielding surface or on reliable supports at least one near each joint and spacing as directed by the Engineer. The support must be strong, neat and shall have provisions for securing the pipes in every direction and easy maintenance. All pipes used for water supply should be thoroughly and efficiently disinfected before taken in to use.

3.02.02 Back Flow

The layout of pipe work shall be such that there is no possibility of back flow towards the source of supply from any cistern or appliances, whether by siphonage or otherwise. All pipe works shall be so laid or fixed and maintained as to be and to remain completely watertight, thereby avoiding waste of water, damage of property and the risk of contamination of the water conveyed.

3.02.03 Contamination

There shall be no cross connection whatsoever between a pipe/fitting for conveying or containing wholesome water and a pipe/fitting for containing impure water or water liable to contamination or of uncertain quality of water which has been used for any other purpose. No piping shall be laid or fixed so as to pass into or through any sewer, scour outlet or drain or any manhole connected therewith.



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3.02.04 Underground Piping

Underground piping shall be laid at such a depth that it is not likely to be damaged by traffic and other loads and frost, where applicable. The size and depth of the trench shall be as approved by the Engineer. Back filling shall be done with selected fine earth, unless otherwise permitted, in 150 mm layers and carefully consolidated. Special care shall be taken while filling in the vicinity of the pipe to avoid damage. Before backfilling, the laid pipe shall be fully tested and approved.

Where the pipe rests on rock it may be bedded on a layer of fine selected material or concrete to avoid local point support. The trench shall be so treated by gradient and filling in the area that it does not act as a drainage channel.

3.02.05 Concealed Piping

Where desired by the Engineer or shown on the drawings the pipes shall be concealed in masonry or concrete of the structure. The Contractor may co-ordinate with the building Contractor for leaving the chases, openings, and conduits as necessary. However, the Contractor will rectify if required the chases, openings, and conduits, supplement and make good after laying and testing of the concealed pipelines.

3.02.06 Jointing of Pipes

All G.I. pipes shall be properly thread/weld jointed and made completely water tight and durable. Burr from the joints shall be removed after screwing. Union joints shall be provided for all required location to facilitate maintenance.

3.02.07 Painting

Where required, underground G.I. pipes shall be given 2 coats of bituminous paint on the outside after laying. When painting is to be done above ground G.I. pipes shall be given one coat of red lead or zinc chromate primer and top coats shall be minimum 2 coats of best quality paint as specified.

3.03.00 RAINWATER DOWN COMERS**3.03.01 Pipes**

Rainwater down comers shall be standard Cast Iron or Asbestos Cement Pipes. In case where specifically desired, M.S. pipes may also be used. M.S. pipes shall be painted outside with two coats of anticorrosive paints under a coat of primer.

Rainwater down comers shall run along and be secured to walls, columns etc.



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Where desired by the Engineer these may have to be installed in chases cut in the structure. All pipes shall be well secured and supported by adequately strong brackets. The brackets may be wrought iron clevis type, split ring type, or perforated strap iron type as approved by the Engineer. For vertical runs each pipe shall hang freely on its brackets fixed just below the socket. Suitable spacer blocks shall be provided against the vertical surface to which the pipe is fixed.

All bends and junctions shall be supplied with watertight cleanouts.

Roof and floor drains and yard gullies shall be installed, if required, by cutting into the structure and grouted with 1:2:4 cement concrete. All gutters shall be provided with removable gratings.

All horizontal pipes shall have a minimum fall of 1 in 100.

3.03.02 Khurras

The khurras shall be constructed before the work in parapet wall is taken up and it shall be 45x45 cm in size, unless otherwise specified and shall be formed of cement concrete of M-20 grade.

3.03.03 Gutters

The gutters shall be made of G.I. or A.C and procured from reputed specialised manufacturers. Each section shall be sufficiently rigid, edges and corners straight and the slopes perfectly uniform. G.I. gutters shall have the edges strengthened by suitable means.

Unless noted otherwise the gutters shall have a minimum fall of 1 in 120. Adequate number of string supports shall be provided so that there is no sagging even when the gutter is full. Each joint must have a support. Unless otherwise specified the supports shall be fabricated M.S. brackets. All junctions shall be thoroughly watertight. The joints may be made by riveting, bolting or soldering. All joints between successive lengths of gutters shall have an overlap of at least 5 cm. The drop in the overlap shall always be in the direction of the fall of the gutter. Ends of gutters shall be closed watertight. Junction with rainwater down comers shall be made fully watertight and secured.

3.04.00 SOIL AND DRAINAGE PIPES**3.04.01 Gradients**

If not specified the minimum gradients of soil and drainage pipeline shall be as follows:

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	100 mm nominal dia : 1 in 35 150 mm nominal dia : 1 in 65 230 mm nominal dia : 1 in 120 300 mm nominal dia : 1 in 200	
3.04.02	Relation with water supply pipelines Unless specifically cleared by the Engineer, under no circumstances shall drainage and sewer pipes be allowed to come close to water supply pipelines.	
3.04.03	Laying Each separate pipe shall be individually set for line and for level. Where lengths of sewer or drain pipes are laid in trench, properly painted sight rails shall be fixed across the trench at a height, equal to length of the boning rod to be used, above the required invert level of the drain or sewer at the point where the sight is fixed. More sight rails shall be required at manholes, change of gradient and intermediate positions if the distance for sighting is more than 50 ft. apart. The excavation shall be boned in at least once in every 6 ft. The foot of the boning rod shall be set on a block of wood of the exact, thickness of the wall of the pipe. Each pipe shall be separately and accurately boned between sight rails.	
3.04.04	Support and Protection of Pipelines All pipes shall be laid with sockets leading uphill. Preferably the pipe shall rest on solid and even foundations for the full length of the barrel. However, the pipe manufacturer's instruction as approved by the Engineer shall be followed in the matter of support and jointing. To achieve full and continuous support, concrete for bedding and packing is the best. Where pipes are not bedded on concrete, the floor shall be left slightly high and carefully placed so that the pipe barrels rest on undisturbed ground. If anywhere the excavation has been carried too low packing shall be done in concrete. Where laid on rock or very hard ground which cannot be easily excavated to a smooth surface, the pipes shall be laid on a cradle of fine concrete floor of gravel and crushed stone over laid with concrete or on a well consolidated gravel and crushed stone bed as desired by the Engineer. PVC or similar pipes shall be laid directly on stable soil and packed with selected soil. The minimum support and protection for glazed stoneware pipes shall be as follows: a) When cover is less than 2 metre below ground level and where pipes are unavoidably exposed above ground surface, the pipes shall be completely encased or surrounded with concrete.	



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- b) Where pipes are laid on soft soil with the maximum water table laying at the invert of the pipe, the sewer shall be bedded on concrete.
- c) Where the pipes have to be laid on soft soil with the maximum water table rising above the invert of the pipe, but below the top of the barrel, the pipe sewer shall be haunched.
- d) Where maximum water table is likely to rise above the top of the barrel or wherever the pipe is laid on soft soil the pipe sewers shall be completely encased or surrounded with concrete.

Vitrified clay pipes shall be laid on a bed of 150 mm thick cement concrete (1:3:6) nominal mix by volume.

Cast iron pipes and concrete pipes may be supported on suitable concrete or brick support, where specified. The supports shall be unyielding and strong enough. At least one support shall be located close to ends. Spacing of intermediate supports shall be as decided by the Engineer. Pipes shall be secured to the supports by approved means.

Anchoring of pipes where necessary shall be achieved by suitable concrete encasing designed for the expected thrust.

3.04.05 Entry into structures

For entry of the pipe lines into any building of structure suitable conduits under the structure or sleeves shall be used. The conduits and sleeves shall be such as to allow easy repairs and replacement of the pipes. When openings or chases are required to be made in the structure for entry of pipelines, locations and sizes shall be marked and checked by the Engineer. After laying of the pipeline the openings and chases shall be mended.

3.04.06 Ducts

Where solid, waste and ventilating pipes are accommodated in ducts, access to cleaning areas shall be provided. Connection to drain shall be through a gully with sealed cover to guard against ingress of sewer gas, vermin, or backflow.

3.04.07 Traps and Ventilating Pipes

Pipes are carrying off the waste from water closets and waste water and overflow water from baths, wash basins, sinks to drains shall be trapped immediately beneath such fixtures. Traps shall have minimum water seal of 50 mm and shall be ventilated whenever such ventilation is necessary to maintain water seal of the trap. Ventilating pipes shall be carried up vertically from the drain to a height of at least 600 mm above the outer covering of the roof of the building or as shown on drawings. All vertical ventilating, anti-



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syphonage and similar pipe shall be covered on top with a cowl. The cowl shall be made of C. I. unless desired otherwise by the Engineer.

3.04.08**Manhole & Inspection Chambers**

At every change of alignment, gradient or diameter there shall be a manhole or inspection chamber. The maximum distance between manholes shall be 30 meter unless specially permitted otherwise. However, for truck route (for pipes above 900 mm dia.) this distance can be increased to 45 M. The distance between manhole or inspection chamber and gully chamber shall not exceed 6 metres unless desired otherwise provision of IS: 4111 (Part-1) shall be followed for construction of a manhole. Manhole shall be constructed so as to be watertight under test. The change in alignment shall be carried out in such a manner as to provide no lodgement for any splashings in case of accidental flashing of the chamber. The channel or drain at the bottom of chamber shall be plastered with 1:2 cement, sand mortar and finished smooth to the grade. The channels and drains shall be shaped and laid to provide smooth flow.

Connecting to existing sewer lines shall be through a manhole.

Unless otherwise specified, 560 mm dia. circular cast iron manhole cover with frame, heavy-duty, conforming to IS: 1726 shall be provided. The covers shall be close fittings so as to prevent gases from coming out.

3.04.09**Cutting of Pipes**

Manufacturer's instructions shall be followed for cutting of pipes where necessary. Suitable and approved tools shall be used for the cutting so as to leave surface clean and square to the axis of the pipe.

3.04.10**Jointing**

Jointing of pipes shall be so planned as to avoid completely any movement or strain to the joints already made. If any joint is suspected to be damaged it shall be opened out and redone.

All joints between pipes, pipes and fittings and manholes shall be gas-tight when above ground and watertight when underground. Method of jointing shall be as per instructions of the pipe and fittings manufacturer and as approved by the Engineer. However, in the absence of any instruction available from the manufacturer the methods as detailed hereunder shall be used.

a) Cast Iron Pipes

Socket and spigot pipes shall be jointed by the cast lead joints. The spigot shall be centred in the socket of the pipe by tightly caulking in sufficient



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turns of tarred gasket or hemp yarn to have unfilled half the depth of socket. When the gasket or hemp yarn has been caulked tightly a jointing shall be placed round the barrel and tightened against the face of the socket to prevent airlock. Molten lead shall then be poured in to fill the remainder of the socket and caulked with suitable tools right round the joint to make up for shrinkage of the molten metal on cooling and shall be finished 3 mm behind the socket face.

Joints in cast iron pipes with special jointing arrangements like 'Tyton' Joints etc. shall follow the instructions of the manufactures.

In special cases if flanged joints are accepted by the Engineer the joints shall be made leak proof by inserting approved type of rubber gaskets. The bolts shall be secured in stages to avoid uneven strain.

b) Concrete Pipes

Jointing of concrete pipes shall be generally of rigid type. Unless otherwise stated collar type joint shall be provided. IS: 783 shall be followed for general guidance.

The two adjoining pipes shall be butted against each other and adjoined in correct position. The collar shall then be slipped over the joint, covering equally both the pipes. The angular space shall be filled with stiff mixture of cement mortar 1:2 (1 cement : 2 sand) which shall be rammed with caulking tool. After a day's work, any extraneous material shall be removed from the inside of the pipe and the newly made joint shall be cured for 7 days.

c) Glazed Stoneware Pipes

Tarred gasket or hemp yarn soaked in thick cement slurry shall first be placed round the spigot of each pipe and the spigot shall then be placed into the socket of the pipe previously laid. The pipe shall then be adjusted and fixed in the correct position and the gasket caulked tightly so as not to fill more than 1/4 of the total depth of the socket. The remainder of the socket shall be filled with a stiff mixture of cement mortar 1:1 (1 cement : 1 sand). A fillet shall be formed round the joint with a trowel, forming an angle of 45 deg. with the barrel of the pipe. The newly made joints shall be protected, until set and shall be cured by covering with damp cloth or other suitable materials.

d) Vitrified clay pipes

The vitrified clay pipe shall be made from refractory clay mixed with crushed pottery and stone and burnt at a high temperature. These shall be hard, compact, and glazed to make them acid resistant and impervious, and



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shall be obtained from approved manufacturer.

Special care shall be taken in handling these pipes. The pipes shall not be jointed until the earth has been partly refilled over the portion of the pipe between the joint holes. Before laying the second pipe, the socket of the first pipe laid shall be thinly painted all round on the inside with cement slurry (1 part of cement and 2 parts of clean, sharp sand). A ring of rope yarn (closely twisted hemp or jute) dipped in neat cement paste or tar or bitumen, shall be inserted in the socket of pipe and driven home with caulking tools. The rope shall fully encircle the spigot with a slight overlap and shall not occupy more than one-fourth of the total depth of the socket. Where the spigot end of the pipe is made for receiving the gasket, it shall be wrapped with two or three turns of tarred spun, as close to the end as possible, before inserting into the socket. The joint shall then be completely filled with cement mortar (1:1), which shall have very little water. A fillet shall be formed round the joint with trowel, forming an angle of 45 degrees with the outside pipe. Special care shall be taken so that any excess mortar etc. left inside the pipe joints is neatly cleaned off immediately after each joint is made. A semi-circular wooden scrapper or a rubber disc to which a long handle is fixed could be used for this purpose.

e) Lead Pipes

The joints in lead pipes shall be made as wiped solder joint. The minimum and the maximum length of the wiped solder joints shall be 8 cm. and 9 cm. respectively. The solders shall generally consist of two parts of lead and one part of tin.

f) Polyethylene Pipes

The joints shall be thermo welded or bolted as per manufacturer's instructions.

g) Jointing Cast Iron Pipes with Stoneware Pipes

Where any cast iron drain pipe, ventilating pipe or trap is connected with a stoneware or semi-vitrified waste pipe, the beaded spigot end of such cast iron drain pipe, waste or ventilating pipe or trap shall be inserted into a socket of such stoneware pipe and the joint made with mortar consisting of one part of cement and one part of clean sand after placing a ratted gasket or hemp yarn soaked in neat cement slurry round the joint and inserted in it by means of a caulking tool.

h) Jointing Stoneware with Cast Iron Pipes

Where any water closet pan or earthenware trap connected to such a pan is to



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be jointed with a cast iron soil pipe, the joint between the stoneware spigot and the cast iron socket shall always be of a flexible nature. Such joint shall be made with a mixture of bitumen and chopped asbestos fibre.

3.04.11 Trenches and other excavations

Width of the trench at the bottom shall be such as to provide 200 mm clearance on either side of the pipe for facility of laying and jointing.

Excavated material shall be stacked sufficiently away from the edge of the trench and the side of the spoil bank shall not be allowed to endanger the stability of the excavation. Spoil may be carted away and used for filling the trench behind the work.

Turf, top soil or other surface material shall be set aside, turf being carefully rolled and stacked for use in reinstatement.

All excavation shall be properly timbered, where necessary.

Efficient arrangements for dewatering during excavation and keeping it dry till backfilling shall be made to the satisfaction of the Engineer. Sumps for dewatering shall be located away from the pipe layout.

Where the excavation proceeds through roads necessary permissions shall be secured by the Contractors from the appropriate authorities.

Special care shall be taken not to damage underground services, cables etc. These when exposed shall be kept adequately supported till the trench is backfilled.

The backfilling shall be done only after the pipeline has been tested and approved by the Engineer. Special care shall be taken under and sides of the pipe during hand packing with selected material. At least 300 mm over the pipe shall also be filled with soft earth or sand. Consolidation shall be done in 150 mm layers. The surface water shall be prevented from getting into the filled up trench. Traffic shall not be inconvenienced by heaping up unduly the backfilling material to compensate future settlement. All future settlements shall be made good regularly to minimize inconvenience of traffic where applicable.

3.04.12 Protection

Open end of each pipe shall be protected during installation by suitable covers or plugs so that the ends, threads, sockets, or spigot are not damaged and no foreign material can find its way into the pipeline. Fittings and fixtures liable to be misused or stolen during the construction phase shall be fitted only before testing and handing over.



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3.05.00 WATER STORAGE TANKS

Overhead/loft type water storage tank shall be made of PVC. These tanks shall be provided for each toilet block and placed on the roof/loft of the building. Tank shall be installed with proper supports and anchorage for applicable wind and seismic condition. Installation of tank shall be carried out according to the recommendation of IS: 12701. These tanks shall rest preferable on flat surface so as to distribute the load evenly. The tank shall be leakproof and water tight.

The outlet pipe shall be 50 mm above the bottom of the tank and provided preferably with strainers. The wash out or draining pipe shall be connected at the lowest point and flush with bottom of tank.

Tank shall be provided with all fittings for inlet, outlet, overflow pipes and ball valves.

3.06.00 SEPTIC TANK AND EFFLUENT DISPOSAL**3.06.01 Septic tank**

Septic tank shall consist of the tank itself with inlet and outlets there from complete with all necessary earthwork and backfilling. The details of septic tank shall be as shown on drawings. This item shall also include ventilating pipe of at least 100 mm dia whose top shall be provided with a suitable mosquito proof wiremesh and cowl. Ventilating pipe shall extend to a height of about 2 meter when the septic tank is at least 15 meter away from the nearest building and to a height of 2 meter above the top of building when it is located closer than 15 meter. Ventilating pipes can be connected to the normal soil ventilating system of the building where allowed.

3.06.02 Effluent Disposal

The effluent from the septic tank shall be disposed by allowing it into an open channel or a body of water if the concerned authority approves or into a soak pit for absorption by soil or shall be allowed to be absorbed by soil through open jointed SW pipes laid in a trench filled with broken bricks.

3.06.03 Soak pit

The soak pit shall be complete. It shall consist of a 900 mm dia pit 1000 mm in depth below the invert level of the inlet pipe. The pit shall be lined with stone; brick or concrete blocks set in cement mortar (1:6) and filled with brickbats. Inlet pipe shall be taken down to a depth of 900 mm from the top as an anti-mosquito measure.

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3.06.04	Open joined SW Pipe/dispersion trenches Minimum dia of the SW pipes shall be 150 mm nominal. The trench for laying the pipes shall be a minimum 600 x 600 mm. The joints of the pipes shall be left unsealed. The entire length of the pipe within the trench shall be buried in a 250 mm layer gravel or crushed stone of uniform size. On top of gravel/crushed stone layer is a 150 mm bed of well-graded coarse aggregate. Ordinary soil is used for filling the top of trench.	
3.06.05	Commissioning septic tank After the septic tank has been proved watertight and the sewage system is checked the tank shall be filled with water to its outlet level before the sewage is let into the tank. It shall be seeded with well digested sludge obtained from septic tank or sludge digestion tank. In the absence of digested sludge a small quantity of decaying organic matter such as digested cow-dung may be introduced.	
3.07.00	Related Works All works, like earthwork, masonry, concrete, steelwork, cutting holes, chases, repairs and rectification associated directly with installation of water supply and sanitation systems shall come under scope of the Contractor unless specifically excluded. These works are not detailed out in this Section.	
3.08.00	Regulation The work which is required to be carried out under this section, shall be executed by a licensed Plumber only (engaged by the Contractor) and he shall obtain all necessary sanctions, permissions, certificates etc., from Municipal and/or other Local Authorities and shall abide by all the rules of such Authorities.	
4.00.00	TESTING AND ACCEPTANCE CRITERIA	
4.01.00	Inspection Before installation All pipes, fittings, and appliance shall be inspected, before delivery at the site to see whether they conform to accepted standards. The pipes and fittings shall be inspected on site before laying and shall be sounded to disclose cracks. Any defective items shall be clearly marked as rejected and forthwith removed from the site.	
4.02.00	Testing of Water Supply pipe line	
4.02.01	Testing of Mains After Laying	



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After laying and jointing, the main shall be slowly and carefully charged with water, so that all air is expelled from the main by providing a 25 mm inlet with a stop-cock, allowed to stand full of water for a few days if time permits, and then tested under pressure. The test pressure shall be 5 Kg/sq.cm or double the maximum working pressure, whichever is greater. The pressure shall be applied by means of a manually operated test pump, or in the case of long mains or mains of a large diameter, by a power driven test pump, provided that the pump is not left unattached. In either case due precaution shall be taken to ensure that the required test pressure is not exceeded. Pressure gauges shall be accurate and shall preferably have been recalibrated before the test. The pump having been stopped, the test pressure shall maintain itself without measurable less for at least five minutes. The end of the main shall be closed by fitting a watertight expanding plug and the plug shall be secured by struts to resist the end thrust of the water pressure in the mains.

4.02.02 Testing of Service Pipes and Fittings

The service pipes shall be slowly and carefully charged with water allowing all air to escape avoiding all shock or water hammer. The service pipe shall then be inspected under working conditions of pressure and flow. When all draw-off taps are closed, the service pipes shall be absolutely watertight. All piping, fittings, and appliances shall be checked for satisfactory support and protection from damage, corrosion, and frost.

4.03.00 Testing of Drain and Sewerage Pipelines

All soil pipes, waste pipes, ventilating pipes and all other pipes, when above ground, shall be gas tight. All sewers and drainpipes laid below ground shall be tested water tight. The method of actual tests shall be decided by the Engineer. All test data shall be recorded and submitted to the Engineer for review and instruction. The Engineer's discretion regarding tolerance shall be final.

General guidance for the tests are given below:



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a) Smoke test

All soil pipes, waste pipes and vent pipes and all other pipes when above ground shall be approved gastight by a smoke test conducted under a pressure of 25 mm of water and maintained for 15 minutes after all trap seals have been filled with water. The smoke is produced by burning oily waste or tarpaper or similar material in the combustion chamber of a smoke machine. Chemical smokes shall not be used.

b) Water test

The pipes shall be subjected to a test pressure of at least 1.5 m head of water at the highest point of the section under tests. The tolerance figure of two litres per centimetre of diameter per kilometre may be allowed during a period of 10 (ten) minutes. The test shall be carried out by suitably plugging the low end of the drain and the ends of connections, if any, and filling the system, with water. A knuckle bend shall be temporarily jointed in at the top end and a sufficient length of the vertical pipe jointed to it so as to provide the required test head or the top end may be plugged with a connection to a hose ending in a funnel which could be raised or lowered till the required head is obtained and fixed suitably for observation.

Subsidence of test water may be due to one or more of the following cases:

- a) Absorption by pipes and joints
- b) Sweating of pipes or joints
- c) Leakage at joints or from defective pipes
- d) Trapped air.

Allowance shall be made for (a) by adding water until absorption has ceased and after which the test proper should commence. Any leakage and the defective part of the work shall be cut out and made good.

c) For straightness

- i) By inserting at the high end of the sewer or drain a smooth ball of a diameter 13 mm less than the pipe bore. In the absence of obstruction, such as yarn or mortar projecting through the joints, the ball will roll down the invert of the pipe and emerge at the lower end; and
- ii) By means of a mirror at one end of the line and lamp at the other. If the pipeline is straight, the full circle of light may be observed. The mirror will also indicate obstruction in the barrel if the pipeline is not straight.

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4.04.00	Fittings and Fixtures etc. All fittings and fixtures shall be connected by water tight joints. No dripping of water shall be acceptable.	
4.05.00	Testing Septic Tank The septic tank shall be tested for water tightness. It shall be filled up with water and allowed to soak for 24 hours. Then, it shall be topped up and allowed to stand again for 24 hours and loss of level recorded. The fall shall not be more than 15 mm in 24 hrs.	
5.00.00	I.S. CODES Important relevant IS Codes for this specification are listed below: Latest editions shall always be consulted. IS: 404 : Lead pipes. IS: 407 : Brass tubes for general purposes. IS: 458 : Concrete pipes (with or without reinforcement) IS: 783 : Code of Practice for laying of concrete pipes. IS: 1172 : Code of basic requirements for water supply, drainage and sanitation. IS: 1200 : Laying of water and sewer lines, including appurtenant items. (Pt.XVI) IS: 1230 : Cast iron rain water pipes and fittings. IS: 1239 : Specification for Mild Steel Tubes and Mild Steel Tubulars and other wrought steel pipe fittings (10 mm to 15 mm nominal diameter). (Pt.I & III) IS: 1536 : Specification for centrifugally cast (Spun) iron pressure pipes for water gas and sewage. IS: 1537 : Specification for vertically cast iron pressure pipes for water, gas and sewage. IS: 1592 : Asbestos cement pressure pipes,	

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	IS: 1626	:	Asbestos cement pressure pipes, gutters and fittings (Spigot and Socket types).
	IS: 2065	:	Code of Practice for Water Supply in buildings.
	IS: 2501	:	Copper tubes for general engineering purposes.
	IS: 2556	:	Specification for vitreous sanitary appliances (vitreous china) Part – I - General requirement
	IS: 2633	:	Method of testing, uniformity of coating on zinc coated articles.
	IS: 3076	:	Low density polyethylene pipes for portable water supplies.
	IS: 3486	:	Specification for Cast iron spigot and socket drain pipes (80 mm to 250 mm nominal diameter).
	IS: 3589	:	Specification for Electrically welded steel pipe for water, gas and sewage (200 mm to 2000 mm nominal diameter).
	IS: 4827	:	Specification for electro plated coatings of nickel and chromium on copper and copper alloy.
	IS: 4964	:	High-density polyethylene pipes for portable water supplies.
	IS: 12701	:	Rotational moulded polyethylene water storage tanks
6.00.00	RATE AND MEASUREMENT		
6.01.00	RATE		
6.01.01	G.I. Pipes For Water Supply		
	Rate shall include providing and fixing of the pipes including all specials and fittings, such as tees, bands, elbows, clamps, drain heads, cleanouts etc. with cutting, making chases and jointing of pipes, making good the walls.		
6.01.02	Rainwater Down-comers		
	Rate shall include providing and fixing of the pipes including all specials and fittings, such as tees, bands, elbows, clamps, drain heads, cleanouts etc. The rate also include cost of jointing and making good the opening in structure.		

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6.01.03	Sanitary Fixtures Rate shall include providing and fixing of sanitary appliances & fixtures and at all elevation, including all accessories and fittings, connections pipes, waste trap and pipes all complete as per description of “Schedule of Items”. Rate shall also include the jointing of waste & traps to drain pipes. 6.01.04 Drainage and Sewer Pipes Rate shall be inclusive of providing, laying and jointing of pipes as specified. Rate also include cost of lead joints or other joint as specified, cost for painting and cutting and making good walls, floors etc. 6.01.05 Floor and Gully Traps Rate of traps is inclusive of all excavation, filling, repair, making good of opening in floor and walls, grating, painting etc. complete as described in “Schedule of Items”. 6.01.06 Manholes, Septic Tank, Soak Pit and Cover Rate of manholes, septic tank, soak pit shall be paid under respective items of work executed like brick work, plastering, concrete, reinforcement steel etc. provided for completion of the structure as per drawing and specifications. Manhole cover shall be paid separately as per description of item. 6.01.07 Water Storage Tank The rate for water storage tank is inclusive of supply and installation of tank with all fittings, inlets, outlets, valves etc. complete. 6.02.00 MEASUREMENTS 6.02.01 Pipe for Water Supply and Drainage For G.I.Pipe of water supply line, rainwater down comers, drainage and sewer pipe, the measurements shall be in running metres and shall be taken along centre line of pipe or specials. The pipe shall be measured separately according to dia. and class of pipe. Fixtures like bibcock, stopcocks, valves etc. shall be measured in numbers.	



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6.02.02

Sanitary Appliances & Fixtures and Allied Works

All sanitary appliances & fixtures like sink, washbasin, WC, shall be measured in numbers for the complete work as described in schedule of items.

Floor and gully traps shall be measured in numbers unless otherwise specified.

Water storage tank shall be measured in numbers for the capacity as specified in “Schedule of Items”.

The item of work executed for completion of manholes, septic tank & soak pit shall be measured in respective items of work like brick work, RCC, plastering etc. CI cover shall be measured in numbers as specified in “Schedule of Items”.



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ROAD AND DRAINAGE



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



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C O N T E N T

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Standard Technical Specification For Road and Drainage 1.00.00 Scope The scope include all works required for the construction of road including construction of embankment, sub-base course, base course, tack coat, bituminous macadam, wearing course, liquid seal coat, shoulder and all incidental items of work specified or not shown but reasonably implied or necessary for the completion of the work etc. The scope also include all works required for the construction of drainage including construction of road side drains, RCC culverts, pipe culverts, drainage pipes, manholes and all other incidental items necessary for the completion of the work etc. 1.01.00 Works To Be Provided By The Contractor The works to be provided by the contractor unless specified otherwise shall include but not be limited to the following. a) Construction of roads including providing all materials, labour, supervision, services, equipments, tools and plants, transportation etc all required for the completion of the work. b) Submission of detailed scheme of all operations required for executing the work (e.g. material handling, placement, services, approaches etc) to the engineer for approval. c) Carrying out tests whenever required by the engineer to assess the quality of work and submission of the test results to the engineer after completion of the same etc. 1.02.00 Work To Be Provided By Others No work under this specification will be provided for by any agency other than the contractor unless specifically mentioned elsewhere in the contract. 1.03.00 Conformity With Designs The contractor shall carryout the work as per the construction drawings, specification and as directed by the engineer.		

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1.04.00	Materials To Be Used All materials required for the work shall be the best commercial variety and as approved by the engineer. 2.00.00	Codes and Standards All works under this specification shall conform to the latest revision and/or replacement of the following or any other IRC/IS Codes and Standard Practices unless specified otherwise. a) Specification for road and bridge works of Ministry of Shipping & Transport (Road Wing) Published by the IRC b) IRC: 19 - Standard specification and code of practice for Water bound Macadam c) IRC :SP 11 - Hand Book of Quality Control for Construction of Roads and Runways d) IS:456 - Indian Standard Code of Practice for Plain and Reinforced Concrete. e) IS:2212 - Code of Practice for Brick work f) IS: 783 - Code of Practice for Laying of Concrete Pipes g) IS: 1201 - Methods of testing tar and bituminous materials to 1220 h) IS: 73 - Specification for paving bitumen i) IS: 215 - Specification for Road tar j) IS: 216 - Coal tar pitch k) IS: 217 - Specification for cut-back bitumen l) IS: 454 - Specification for cut-back bitumen from waxy crude m) IS: 1834 - Specification for hot applied sealing compound for joint in concrete n) IS: 1838 - Specification for performed fillers for expansion joints in concrete, non extruding and resilient type Part I Bitumen impregnated fibre



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Part II CNSL Aldehyde resin and coconut pith

- o) IS : 334 - Glossary of terms relating to bitumen and tar
- p) IS: 1077 - Common burnt clay building bricks
- q) IS : 3117 - Specification for bitumen emulsion roads (anionic type)
- r) IS : 1200 - Method of measurement of building and civil engineering work (Part-17)- Road work including airfield pavements
- s) Other specifications mentioned elsewhere in this specification.

In case any particular aspect of work is not covered specifically by the specification/Indian Standard Code of practices, any other standard practice as may be specified by the engineer shall be followed.

2.01.00**Quality Control**

The Contractor shall establish and maintain quality control for all materials, procedures, workmanship and equipments used. All works shall conform to the lines, grades, cross sections and dimensions shown on the drawings, specification and as directed by the engineer. Permitted tolerances for road works are described hereinafter.

a) Horizontal Alignment

Horizontal alignment shall be reckoned with respect to the centre line of the carriageway as shown on the drawings. The edges of the carriageway as constructed shall be correct within a tolerance of $\pm 25\text{mm}$ therefrom. The corresponding tolerance for edges of the roadway and lower layers of the pavement shall be $\pm 40\text{mm}$.

b) Longitudinal Profile

The finished levels of the sub-grade and different pavement courses as constructed shall not vary from those calculated with reference to the longitudinal and cross-profile of the road shown on the drawings or as directed by the engineer and shall not exceed the tolerances as mentioned below.

Sub-grade	$\pm 25\text{ mm}$
Sub-base	$\pm 20\text{ mm}$
Base course	$\pm 15\text{ mm}$
Wearing course	$\pm 10\text{ mm}$

Tolerance in wearing course shall not be permitted in conjunction with the positive tolerance on base course if the thickness of the wearing course is thereby



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reduced by more than 6 mm.

c) Surface Regularity of Sub-grade and Pavement Courses

The surface regularity of the completed sub-base, base course and wearing surfaces in the longitudinal and transverse directions shall be within the tolerances indicated in Table - I. The longitudinal profile shall be checked with a 3m long straight edge at the middle of each traffic lane along a line parallel to the centre of the road. The transverse profile shall be checked with a set of three camber boards at intervals of 10m.

TABLE –I

PERMITTED TOLERANCE OF SURFACE REGULARITY FOR PAVEMENT COURSES

Sl. No.	Type of Construction	Longitudinal profile with 3m straight edge					Cross Profile	
		Maximum permissible Undulation (mm)	Maximum number of undulations permitted in any 300m length with undulation exceeding (mm)				Maximum permissible variation from specified profile under camber template (mm)	
			18	12	10	6		
1	2	3	4	5	6	7	8	
1.	Earthen sub-grade	25	30	-	-	-	15	
2.	Granular sub-base	15	-	30	-	-	12	
3.	Water Bound Macadam with oversize metal (40-90 mm size)	15	-	30	-	-	12	
4.	Water Bound Macadam with normal size metal (20-50 mm and 40-63 mm size), Bituminous Penetration Macadam	12	-	-	30	-	8	
5.	Surface dressing** (two coat) over WBM (20-50 mm or 40-63 mm size metal), Bituminous penetration macadam	12	-	-	20	-	8	
6.	Open graded premix carpet, mix seal Surfacing	10	-	-	-	30	6	
7.	Bituminous macadam	10	-	-	-	20****	6	
8.	Semi-dense carpet	10	-	-	-	20****	6	

[illegible]

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	The trees shall be cut into suitable pieces as instructed by the Engineer. Before earthwork is started, all the spoils and unserviceable materials and rubbish shall be burnt or removed from the site to the approved disposal areas as may be specified. Useful materials, saleable timbers, firewood etc shall be the property of the Owner and shall be stacked properly at the work site in a manner as directed by the Engineer. 3.03.00 Filling in Embankment 3.03.01 General The material used for constructing the embankment shall be earth, moorum, gravel or a mixture of the above or any other material approved by the Engineer. The material shall be free from lumps and clods, boulders and rock pieces, roots and vegetation, harmful salts and chemicals, organic materials, loose silts, fine sands and expansive clays in order to provide a stable embankment. The filling and compaction operation should be such that the best available materials are saved for the top portion and will result in an acceptable and uniform gradation of material and provide impermeability and stability to the embankment when compacted. The size of the coarse material in the mixture of earth shall ordinarily not exceed 75mm. However the Engineer may at his discretion permit the use of material coarser than the specified if he is satisfied that the same will not present any difficulty as regard to the placement and compaction of the fill material are concerned. Ordinarily, only the materials satisfying the density requirements as given below in Table-II shall be employed for embankment construction.	



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Table - II**Density Requirements of Embankment Materials**

Sl. No.	Type of Work	Maximum laboratory dry density when tested as per IS: 2720 (Part - VII)
1.	Embankment upto 3m height	Not less than 1.44 gm/cc
2.	Embankment exceeding 3m height and embankment of any height subject to long period of inundation	Not less than 1.52 gm/cc
3.	Top 0.5m of the embankment below sub-base and shoulders (where earth shoulders are specified)	Not less than 1.65 gm/cc

Expansive clays exhibiting marked swell and shrinkage properties shall not be used for embankment construction.

The material for embankment construction shall be obtained from approved sources with preference given to the materials available from nearby road excavation or any other excavation under the same contract.

3.03.02**Setting Out**

After the site clearance, the work shall be set out true to lines, curves, slopes, grades and sections as shown on the approved drawings or as directed by the Engineer. The contractor shall provide all labour, survey instruments and materials such as strings, pegs, nails, bamboo, stones, lime, mortar, concrete etc required in connection with the setting out of the works and establishment of the bench marks. The limits of the embankment shall be marked by fixing batter pegs on both sides at regular intervals as guides before commencing the earthwork. To ensure the safety, the pegs should normally be fixed about 500mm away from the actual limits of the fill and to be painted in a distinct colour. The centreline of the embankment shall be pegged at regular intervals of 25/30m and at all skews/curves. The actual profile of the embankment shall be made at every third centre line peg with bamboo posts and strings. Preferably prototype profiles developed with wooden planks need to be fixed at every 200m and at the intersection points at curves. The profile shall be about 3m long.



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3.03.03**Stripping and Storing top soil**

The construction of the earthen embankment by filling shall conform to the dimensions, slopes and other details shown in the approved drawings. Before commencement of the embankment construction, the surface area of ground to be occupied after clearing and grubbing shall be stripped off to a minimum depth of 150mm or more as directed by the Engineer in order to remove all perishable materials and any soil which may become unstable on saturation or may interfere with the development or proper bonding between the foundation and embankment. It is not necessary to remove all the soil containing fine hair like roots but only the rather heavy mats are to be removed. In localities where most of the available embankment fill materials are not conducive to plant growth or when so directed by the Engineer, the top soil suitable for plant growth existing over the embankment foundation areas shall be stripped to specified depths not exceeding 150mm and stored for covering the embankment slopes where revegetation is desired.

3.03.04**Compacting Original Ground**

In all cases, the original ground after stripping shall be compacted by rolling with a minimum six passes of 8-10 tonne roller and as directed by the Engineer.

Where the height of the proposed embankment is less than 0.5m and the original ground does not already have a relative compaction of atleast 95 percent of Standard Proctor density (maximum dry density), the same shall be loosened upto a depth of 0.5m and filled in layers not exceeding 250mm in loose thickness and each layer shall be watered and compacted to 100% maximum dry density of the fill material determined in accordance with IS:2720, Part-VII. However before relaying and compacting the loosened material, the surface below this level shall be suitably compacted as directed by the Engineer with a minimum six passes of 8 - 10 tonne roller.

Where so directed by the Engineer, any unsuitable material occurring in the embankment foundation shall be removed and replaced with approved materials suitably compacted. Embankment work shall not proceed until the foundation soil of the embankment is inspected by the Engineer and approved.

3.03.05**Filling**

The embankment material shall be spread uniformly over the entire width of the embankment in layers not exceeding 250mm in loose thickness. Successive layers of embankment shall not be placed until the layer under construction has been thoroughly compacted to the requirements set down hereunder. Moisture content of the fill material shall be checked at the source of supply and if found less than that specified for compaction, the same shall be made good either at the source or after spreading the soil in loose thickness



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for compaction. In the latter case water shall be sprinkled directly from a hose line or from a truck mounted water tank and flooding shall not be permitted under any circumstances. After adding required amount of water, the soil shall be processed by means of harrows, rotary mixers or by any other approved method until the layer is uniformly wet.

If the material delivered to the road bed is too wet, it shall be dried by aeration and exposure to the sun till the moisture content is acceptable for compaction. Should circumstances arise where owing to wet weather, the moisture content cannot be reduced to the required amount by the above procedure, the work on compaction shall be suspended.

Moisture content of each layer shall be checked in accordance with IS:2720, Part-II and unless otherwise specified shall be so maintained making due allowance for evaporation losses that during compaction, the moisture content shall be in the range of 1 percent above to 2 percent below the optimum moisture content as determined in accordance with IS:2720, Part-VII.

Clods or hard lumps of earth shall be broken to have a maximum size of 150mm when being placed in the lower layers of the embankment and a maximum size of 60mm when being placed in the top 0.5m portion of the embankment below sub-base.

Hauling equipment shall be dispersed uniformly over the entire surface of the previously constructed layer to minimise rutting or uneven compaction.

Where the embankment is to be constructed across a low swampy ground that will not support the weight of trucks or other hauling equipments, the lower part of the fill shall be constructed by dumping successive loads in a uniformly distributed layer to a thickness not greater than that necessary to support the hauling equipment while placing subsequent layers.

3.03.06

Compaction

Compaction equipment approved by the Engineer shall only be employed for construction. If directed by the Engineer, the Contractor shall demonstrate the efficiency of the plant he intends to use by carrying out compaction trials. Each layer shall be thoroughly compacted to the density as specified in Table-III. Subsequent layers shall be placed only after the finished layer has been tested and accepted by the Engineer.

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Table - III

Compaction Requirements For Embankment

Sl. No.	Type of work/material	Field dry density as a percentage of maximum laboratory dry density as per IS : 2720, Part-VII
1.	Top 0.5m portion of embankment below sub-base and shoulders	Not less than 100
2.	Other portions of embankment	Not less than 95

When density measurements reveal any soft area in the embankment, further compaction shall be carried out as directed by the Engineer. If in spite of that the specified compaction is not achieved, the material in the soft area shall be removed and replaced with approved material and compacted to the density requirements and satisfaction of the Engineer.

3.03.07 Drainage

The surface of the embankment at all times during construction shall be maintained at such a cross fall as will shed water and prevent ponding.

3.03.08 Finishing Operations

Finishing operations shall include the work of shaping and dressing the shoulders, road bed and side slopes to conform the alignment, levels, cross sections and dimensions as shown on the drawings or as directed by the Engineer. Both the upper and lower ends of the side slopes shall be rounded off to improve the appearance and merge the embankment with the adjacent terrain.

3.04.00 Turfing With Sods

3.04.01 General

This work shall consist of furnishing and laying live sod of perennial turf forming grass on embankment slopes, shoulders or other locations as shown on the drawings or as directed by the Engineer. Unless otherwise specified the work shall be taken up following the construction of embankment provided the season is favourable for establishment of the sod.

3.04.02 Materials

The sod shall consist of dense, well rooted growth of permanent and desirable grasses indigenous to the locality where it is to be used and shall be practically



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free from weeds and other undesirable matters. At the time the sod is cut, the grass shall have a length of approximately 50mm and the sod shall be free from any debris.

Thickness of the sod shall be as uniform as possible with about 50 to 80mm of soil covering the grass roots depending on the nature of the sod so that practically all the dense root system of the grass are retained in the sod strip. The sods shall be cut in rectangular strips of uniform width not less than 250mm x 300mm in size but not so large so that it is convenient to handle and transport without damage. During wet weather the sod shall be allowed to dry sufficiently to prevent rearing during handling and during dry weather it shall be watered before lifting to ensure its vitality and to prevent dropping of soil during handling.

3.04.03 Placing The Sods

The area to be sodded shall be previously constructed to the required slope and cross section. Soil in the area shall be loosened, freed from all stones larger than 50mm size, sticks, stumps and any other undesirable foreign matters etc and brought to a reasonably granular texture to a depth not less than 25mm for receiving the sod.

Where required, top soil shall be spread over the slopes. Prior to placing the top soil, the slopes shall be roughened and wetted in order to have a satisfactory bond. The depth of top soil (to be spread) shall be 75mm.

Following soil preparation and top soiling (if required), fertilizer and ground limestone when specified shall be spread uniformly. After spreading, the materials shall be incorporated in the soil by discing or other means. The prepared sod bed shall be moistened if not already sufficiently moist and the sod shall be placed thereon within 24 hours after the same has been cut. Each sod strip shall be laid in close contact with each other and shall be lightly tamped with suitable wooden or metal tampers so as to eliminate air pockets and to press it into the underlying soil. At points where water may flow over the sod, the upper edges of the sod strips shall be turned into the soil below the adjacent area and a layer of earth shall be placed over it followed by thorough compaction.

3.04.04 Staking the Sods

Where the side slope is 2 to 1 or steeper and the distance along the slope is more than 2m, the sods shall be staked with pegs or nails spaced approximately 500 to 1000mm along the longitudinal axis of the sod strips. Stakes shall be driven approximately plumb through the sods and to be almost flushed with them.

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3.04.05 Top Dressing After the sods have been laid in position, the surface shall be cleaned of any loose sod, excess soil and other foreign materials. Thereafter a thin layer of top soil shall be scattered over the top dressed surface and the area shall be thoroughly moistened by sprinkling water.		3.04.06 Watering and Maintenance The turfing so laid shall be well watered and protected until final acceptance. Watering shall be done in such a way that no erosion or damage to the sodded areas/embankment occur. The Contractor shall erect necessary warning signs and barriers, repair or replace the sods which are failing to show uniform growth of grass or damaged by his operation and shall maintain the sod at his own cost until final acceptance.	
3.05.00 Shoulder Construction			
3.05.01 Description		This work shall consist of constructing shoulder on either side of the pavement in accordance with the requirements of this specification and in conformity with the lines, grades and cross sections shown on the approved drawings and as directed by the Engineer.	
3.05.02 Materials		Shoulder shall be made of selected earth or granular material as specified conforming to relevant IRC standards.	
3.05.03 Construction Operations		Except in the case of bituminous pavements, the shoulders shall be constructed in advance to the laying of pavement courses. The compacted thickness of each layer of shoulder shall correspond to the compacted layer of pavement course to be laid adjacent to it. After compaction, the inside edges of shoulders shall be trimmed vertical and the area enclosed between the shoulders shall be cleaned of all spilled materials before proceeding with the construction of the pavement layer. In the case of bituminous pavements, shoulder shall be constructed only after the pavement courses have been laid and compacted. Regardless of the method of laying, all shoulder construction material shall be placed directly on the shoulder. Any spilled material dragged on to the pavement surface shall be immediately removed without any damage to the	

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	pavement and the area so affected shall be thoroughly cleaned. During all stages of shoulder construction, the required crossfall shall be maintained to drain off surface water. 3.06.00 Kerb 3.06.01 Material Kerb if required for the construction of footpath shall consist of precast concrete blocks with concrete grade of M-20. The blocks shall be of 100mm thick and of suitable length. The depth of blocks unless otherwise mentioned elsewhere shall be 375mm considering 225mm height of footpath above the road level. 3.06.02 Laying The kerb shall be laid by cutting trenches of 150mm deep. The width of the trench shall be minimum and just sufficient to insert the kerbs. The inside faces of the kerbs shall be in plumb and the gap between the block shall not be more than 10mm. The gap shall be filled with cement mortar as specified. The kerbs shall be thoroughly packed with a mixture of stone chips (50%) and moorum (50%) at the outside face. The laying and packing shall be done in a proper workmanlike manner acceptable to the Engineer. 3.07.00 Sub-base (Granular Sub-base) 3.07.01 Description This work shall consist of laying and compacting well graded material on the prepared sub-grade in accordance with the specification. The material shall be laid in one or more layers as shown on the drawings and shall conform to the lines, grades and cross sections shown on the drawings and as directed by the Engineer. 3.07.02 Materials The materials to be used for the work shall be natural sand, moorum, gravel, crushed stone, crushed slag, crushed concrete, brick metal, laterite, kankar etc or combinations thereof depending upon the grading required. The mixed materials shall be free from organic and other deleterious constituents and conform to one of the three grading given in Table - IV below.	



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**Table - IV
Grading for Granular Sub-base Material**

Sieve designation	Percent by weight passing the sieve		
	Grading 1	Grading 2	Grading 3
80 mm	100	100	100
63 mm	90 - 100	90 - 100	90 - 100
4.75 mm	35 - 70	40 - 90	50 - 100
75 micron	0 - 20	0 - 25	0 - 30
Minimum CBR value for the fraction of material passing 20 mm sieve.	30 %	25%	20%

Note : The materials passing 425micron sieve for all the three gradings when tested according to IS : 2720, Part V shall have liquid limit and plasticity index not more than 25 percent and 6 percent respectively.

3.07.03 Physical Requirements

The fraction of materials passing 20mm sieve shall give a CBR value as specified in Table – IV when tested in accordance with IS : 2720, Part XVI after preparing the samples at maximum dry density and optimum moisture content corresponding to IS : 2720, Part VII and soaking the same in water for 4 days.

3.07.04 Spreading and Compacting

Immediately prior to laying of sub-base, the sub-grade already finished shall be prepared by removing all vegetations and other extraneous matters, lightly sprinkled with water if necessary and rolled with one pass of 8 - 10 tonne smooth wheeled roller.

The sub-base material shall be spread on the sub-grade with the help of a drag spreader, motor grader or other approved means. The thickness of loose layers shall be so regulated that the maximum thickness of each layer after compaction shall not exceed 150mm.



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Moisture content of the loose material shall be checked in accordance with IS : 2720, Part II and shall be suitably adjusted by sprinkling additional water from a hose line, truck mounted water tank or other approved means so that at the time of compaction it shall be from 1 percent above to 2 percent below the optimum moisture content. While adding water, due allowance shall be made for evaporation losses. After water has been added, the material shall be processed by mechanical or other approved means if so directed by the Engineer until the layer is uniformly wet.

Immediately thereafter, rolling shall be done with 8 to 10 tonne smooth wheeled rollers or with any other approved plant. Rolling shall commence from the edges and progress towards the centre longitudinally except on super elevated portions where it shall progress from the lower to the upper edge parallel to the centre line of the pavement. Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. During rolling, the grade and camber shall be checked and any high spots or depressions which become apparent shall be corrected by removing or adding fresh material.

Rolling shall be continued till the density achieved is at least 100% of the maximum dry density of the material determined as per IS : 2720, Part VII. The surface of any layer of material on completion of compaction shall be well closed, free from movement under compaction plant and from compaction planes, ridges, cracks or loose materials. All loose, segregated or otherwise defective areas shall be made good to the full thickness of layer and recompacted.

3.08.00 Water Bound Macadam Sub-base/Base Course**3.08.01 Description**

Water bound macadam shall consist of clean crushed aggregates mechanically interlocked by rolling and bonded together with screenings, binding material wherever necessary and water, laid on the prepared sub-grade or sub-base as the case may be and finished in accordance with the specification and in conformity with the lines, grades and cross-sections shown on the approved drawings.

3.08.02 Materials**a) Coarse Aggregates - General Requirements**

Coarse aggregates shall be either crushed or broken stone. The aggregates shall conform to the physical requirements set forth in Table - V.

Table – V



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Physical Requirements of Coarse Aggregates for Water Bound Macadam

Sl.No.	Type of Construction	Test	Test method	Requirements
1.	Sub-base	Los Angeles Abrasion Value * or Aggregate Impact Value	IS : 2386 (Part IV) IS : 2386 (Part IV) or IS : 5640**	50 percent maximum 40 percent maximum
2.	Base	a) Loss Angeles Abrasion value* or Aggregate Impact Value b) Flakiness Index ***	IS : 2386 (Part IV) IS : 2386 (Part IV) or IS : 5640 ** IS : 2386 (Part I)	50 percent maximum 40 percent maximum 15 percent maximum

* Aggregates shall satisfy requirements of either of the two tests.

** Aggregates like brick metal, kankar and laterite which get softened in presence of water shall be tested for impact value under conditions in accordance with IS : 5640.

*** The requirements of Flakiness Index shall be enforced only in case of crushed or broken stone and crushed slag.

b) Crushed or Broken Stone

Crushed or broken stone shall be hard, durable and free from excess flat, elongated, soft and disintegrated particles, dirt and other objectionable matters.

c) Grading Requirements of Coarse Aggregates

The coarse aggregates shall conform to one of the gradings given in Table – VI. However the use of Grading-1 shall be restricted to sub-base courses only.

Table - VI
Grading Requirements of Coarse Aggregates



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SPECIFICATION NO. PE-TS-999-600-C016

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Grading	Size range	Sieve designation	Percent by weight passing the sieve
1.	90mm to 40 mm	100 mm 80 mm 63 mm 40 mm 20 mm	100 65 - 85 25 - 60 0 - 15 0 - 5
2.	63 mm to 40 mm	80 mm 63 mm 50 mm 40 mm 20 mm	100 90 - 100 35 - 70 0 - 15 0 - 5
3.	50 mm to 20 mm	63 mm 50 mm 40 mm 20 mm 10 mm	100 95 - 100 35 - 70 0 - 10 0 - 5

d) Screenings

Screenings to fill the voids in the coarse aggregate shall generally consist of the same material as the coarse aggregates. However where permitted, predominantly non-plastic material such as moorum or gravel (other than rounded river borne material) may be used for this purpose provided liquid limit and plasticity index of such material is below 20 and 6 respectively and fraction passing 75 micron sieve does not exceed 10 percent.

As far as possible, screenings shall conform to the grading set forth in Table-VII. Screenings of Type-A in Table-VII shall be used with coarse aggregates of Grading-1 in Table-VI. Screenings of Type-A or B shall be used with coarse aggregates of Grading-2. Screenings of Type-B shall be used with coarse aggregates of Grading-3.

**Table - VII
Grading For Screenings**



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Grading classification	Size of screenings	Sieve designation	Percent by weight passing the sieve
A	12.5 mm	12.5 mm	100
		10.0 mm	90 - 100
		4.75 mm	10 - 30
		150 micron	0 - 8
B	10 mm	10 mm	100
		4.75 mm	85 - 100
		150 micron	10 - 30

e) Binding Material

Binding material to be used for water bound macadam construction shall comprise of a suitable material approved by the Engineer having plasticity index value less than 6 as determined in accordance with IS : 2720, Part V. Application of binding material may not be necessary when the screenings used are of crushable type such as moorum or gravel.

3.08.03**Construction Operations**

a) The sub-grade/sub-base to receive the water bound macadam coarse shall be prepared to the specified grade and camber and made free of any dust and other extraneous materials. Any ruts or soft yielding places shall be corrected in an approved manner and rolled until firm. Where water bound macadam is to be laid over an existing black topped surface, 50mm x 50mm furrows shall be cut at an angle of 45 degrees to the centre line of the road at 1m intervals in the latter before laying the coarse aggregates.

b) Inverted Choke

If water bound macadam is to be laid directly over the sub-grade without any other intervening pavement course, a 25mm course of screenings (Grading-B) shall be spread on the prepared sub-grade before application of coarse aggregates is taken up.

c) Spreading Coarse Aggregates

The coarse aggregates shall be spread uniformly over the prepared surface in such quantities that the thickness of each compacted layer is limited to 100mm for Grading-1 and 75 - 100mm for Grading-2 and 3. The spreading shall be done from stockpiles along the side of the roadway or directly from the vehicles. In no case shall the aggregate be dumped in heaps directly on the surface prepared to receive the aggregates nor shall hauling over permitted. The surface of the aggregates spread shall be carefully checked with templates



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and all high or low spots remedied by removing or adding aggregates as may be required. No segregation of large or fine particles shall be allowed and the coarse aggregates as spread shall be of uniform gradation with no pockets of fine material. The coarse aggregates shall not normally be spread more than 3 days in advance of the subsequent construction operation.

d) Rolling

Immediately following the spreading of the coarse aggregates, rolling shall be started with three wheeled power rollers of 8 to 10 tonne capacity or with tandem or vibratory rollers of approved type. The weight of the roller shall depend upon the type of the aggregate and be indicated by the Engineer.

Except on super elevated portions where the rolling shall proceed from inner edge to the outer, rolling shall begin from the edges gradually progressing towards the centre. First the edge/edges shall be compacted with roller running forward and backward. The roller shall then move inwards parallel to the centre line of the road. Each pass of the roller shall uniformly overlap not less than one half the width of the track made in the preceding pass.

Rolling shall continue until the aggregates are thoroughly keyed and the creeping of aggregates ahead of the roller is no longer visible. During rolling slight sprinkling of water may be done if necessary. Rolling shall not be done when the sub-grade is soft or yielding or when it causes a wavelike motion in the sub-grade or sub-base course.

The rolled surface shall be checked transversely and longitudinally with templates and any irregularities found shall be corrected by loosening the surface, adding or removing necessary amount of aggregates and rerolled until the entire surface conform to the desired camber and grade. In no case shall the use of screenings be permitted to make up the depressions.

e) Application of Screenings

After the coarse aggregate has been rolled, screenings to completely fill the interstices shall be applied gradually over the surface. These shall not be damp or wet at the time of application. Dry rolling shall be done while the screenings are being spread so that vibrations of the roller cause them to settle into the voids of the coarse aggregates. The screenings shall not be dumped in piles but be spread uniformly in successive thin layers either by the spreading motion of hand shovels or by mechanical spreader or directly from trucks. Trucks operating for spreading the screenings shall be so driven as not to disturb the coarse aggregates.

The screenings shall be applied at a slow and uniform rate (in three or more applications) so as to ensure filling of all voids. This shall be accompanied by dry rolling and brooming with mechanical brooms or hand brooms or with



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both. In no case shall the screenings be applied so fast and thick as to form cakes or ridges on the surface in such a manner as would prevent filling of voids or prevent the direct bearing of the roller on the coarse aggregate. These operations shall continue until no more screenings can be forced into the voids of the coarse aggregates.

The spreading, rolling and brooming of screenings shall be carried out in only such lengths of road which could be completed within one day's operation.

f) Sprinkling and Grouting

After the screenings have been applied, the surface shall be copiously sprinkled with water, swept and rolled. Hand brooms shall be used to seep the wet screenings into the voids and to distribute them evenly. The sprinkling, sweeping and rolling operations shall be continued with additional screenings applied as necessary until the coarse aggregates are thoroughly keyed, well bonded and firmly set to its full depth and a grout has been formed of screenings. Care shall be taken to see that the base or sub-grade does not get damaged due to the addition of excess quantity of water during construction.

g) Application of Binding Material

After the application of screenings, the binding material where it is required to be used shall be applied successively in two or more thin layers at a slow and uniform rate. After each application, the surface shall be copiously sprinkled with water and the resulting slurry shall be swept in with hand brooms or mechanical brooms to fill the voids properly and rolled during which water shall be applied to the wheels of the rollers if necessary to wash down the binding material sticking to them. These operations shall continue until the resulting slurry after filling the voids form a wave ahead of the wheels of the moving roller.

h) Setting and Drying

After the final compaction of water bound macadam course, the road shall be allowed to dry overnight. Next morning hungry spots shall be filled with screenings or binding material as directed, lightly sprinkled with water if necessary and rolled. No traffic shall be allowed on the road until the macadam is set. The Engineer shall have the discretion to stop hauling traffic from using the complete water bound macadam course if in his opinion it would cause excessive damage to the surface.

3.09.00 Tack Coat

3.09.01 Description

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	The work shall consist of application of a single coat of low viscosity liquid bituminous material to an existing road surface preparatory to another bituminous construction. 3.09.02 Materials The binder used for tack coat shall be bitumen of a suitable grade as approved by the Engineer and conforming to IS-73, IS-217 or IS-454 as applicable or any other approved cutback. 3.09.03 Construction Operations a) Preparation of Base The surface on which the tack coat is to be applied shall be thoroughly swept and scraped clean of dust and any other extraneous materials before the application of the binder. b) Application of Binder Binder shall be heated to the temperature appropriate to the grade of bitumen used and approved by the Engineer and sprayed on the base at the rate specified below. The rate of spread in terms of straight run bitumen shall be 5 kg per 10 square metre area for an untreated water bound macadam surface. The binder shall be supplied uniformly with the aid of sprayers. The tack coat shall be applied just ahead of the oncoming bituminous construction. 3.10.00 Bituminous Macadam Binder Course 3.10.01 Description This work shall consist of construction in a single course of 50mm/75mm thickness of compacted crushed aggregates premixed with a bituminous binder laid immediately after mixing on a base prepared previously in accordance with the specification and in conformity with the lines, grades and cross sections shown on the approved drawings. 3.10.02 Materials a) Binder The Binder shall be straight run bitumen of a suitable grade as directed by the Engineer complying with IS : 73. b) Aggregates	



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The aggregates shall consist of crushed stone, crushed gravel (shingle) or other stones. They shall be clean, strong, durable, fairly cubical in shape and free from any disintegrated pieces, organic and other deleterious matter and adherent coats. The aggregates shall preferably be hydrophobic and of low porosity.

The aggregates shall satisfy the physical requirements set forth in Table - VIII.

Table – VIII**Physical Requirements of Aggregates For Bituminous Macadam**

Sl. No.	Test	Test method	Requirements
1.	Los Angeles Abrasion Value *	IS : 2386 (Part IV)	35 percent maximum
2.	Aggregate Impact Value *	IS : 2386 (Part IV)	30 percent maximum
3.	Flakiness Index	IS : 2386 (Part I)	35 percent maximum
4.	Stripping Value	IS : 6241 (Part IV)	25 percent maximum
5.	Water Absorption	IS : 2386 (Part III)	2 percent maximum

*Aggregates may satisfy requirements of either of the two tests.

The aggregates for bituminous macadam for different thickness shall conform to Grading- A or B as given in Table-IX or X as the case may be.

Table-IX**Aggregates Grading For 75mm Compacted Thickness of Bituminous Macadam**



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Sieve Designation	Percent by weight passing the sieve	
	Grading A	Grading B
63 mm	100	
50 mm	90 - 100	
40 mm	35 - 65	100
25 mm	20 - 40	70 - 100
20 mm	-	50 - 80
12.5 mm	5 - 20	-
4.75 mm	-	10 - 30
2.36 mm	-	5 - 20
75 micron	0 - 5	0 - 4

Table-X

Aggregates Grading For 50mm Compacted Thickness of Bituminous Macadam

Sieve Designation	Percent by weight passing the sieve	
	Grading A	Grading B
50 mm	100	
40 mm	90 - 100	
25 mm	50 - 80	100
20 mm	-	70 -100
12.5 mm	10 - 30	-
10 mm	-	35 - 60
4.75 mm	-	15 - 35
2.36 mm	-	5 - 20
75 micron	0 - 5	0 - 4

c) Proportioning of Materials

The binder content for premixing shall be 3.5 and 4.0 percent by weight of the total mix for aggregate Grading-A and B respectively unless directed otherwise by the Engineer. The quantity of aggregates to be used shall be sufficient to yield the specified thickness after compaction.

d) Variation in Proportioning of Materials

The Contractor shall have the responsibility for ensuring proper proportioning of materials and producing a uniform mix. A variation in binder content upto ± 0.3 percent by weight of total mix shall however be permissible for individual specimens taken for quality control tests.

3.10.03

Construction Operations



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a) Weather and Seasonal Limitations

Bituminous macadam shall not be laid during rainy weather or when the base course is damp or wet.

b) Preparation of Base

The base on which the bituminous macadam is to be laid shall be prepared, shaped and conditioned to the specified lines, grade and cross sections as shown on the drawings and as directed by the Engineer. The surface shall be thoroughly swept and scraped clean and free of any dust and foreign matter.

c) Tack Coat

A tack coat shall be applied over the base.

d) Preparation and Transport of Mix

Hot mix plant of adequate capacity shall be used for preparing the mix. The temperature of binder at the time of mixing shall be in the range 150 Deg. - 165 Deg. C and to that of aggregates shall be in the range 125 Deg. - 150 Deg. C provided the temperature difference between the binder and the aggregate at no time exceeds 25 Deg. C. Mixing shall be thorough to ensure that a homogenous mixture is obtained in which all particles of the aggregates are coated uniformly. The mixture shall be transported from the mixing plant to the point of use in a suitable vehicle. The vehicle employed for transport shall be clean and be covered over in transit if so directed by the Engineer.

e) Spreading

After mixing, the mix shall be spread immediately by means of a self propelled mechanical paver with suitable screeds capable of spreading, tamping and finishing the mix to the specified lines, grade and cross sections. However in restricted locations and in narrow widths where the available plants cannot operate in the opinion of the Engineer may permit manual laying of the mix. The temperature of mix at the time of laying shall be in the range 110 Deg. - 135 Deg. C.

In multilayer construction, the longitudinal joint in one layer shall offset into the layer below by about 150mm. However, the joint in the topmost layer shall be at the centre line of the pavement.

Longitudinal joints and edges shall be constructed true to the delineating lines parallel to the centre line of the road. All joints shall be cut vertical to the full thickness of the previously laid mix and the surface painted with hot bitumen before placing fresh material.



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f) Rolling

After spreading of mix, the rolling shall be done with 8 to 10 tonne power roller or with any other approved plant. Rolling should start as soon as the materials are spread. Rolling shall be done with care to avoid any undulation in the pavement surface.

Rolling on the longitudinal joint shall be done immediately after the paving operation. After this, the rolling shall commence at the edges and progress towards the centre longitudinally except on superelevated portions where it shall progress from the lower to the upper edge parallel to the centre line of the pavement.

The initial or breakdown rolling shall be done as soon as it is possible to roll the mixture without cracking the surface and no mix pick up on the roller wheels. The second or intermediate rolling shall follow the break down rolling as early as possible and be done while the paving mix is still at a temperature that will result in maximum density. The final rolling shall be done while the material is still workable enough for removal of roller marks.

When the roller has passed over the whole area once, any high spots or depressions which become apparent shall be corrected by removing or adding fresh materials. The rolling shall then be continued till the entire surface has been rolled to compaction and there is no crushing of aggregates and till all the roller marks are eliminated. Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. The roller wheels shall be kept damp if necessary to avoid the bituminous material from sticking on the wheels and being picked up. In no case shall fuel/lubricating oil be used for this purpose.

Rolling operation shall be completed in every respect before the temperature of the mix fall below 80 Deg. C.

Rollers shall not stand on the newly laid material as it may lead to undue deformation. The edges along and transverse of the bituminous macadam laid and compacted earlier shall be cut to their full depth so as to expose fresh surface which shall be painted with a thin surface coat of appropriate binder before the new mix is placed against it.

The bituminous macadam shall be provided with a final surfacing without any delay. If there is to be any delay the course shall be covered by seal coat before allowing any traffic over it.

3.11.00 Open Graded Premix Carpet**3.11.01 Description**

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3.11.02 This work shall consist of laying and compacting open graded carpet of specified thickness in a single course of suitable small sized aggregates premixed with bituminous binder on a previously prepared base to form wearing course in accordance with the specification. Materials a) Binder The binder shall be bitumen of suitable grade as approved by the Engineer and satisfying the requirements of IS: 73, 217, 454 or any other approved cutback as applicable. b) Aggregates The aggregates shall consist of angular fragments of clean, hard, tough and durable rock of uniform quality throughout. They shall be obtained by crushing rock, gravel or river shingle and be free of elongated and flaky pieces, soft and disintegrated materials, vegetable and any other deleterious matter etc. They shall preferably be hydrophobic type. The aggregates shall satisfy the quality requirements set forth in Table-VIII except that the flakiness Index shall be limited to a maximum of 30. c) Proportioning of Materials The materials shall be proportioned as per the quantities given in Table-XI for 20mm thick open graded premix carpet. Table - XI		



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**Quantity of Materials Required For 10 Sq. M of Road Surface For 20mm Thick Open
Graded Premix Carpet**Aggregates for Carpet

i)	Stone Chippings - 12mm size ; passing 20 mm sieve and retained on 10 mm sieve	0.18 Cu.m
ii)	Stone Chippings - 10 mm size; passing 12.5 mm sieve and retained on 6.3 mm sieve	0.09 Cu.m
Total		0. 27 Cu.m

Binder for premixing (quantities in terms of straight run bitumen)

i)	For 0. 18 Cu.m of 12 mm size stone Chippings at 52 Kg per Cu.m	9.5 Kg
ii)	For 0.09 Cu. M of 10mm size stone Chippings at 56 Kg per Cu.m	5.1 Kg
Total		14.6 Kg

3.11.03 Construction Operation**a) Weather and Seasonal Limitations**

Open graded premix carpet shall not be laid during rainy weather or when the base course is damp or wet or when the atmospheric temperature in shade is 16 Deg. C or below.

b) Preparation of Base

The underlying base on which the bituminous carpet is to be laid shall be prepared, shaped and conditioned to the specified lines, grade and cross section in accordance with the drawing, specification and as directed by the Engineer. The surface shall be well cleaned by removing caked earth and other foreign matters with wire brushes, sweeping with brooms and finally dusting with sacks as necessary.

c) Tack Coat



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A tack coat complying with clause 3.09.00 shall be applied over the base preparatory to laying of the carpet. However application of tack coat shall not be necessary when the laying of carpet follows soon after laying the bituminous course.

d) Preparation of Premix

Mixers of approved type shall be employed for mixing the aggregates with the bituminous binder. The binder shall be heated to the temperature appropriate to the grade of bitumen approved by the Engineer in boilers of suitable design avoiding local overheating and ensuring a continuous supply. The aggregates shall be dry and suitably heated to a temperature as directed by the Engineer before these are placed in the mixer. After about 15 seconds of dry mixing, the heated binder shall be distributed over the aggregates at the rate specified. The mixing of binder with chipping shall be continued until the chippings are thoroughly coated with the binder. The mix shall be immediately transported from the mixer to the point of use in suitable vehicles or wheel barrows. The vehicles employed for transport shall be clean and be covered over in transit if so directed.

e) Spreading and Rolling

The premixed material shall be spread on the road surface with rakes to the required thickness and camber or distributed evenly with the help of a drag spreader without any undue loss of time. The camber shall be checked by means of camber boards and inequalities evened out. As soon as sufficient length of bituminous material are laid, rolling shall be commenced with 6 to 8 tonne power rollers preferably with smooth wheel tandem type or with any other approved plant. Rolling shall begin at the edges and progress toward the centre longitudinally except on the superelevated portions where it shall progress from the lower to upper edge parallel to the centre line of the pavement.

When the roller has passed over the whole area once, any high spots or depressions which become apparent shall be corrected by removing or adding premixed materials. Rolling shall then be continued until the entire surface has been rolled to compaction and all the roller marks have been eliminated. In each pass of the roller, preceding track shall be overlapped uniformly by at least 1/3 width. The roller wheels shall be kept damp to prevent the premix from adhering to the wheels and being picked up. In no case shall fuel/lubricating oil be used for this purpose. Rollers shall not stand on newly laid material as it may lead to undue deformations.

The edges along and transverse of the carpet laid and compacted earlier shall be cut to their full depth so as to expose fresh surface which shall be painted with a thin surface coat of approved binder before the new mix is placed against it.



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f) Seal Coat

A seal coat conforming to clause 3.12.00 shall be applied to the surface immediately after laying the carpet. No traffic shall be allowed on the road till the seal coat has been placed.

3.12.00 Seal Coat**3.12.01 Description**

This work shall consist of application of a seal coat as specified for sealing the voids in the bituminous surface laid to the specified levels, grade and camber.

Type-A : Liquid seal coat comprising of an application of a layer of bituminous binder followed by a cover of stone chippings.

Type-B : Premixed seal coat comprising of a thin application of fine aggregate premixed with bituminous binder.

3.12.02 Materials**a) Binder**

The binder shall be bitumen of suitable grade as directed by the Engineer and conforming to the requirements of IS : 73, 217 or 454 as applicable or any other approved cutback.

The quantity of binder to be adopted in terms of straight run bitumen shall be 9.8 Kg and 6.8 Kg per 10 square metre area for Type-A and Type-B seal coat respectively.

b) Stone Chippings for Type A Seal Coat

The stone chippings shall consist of angular fragments of clean, hard, tough and durable rock of uniform quality throughout. They shall be free of elongated or flaky pieces, soft or disintegrated stone, vegetable or other deleterious matters etc. Stone chippings shall be of 6mm size defined as 100 percent passing through 10mm sieve and retained on 2.36mm sieve. The quantity used for spreading shall be 0.09 cu.m per 10 sq.m area. The chippings shall satisfy the quality requirements spelled out in Table- VIII except that the upper limit for flakiness Index shall be 30.

c) Fine Aggregate for Type B Seal Coat



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The fine aggregate shall be sand or fine grit and shall consist of clean, hard, durable, uncoated dry particles and shall be free from dust, soft or flaky material, organic matter or other deleterious substances. The aggregate shall pass 1.7 mm sieve and be retained on 180 micron sieve. The quantity used for premixing shall be 0.06 cubic metre per 10 square metre area.

3.12.03

Construction Operations

a) Preparation of Base

The seal coat shall be applied immediately after laying the bituminous course which is required to be sealed. Before application of seal coat, the surface shall be cleaned free of any dust or other extraneous matters.

b) Construction of Type-A Seal Coat

The binder shall be heated in boilers of suitable design to the temperature appropriate to the grade of bitumen approved by the Engineer and sprayed on the dry surface in a uniform manner preferably with the help of mechanical sprayers. Excessive deposits of binder caused by stopping or starting of the sprayer or through leakage or due to any other reason shall be suitably corrected before the stone chippings are spread.

Immediately after the application of binder, stone chippings in a dry and clean state shall be spread uniformly on the surface preferably by means of a mechanical grittier or otherwise manually so as to cover the surface completely. If necessary the surface shall be broomed to ensure uniform spread of chippings. Immediately after the application of the cover material, the entire surface shall be rolled with a 8 - 10 tonne smooth wheeled roller. Rolling shall commence from the edges and progress towards the centre except in superelevated portions where it shall proceed from the inner edge to the outer. Each pass of the roller shall uniformly overlap not less than one third of the track made in the preceding pass. While rolling is in progress additional chippings shall be spread by hand in whatever quantities required to make up the irregularities. Rolling shall continue until all aggregate particles are firmly bedded in the binder and present an uniform closed surface.

c) Construction of Type-B Seal Coat

Mixers of approved type shall be employed for mixing the aggregates with the bituminous binder. The binder shall be heated in boilers of suitable design to the temperature appropriate to the grade of bitumen approved by the Engineer. Also the aggregates shall be dry and suitably heated to a temperature as directed by the Engineer before the same are placed in the mixer. Mixing of binder with aggregates to the specified proportions shall be continued till the latter is thoroughly coated with the former. The mix shall be immediately

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		transported from the mixing plant to the point of use and spread uniformly on the bituminous surface to be sealed. As soon as sufficient length has been covered with the premixed material, the surface shall be rolled with 6 - 8 tonne smooth wheeled power rollers. Rolling shall be continued till the premixed material completely seals the voids in the bituminous course and a smooth uniform surface is obtained. 3.12.04 Opening to Traffic In case of Type-B Seal coat, traffic may be allowed soon after the final rolling when the premixed materials are cooled down to the surrounding temperature. However in case of Type- A seal coat, the traffic shall not be permitted until the following day. 3.13.00 Repair of Existing Water Bound Macadam Surfaces Pot holes or patches and ruts in the water bound macadam base or surface course which is to be surface treated shall be repaired by removing all loose materials by cutting in rectangular patches and replacing with suitable materials. The repair shall be done as under. Pot holes, patches and ruts shall be drained of any water and cut to regular shape with vertical sides and then be filled either with i) coarse aggregates and screenings conforming to the specification for water bound macadam and compacted with rollers or other approved rammer etc or with ii) premixed material conforming to the specification for open graded premix carpet and compacted with rollers or other approved means after painting the sides and bottom of the holes with a thin application of bitumen or a combination of both as directed by the Engineer. 3.14.00 Road Side Drains 3.14.01 Drains The road side drains shall be made in sizes and slopes as shown on the approved drawings. The sides and bottom shall be neatly dressed after excavation. Proper connections shall be made to the culverts outside the plant area as per the drawings and instructions of the Engineer. The excavated spoils other than that required for backfilling shall be transported and filled in low areas within the plant area or in embankments as instructed by the Engineer. The lining for drains shall be as per the drawings. Lining of drains may be of bricks or cement concrete blocks of specified grade as shown on the approved drawing or as directed by the Engineer. If shown on approved drawing, drains shall be of R.C.C. construction with necessary slopes.			

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3.15.00	Culverts Excavation in trenches for foundation of culverts and wing walls shall be done with side slopes as per the drawings and instructions of the Engineer after clearing the site etc. As described in the “Specification for Earthwork in Excavation and Backfilling”, backfilling in layers with watering and compaction shall be done after the construction of foundations. The construction of culverts shall be done true to the lines and levels as shown on the drawings. The specification for Masonry and/or Plain and Reinforced Cement concrete shall be followed as applicable.	
3.16.00	Pipe Culverts and Drainage Pipes	
3.16.01	Materials	
	The drainage pipes shall be made of R.C.C and shall be either class NP-2 or NP-3 as shown on the approved drawings. Pipe culverts shall be made of reinforced concrete pipe and shall be of class NP4 or RDSO class for railways as shown in the drawing. All pipes shall meet the requirements of IS : 458 and shall be procured from approved manufacturers with collars as per manufacturer’s specification. The tenderer shall specifically mention the particular manufacturer’s product he proposes to use. Cement shall be ordinary Portland Cement as per IS:269. Coarse Aggregates shall be as per IS:383. Maximum size shall not exceed one third the thickness of the pipe or 20 mm whichever is smaller. Fine aggregates for concrete shall be as per IS:383.	
3.16.02	Laying of Pipes	
	Laying of concrete pipes shall correspond to IS:783 and as per the specification given below. a) The foundation bed for pipe shall be excavated true to lines and grades shown on the drawings and as directed by the Engineer. When trenching is involved, its width on either side of the pipe shall not be less than 150mm and not more than one third the diameter of pipe unless otherwise instructed/permitted by the Engineer. The sides of the trench shall be as nearly vertical as possible. Side slope, shoring, bailing out water etc as required shall be done by the Contractor. Side slips if there be any shall be removed by the Contractor. After laying of the pipes are completed, backfilling of the trenches shall be done as per “Specification for Earthwork in Excavation and Backfilling” to the satisfaction of the Engineer. The surplus spoils shall be transported and filled in low areas within the plant area as instructed by the Engineer.	



TITLE:

**TECHNICAL SPECIFICATION FOR
ROAD AND DRAINAGE**

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When bedrock or boulder stratum is encountered during excavation, the excavation shall be taken down to at least 200mm below the bottom of the pipe with prior permission of the Engineer and all rock/boulders in the area shall be removed and space filled with approved earth free from stone or fragmented materials, shaped to the requirements and thoroughly compacted to provide adequate support for the pipe.

Filling of trench shall be carried out simultaneously on both sides of the pipe in such a manner that unequal pressures do not occur and shall be done as per the “Specification for Earthwork in Excavation and Backfilling”. When two or more pipes are to be laid adjacent to each other, they shall be separated by a distance equal to at least half the diameter of the pipe subject to a minimum of 450 mm. Laying of pipes shall start from the outlet and proceed towards inlet. All pipes and fittings shall be gradually lowered into the trench or placed on the supports by approved means taking due care to avoid any damage. Under no circumstances the pipes shall be dropped into the trench or on supports from heights.

b) Pipe bedding shall be first class projection bedding for positive projecting pipes as per IS : 783 having a projection ratio not greater than 0.70. The pipe shall be carefully laid on bedding made up of fine granular materials in an earth foundation; the bedding shall be carefully shaped to fit the lower part of the pipe exterior for at least ten percent of its overall height and in which the fill material is thoroughly compacted in layers not exceeding 150mm in depth around the pipe for the remainder of the pipe laid in trench.

When indicated on the drawings or directed by the Engineer, the pipe shall be bedded on a cradle constructed of concrete having a mix not leaner than M-15. The shape and dimension of the cradle shall be as indicated on the drawing or as directed by the Engineer. The pipe shall be laid on the concrete bedding before the concrete is set.

c) The drop walls shall be made with first class brickwork in 1:4 cement mortar.

d) The pipe culverts shall be made with proper care with respect to the invert of the pipe, gradient if any etc as specified on the drawings and as instructed by the Engineer.

e) Where R.C.C pipes are encased in concrete at road crossings or at other places the pipes need be suitably supported avoiding reinforcements of concrete blocks, joints properly done before concreting is taken up. Concreting of total height of block may be done in a single operation or may be done upto some height for pipes to be properly laid in position and the balance height of the block shall be concreted subsequently.

f) The R.C.C. pipes shall be joined with cement mortar. Cement mortar shall consist of 1 part of cement and 2 part of clean sand with only enough water for workability. Procedure of jointing shall be as per IS : 783.

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	3.16.03 Relation With Water Supply Pipeline Unless specifically cleared by the Engineer, under no circumstances shall the drainage pipes be allowed to come close to water supply pipelines. 3.17.00 Manholes and Inspection Chambers The maximum distance between the manholes shall be 30m unless specifically permitted otherwise. In addition, at every change of alignment, gradient or diameter there shall be a manhole or inspection chamber. The distance between the manhole or inspection chamber and gully chamber shall not exceed 6 meters unless permitted otherwise. Manhole shall be constructed so as to be water tight under test. The channel or drain at the bottom of chamber shall be plastered with 1:2 cement sand mortar and finished smooth to the grade. The channels and drains shall be shaped and laid to provide a smooth flow. Connection to the existing pipelines shall be through a manhole. Manholes shall be provided with standard covers usually of C.I. or as directed by the Engineer. The cover shall be closely fitted so as to prevent gases from coming out. 4.00.00 Testing and Acceptance Criteria All testing as mentioned in the specification and as mentioned in Clause No. 900 of the “Specification for Roads and Bridge Works, 1983” published by IRC on behalf of Ministry of Shipping and Transport (Roads Wing) shall be carried out by the Contractor as per the direction of the Engineer. 5.00.00 MEASUREMENT Method of measurement shall be as per the latest version of IS:1200, Part-17 and as directed by the Engineer.	



TITLE:

**TECHNICAL SPECIFICATION FOR
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SUB-SECTION – D 17

FABRICATION OF STRUCTURAL STEEL WORK



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



TITLE:

**TECHNICAL SPECIFICATION FOR
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SUB-SECTION – D XVII

FABRICATION OF STRUCTURAL STEEL WORK

1.00.00 SCOPE

This specification covers supply, fabrication, testing, painting and delivery to site of structural steelwork including supply of all consumable stores and rivets, bolts, nuts, washers, electrodes and other materials required for fabrication and field connections of all structural steelwork covered under the scope of the contract.

2.00.00 GENERAL

2.01.00 Work to be provided for by the Contractor

The work to be provided for by the Contractor, unless otherwise specified elsewhere in the contract, shall include, but not be limited to the following

- a) Preparation of complete detailed fabrication drawings and erection marking drawings required for all the structures covered under the scope of the contract based on the approved design drawings. As decided by the Engineer, some or all of these detailed drawings will have to be submitted for approval.
- b) To submit revised design with calculations and detailed fabrication drawings in case any substitution of the designed sections are to be made.
- c) To submit design calculations for joints and. connections developed by the contractor along with detailed fabrication drawings.
- d) Furnish all materials, labour, tools and plant and all consumables required for fabrication and supply, all necessary rivets, bolts, nuts, washers, tie rods and welding electrodes for field connections,
- e) Furnish shop painting of all fabricated steelwork as per requirements of this Specification.
- f) Suitably mark, bundle, and pack for transport all fabricated materials.
- g) Prepare and furnish detailed Bill of Materials, Drawing Office Dispatch lists, Rivet and Bolt List and any other list of bought out items required in connection with the fabrication and erection of the structural steelwork.
- h) Insure, load and transport all fabricated steelwork field connection materials to site.
- i) Maintain a fully equipped workshop at site for fabrication, modification

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	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)	

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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 locknuts (dia, range 6 to 39 mm) IS : 1367 - Technical supply conditions for threaded fasteners IS : 1442 - Covered electrodes for the metal arc 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					

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	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.	

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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				

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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 $\frac{L}{A}$, 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		

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	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.I & 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.				

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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				

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		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				

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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.		

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	Titanium 0.75% Max. Nitrogen 0.03% Max. The mechanical properties shall be as follows: <table> <tr> <th>Description</th><th>Value</th><th>Remarks</th></tr> <tr> <td>Hardness Rock Well B Scale</td><td>90</td><td>Max.</td></tr> <tr> <td>Tensile Strength</td><td>450 MPa</td><td>Min.</td></tr> <tr> <td>Yield Strength</td><td>300 MPa</td><td>Min.</td></tr> <tr> <td>Elongation</td><td>25%</td><td>Min.</td></tr> </table>	Description	Value	Remarks	Hardness Rock Well B Scale	90	Max.	Tensile Strength	450 MPa	Min.	Yield Strength	300 MPa	Min.	Elongation	25%	Min.	
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																

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		store. c) In case the contractor does the cutting of the stainless steel without approved cutting plan then all the wastage (i.e. the difference between the weight of stainless steel plate cuts and the actual finished weight considered for the measurement for payment) shall be subjected to the penal recovery at the rate mentioned above. 2.10.04 Cuffing Cutting may be affected by shearing, or by using plasma. The cut edges of all plates shall be perfectly straight and uniform through out. Cutting shall be done as per the cutting plan shown in the fabrication drawing. Should the Engineer find it necessary, the edges shall be ground smooth afterwards by contractor within the unit rates quoted by him. All the edge s shall be ground smooth before they are welded. 2.10.05 Jointing Welding shall join stainless steel. All weld joints (along the inclined plane) shall be staggered. Any common welding process can weld stainless steel viz. MIG, metal arc or plasma using the covered compatible electrodes as per IS: 5206 or by inert gas arc welding as per IS: 2811. Shielding gas shall be Argon + Hydrogen mixture or Argon + Oxygen mixture. However, Argon + Oxygen mixture shall be preferred. Carbon-di-oxide mixture shall be avoided. 308L and 315L electrodes/fillers shall be used for the welding of Stainless Steel to Stainless Steel and Stainless Steel to Mild Steel respectively. However, the welding process and the type of the electrodes to be used for welding shall be as per welding procedure, as approved by the Engineer. On the basis of the welding procedure, the Contractor shall conduct qualification test. 2.10.06 Bending The stainless steel plates shall be subjected to cold forming and bending in order to get the desired shape and profile. 2.10.07 Welding sequence The type of electrodes, welding sequence, preheat and interpass temperature and post weld heat treatment shall be as approved by the Engineer. 2.10.08 Acceptance Criteria of Fabricated Structures The acceptance of the fabricated structure work shall depend upon correct dimensions and alignment, absence of distortion in the structure, satisfactory results from the inspection and testing of the welded structure joints and the test specimens, general workmanship being good meeting the tolerance requirements given in IS: 7215.			

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2.11.00 2.11.01	BEARINGS 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.	

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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

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The Contractor shall establish and maintain quality control procedures for different items of work and materials to the extent he deems necessary to ensure that all work is performed in accordance with this specification. In addition to the Contractor's quality control procedures, materials and workmanship at all times shall be subjected to inspection by the Engineer or Engineer's representative. As far as possible, all inspection by the Engineer or Engineer's representative shall be made at the Contractor's fabrication shop whether located at Site or elsewhere. The Contractor shall co-operate with the Engineer or Engineer's representative in permitting access for inspection to all places where work is being done and in providing free of cost all necessary help in respect of tools and plants, instrument, labour and materials required to carry out the inspection. The inspection shall be so scheduled as to provide the minimum interruption to the work of the Contractor. Materials or workmanship not in reasonable conformance with the provisions of this Specification may be rejected at any time during the progress of the work. The quality control procedure shall cover but not be limited to the following items of work a) Steel: Quality manufacturer's test certificates, test reports of representative samples of materials from unidentified stocks if permitted to be used. b) Rivets, Bolts, Nuts & Washers : Manufacturer's certificate, dimension checks, material testing. c) Electrodes : Manufacturer's certificate, thickness and quality of flux coating. d) Welders : Qualifying Tests e) Welding sets : Performance Tests f) Welds : Inspection, X-ray, Ultrasonic tests g) Paints : Manufacturer's certificate, physical inspection reports h) Galvanizing : Tests in accordance with IS 2633 - Method for testing uniformity of coating on Zinc Coated Articles and IS : 4759 - Specification for Hot-Dip Zinc coatings on Structural Steel and other allied products.					
2.14.00 Standard dimensions, forms and weights					

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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: - Assembly drawings giving exact sizes of the sections to be used and identification marks of the various sections. - Dimensional drawings of base plates, foundation bolts location etc. - Comparison sheets to show that the proposed alternative section, if any, is as strong as the original sections shown on the Design Drawings. - Complete Bill of Materials and detailed drawings of all sections as also their billing weights. - 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		

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	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	

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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				

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3.02.02	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. 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	

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		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 through 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			

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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 shop 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 mm 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		

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	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-butt 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	

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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				

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	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.				

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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.				

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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.		

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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.	

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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.		

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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: - Name and address of the consignee - Name and address of the consignor - Gross weight of the package in tonnes and its dimensions - Identification marks and/or number of the package - 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 - - Name of the Contractor - Number and date of the Contract - Name of the office placing the contract - Nomenclature of stores	

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	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	SHEET 33 OF 40

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	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	

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		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.			

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6.01.08 6.01.09 6.01.10 6.01.11 6.01.12 6.01.13 6.01.14	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. 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. 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. 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. The bidder's rates for permanent mild steel bolts, nuts and washers shall include the supply and fixing of such bolts, nuts and washers in position, for various types of Structural Steel works, as per the technical specification. 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. 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 unutilized 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.		

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	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	

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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				

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	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.	



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SECTION - D (PART I)

SUB-SECTION – D 18

ERECTION OF STRUCTURAL STEELWORK



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



TITLE:

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SUB-SECTION – D 18 ERECTION OF STRUCTURAL STEELWORK 1.00.00 SCOPE This specification covers the erection of structural steelwork including receiving and taking delivery of fabricated structural steel materials arriving at site, installing the same in position, painting and grouting the stanchion bases all complete as per Drawings, this Specification and other provision of the Contract. 2.00.00 GENERAL 2.01.00 Work to be provided for by the Contractor, unless otherwise specified in the Contract, shall include but not be limited to the following: a) The Contractor shall provide all construction and transport equipment, tools, tackle, consumables, materials, labour, and supervision required for erection of the structural steelwork. b) Receiving, unloading, checking, and moving to storage yard at Site including prompt attendance to all insurance matters as necessary for all fabricated steel materials arriving at Site. The Contractor shall pay all demurrage and/or wharfage charges etc. on account of default on his part. c) Transportation of all fabricated structural steel materials from Site storage yard, handling, rigging, assembling, riveting, bolting, welding and satisfactory installation of all fabricated structural steel materials in proper location according to approved erection drawings and/or as directed by the Engineer. If necessary suitable temporary approach roads to be built for transportation of fabricated steel structures. d) Checking 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		



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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 of the Engineer.

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2.05.00	Material				
2.05.01	General	All fabricated steel structures and connection materials shall be supplied by the Contractor to the site. The Contractor shall take delivery from railway wagons or trucks at site, and unload the materials and perform all formalities like checking of materials and attend to insurance matters in accordance with Sub-Clause 2.01.00 and as specified hereinbefore.			
2.05.02	Materials to conform to Indian standards	All materials required to be supplied by the Contractor under this contract shall conform to the relevant Indian Standard specifications.			
2.06.00	Storage of Materials				
2.06.01	General	All material shall be so stored as to prevent deterioration and to ensure the preservation of their quality and fitness for use in the works. Any material which has been deteriorated or damaged beyond repairs and has become unfit for use shall be removed immediately from the site, failing which, the engineer shall be at liberty to get the materials removed by agency and the cost incurred thereof shall be realised from the Contractor's dues.			
2.06.02	Yard	The Contractor will have to establish a suitable yard in an approved location at site for storing the fabricated steel structures and other raw steel materials such as structural sections and plates as required. The yard shall have facilities like drainage, lighting, and suitable access for large cranes, trailers, and other heavy equipments. The yard shall be fenced all around with security arrangement and shall be of sufficiently large area to permit systematic storage of the fabricated steel structures without overcrowding and with suitable access for cranes, trailers and other equipment for use in erection work in proper sequence in accordance with the approved Programme of work. The Tenderer must visit the site prior to submission of his tender to acquaint himself with the availability of land and the development necessary by way of filling, drainage, access roads, fences, sheds etc. all of which shall be carried out by the Contractor at his own cost as directed by the Engineer.			
2.06.03	Covered Store	All field connection materials, paints, cement etc. shall be stored on well			

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	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.	

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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 erection shall install, free of cost to the Owner, 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.	



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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



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there shall be no rotation of the part not turned by the wrench.

TABLE-I

Bolts length not exceeding 8 times dia or 200 mm	Bolt length exceeding 8 times dia or 200 mm	Remarks
1/2 turn	2/3 turn	Nut rotation is relative to bolt regardless of the element (nut or bolt) being turned. Tolerance on rotation-30° over or under.

Bolts may be installed without hardened washers when tightening is done by the turn -of-nut -method. However, normal washers shall be used.

Bolts tightened by the turn-of-nut method may have the outer face of the match-marked with the protruding bolt point before final tightening, thus affording the inspector visual means of noting the actual nut rotation. Such marks can be made by the wrench operator by suitable means after the bolts have been brought up snug tight.

b) Torque Wrench Tightening

When torque wrenches are used to provide the bolt tensions, the bolts shall be tightened to the torques specified in TABLE-II (See Note below the Table). Nuts shall be in tightening motion when torque is measured. When using torque wrenches to install several bolts in a single joint, the wrench shall be returned to touch up bolts previously tightened, which may have been loosened by the tightening of subsequent bolts, until all are tightened to the required tension.

TABLE-II

Nominal Bolt Diameter (mm) (Kg.M) of IS:1367	Torque to be applied for bolt class 8.8
20	59.94
22	81.63
24	103.73

Note: The above torque values are approximate for providing tensions of 14.



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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



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or makes it impossible to fill the holes properly or to adjust accurately after reaming, shall not be allowed.

Any error in shop work which prevents the proper assembling and fitting of parts by moderate use of drift pins and reamers shall immediately be called to the attention of the Engineer and approval of the method of correction obtained. The use of gas cutting torches at erection site is prohibited.

3.03.00 Grouting of stanchion bases and bearings of beams and girders on stone, brick or concrete (Plain or reinforced)

Grouting shall be carried out with Ordinary Cement grout as described below:

The mix shall be one (1) part cement and one (1) part sand and just enough water to make it workable. The positions to be grouted shall be cleaned thoroughly with compressed air jet and wetted with water and any accumulated water shall be removed. These shall be placed under expert supervision, taking care to avoid air locks. Edges shall be finished properly. If the thickness of grout is 25 mm or more, two (2) parts of 6 mm down graded stone chips may be added to the above noted cement-sand grout mix, if required, by the Engineer or shown on the drawings.

No grouting shall be carried out until a sufficient number of bottom lengths of stanchions have been properly lined, leveled, and plumbed and sufficient floor beams are tied in position.

Whatever method of grouting is employed, the operation shall not be carried out until the steelwork has been finally levelled and plumbed, the stanchion bases being supported meanwhile by steel wedges, and immediately before grouting, the space under steel shall be thoroughly cleaned.

If required by the Engineer, certain admixtures like aluminium powder, “ironite” or equivalent, may be required to be added to the grout to enhance certain desirable properties of the grout. Approved non-shrink pre-mixed grout having required flowability and compressive strength may also be used with Engineer's approval.

3.04.00 Painting after Erection

Field painting shall only be done after the structure is erected, levelled, plumbed, aligned and grouted in its final position, tested and accepted by the Engineer. Normally, final painting shall be done only after the floor slabs are concreted and masonry walls are built. However, touch up painting, making good any damaged shop painting and completing any unfinished portion of the shop coat shall be carried out by the Contractor free of cost to the Owner. The materials and specification for such painting in the field shall be in accordance with the requirements of the specification for fabrication of structural



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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.



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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.



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When a structure of the same type is selected for a check test, it shall be subjected, in addition to its actual dead load, to a superimposed test load, equal to 1.5 time the specified live load, in a manner and to an extent prescribed by the Engineer. This load shall be maintained for 24 hours, during which time, the maximum deflection shall be recorded. The check test shall be considered satisfactory, provided that the maximum strain or deflection recorded in the check test does not exceed by more than 20% of the maximum strain or deflection recorded at similar load in the test on the prototype.

4.01.04

Repair for subsequent test and use after strength tests

An actual structure which has passed the “Strength Test” as specified in Sub-clause 4.1.2 hereinbefore and is subsequently to be erected for use, shall be considered satisfactory for use after it has been strengthened by replacing any distorted members and has subsequently satisfied the 'Stiffness Test' as specified in Sub-clause 4.01.01 hereinbefore.

4.02.00

Tolerances

Some variation is to be expected in the finished dimensions of structural steel frames. Unless otherwise specified, such variations are deemed to be within the limits of good practice when they are not in excess of the cumulative effect of detailed erection clearances, fabricating tolerances for the finished parts and the rolling tolerances for the profile dimensions permitted under the Specifications for fabrication of structural steel work applicable to this Project and as specified below: The specified tolerance is mainly for welded erection. In case of bolted erection, no tolerance is desired so that all prefabricated bolt holes are matched on erection.

I. For Buildings Containing Cranes

Component	Description	Variation Allowed
1.	2.	3.
Main columns	a) shifting of column axis at foundation level with respect to building line	
	i) In longitudinal direction	i) ± 3.0 mm
	ii) In lateral direction	ii) ± 3.0 mm
	b) Deviation of both major column axis from vertical between foundation and	

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		c) Relative shifting of ends of adjacent crane rail in plan and elevation after thermite welding.	1.0 mm.		
		d) Deviation of crane rail axis from centre line of web.	± 3.5 mm		
Setting of Expansion gaps	At the time of setting of the expansion gaps, due regard shall be taken of the ambient temperature above or below 30°C. The coefficient of expansion or contraction shall be taken as 0.000012 per °C per unit length.				
iv) For Building without Cranes					
The maximum tolerances for line and level of the steel work shall be ±3.0 mm on any part of the structure. The structure shall not be Out of Plumb more than 3.5 mm on each lox section of height and not more than 7.0 mm per 30 m section.					
These tolerances shall apply to all parts of the structure unless the drawings issued for erection purposes state otherwise.					
4.03.00	Acceptance				
Structures and members have passed the tests and conform to all requirements specified in the foregoing Sub-clause 4.01.00, 4.01.01, 4.01.02, 4.01.03 and 4.01.04 and other applicable provisions of this specification and are within the limits of tolerances specified in Sub-clause 4.02.00 and/or otherwise approved by the Engineer shall be treated as approved and accepted for the purpose of fulfillment of the provisions of this contract.					
5.00.00	INFORMATION TO BE SUBMITTED				
5.01.00	Before Tender				
5.01.01	Tentative Programme				
The Tenderer shall submit a tentative programme based on the information available in the Tender Document and visit to site indicating the structure-wise erection schedule proposed to be maintained by the Contractor to complete the job in time in accordance with the Contract.					

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5.01.02	Constructional Plant and Equipment, Tools, Temporary works & manpower A detailed list Of all constructional plant and equipment like cranes, derricks, winches, welding sets, erection tools etc. along with their make, model, present condition and location available with the Tenderer which he will be able to employ on the job to maintain the progress of work in accordance with the Contract shall be submitted along with the Tender. The total number of each category of experienced personnel like fitters, welders, riggers etc. that he will be able to employ on the job shall also be indicated.	
5.01.03	Erection Yard A site plan showing the layout and location of the erection yard proposed to be established by the tenderer shall also be attached with the tender indicating the storage space for fabricated steel materials, site-fabrication and repair shop, covered stores, offices, locations of erection equipments and other facilities. The Engineer shall have the right to modify the arrangement and location of the proposed yard to suit site conditions and the Contractor shall comply with the same without any claim whatsoever.	
5.02.00	After award of the Contract After award of the contract, the Contractor shall submit the following:	
5.02.01	Detailed Programme The Contractor shall submit a detailed erection programme within a month of the award of the Contract for completion of the work in time in accordance with the Contract. This will show the target programme, with details of erection proposed to be carried out in each fortnight, details of major equipment required, and an assessment of required strength of various categories of workers in a proforma approved by the Engineer.	
5.02.02	Fortnightly Progress Report The Contractor shall submit fortnightly progress reports in triplicate to the Engineer showing along with necessary photographs, 125 mm x 90 mm size, and all details of actual achievements against the target programme specified in Sub-clause 5.02.01 above. Any shortfall in the achievement in a particular fortnight must be made up within the next fortnight. Along with this report, the Contractor shall also furnish details of fabricated materials in hand at site and the strength of his workers.	

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SECTION-I **SCOPE OF WORKS (STORAGE SHED)**

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.)

1.2.1 BROAD DESCRIPTION OF WORK

- 1.2.1.1 Design, Procurement, Supply, Receipt at Site, Erection, Painting & Finishing works etc and Handing over to site Removable/ Re-erectable type Pre-Engineered, Pre- fabricated Steel Closed Storage Sheds- 1 nos. of size 30m X 15m x 6m including construction of civil foundation as per the technical specification in this tender for 3x27.5 MW Hydro Electric Project, Kuttiyadi, Kozhikode District, Kerala, India.
- 1.2.1.2 One (01) no. site office Bunk House (Size 6.1mts length x 3.05 mts. width x 3 mts. height) is to be placed at site by BHEL. Following facilities/ works to be undertaken by bidder for Bunk House.
 - 1.2.1.2.1 Preparation of Area: Soling has to be done for placing the Bunk House.
 - 1.2.1.2.2 Lowering and placing of Bunk House in designated area.
 - 1.2.1.2.3 1 phase power supply (5kW) from nearest source to Bunk house: Laying and termination of power cable from nearest power source to the Bunk house. Termination of cable to be done at both sides. A switchboard to be provided which is to be mounted inside Bunk house, with four 5 A points and two 15A points. Approximate length of cable required would be 100 mts.
 - 1.2.1.2.4 Drinking water connection from the nearest source to Bunk house: Laying of ½ inch pipeline along with fittings and tap mounted on wash basin from nearest drinking source to Bunk house. Approximate length of pipeline required would be 100 mts
- 1.2.1.3 The scope includes above but is not limited to the following job –
 - 1.2.1.3.1 Leveling, excavation, construction of civil foundations including supply, unloading of cement, aggregate & reinforcement steel.
 - 1.2.1.3.2 Supply, Unloading, alignment & erection of pre-fabricated Structural Steel members.
 - 1.2.1.3.3 Supply, Unloading, Installation and commissioning of electrical fittings and fixtures etc., handover to BHEL all complete as per

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drawings and specification.

- 1.2.1.4 This also includes guarantee for 12 months of operations for the design performance, materials supplied & erection works.
- 1.2.1.5 All design work of prefabricated storage sheds shall have to be vetted by civil design agency/chartered engineer/ consultant of good reputation/Civil engineering department of reputed engineering college.
- 1.2.1.6 Testing of concrete, earthwork other allied works, preparation of bar bending schedules on the basis of construction drawings, etc. are included in the rates of items of work. For Doors, Windows, ventilators, Steel, structural steel and for other items as specified technical specification, necessary manufacturer's test certificate (MTC) shall be furnished to BHEL engineer for approval.
- 1.2.1.7 The works to be performed under this contract consist of providing all labour, supervision, material, scaffolding, construction equipment, tools and plants, temporary works, supplies, transportation and all incidental items not shown or specified but reasonably implied or necessary for the proper completion of work in all respects. All quality standards, tolerances, welding standards & other technical requirements shall be strictly adhered to.
- 1.2.1.8 Fairly levelled ground shall be provided to the contractor at site. The area of work shall be cleared of any vegetation, rubbish and other objectionable matter of minor nature and materials remove shall be burnt or otherwise disposed off as directed by the BHEL site engineer. No separate payment for these operations shall be made. The cost of all these operations shall be deemed to have been included in the price quoted by the bidder.
- 1.2.1.9 Bidders may take note of the following points while sending their offers:
 - a) The quoted prices shall include transit freight, handling at site, assembly and erection. Applicable taxes shall be paid extra. Also refer the clauses mentioned in Volume-IA- Part I- Chapter-VIII Taxes and Other Duties.
 - b) The unit rates shall include all materials, equipment, fixtures, labour charges, required temporary works and everything whether of permanent or temporary in nature necessary for the completion of job in all respects.
 - c) The materials and workmanship must be of good quality and accepted standards and specifications. The site engineer reserves the right to reject any material not complying with relevant standards/ specification. After completion of work, the building and areas

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around them should be cleared of all rubbish, debris etc. and handed over in fit condition for occupation.

- 1.2.1.10 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 COVID -19 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:
- 1.2.1.10.1 All work places shall have adequate arrangements for temperature screening and provide sanitizers at convenient places.
- 1.2.1.10.2 Work places shall have a gap of one hour between shifts and will stagger the lunch breaks of staff, to ensure social distancing.
- 1.2.1.10.3 Use of AROGYA SETU will be encouraged for all employees both private and public.
- 1.2.1.10.4 Contractor shall sanitize their work place between shifts.
- 1.2.1.10.5 Large meetings to be prohibited. Spitting shall be strictly prohibited. Wearing of face cover is compulsory.
- 1.2.1.10.6 Government order (state/ center) being issued time to time for protective measures of COVID-19 pandemic shall be complied with strictly until government (state/ center) declares end of pandemic.
- 1.2.1.10.7 **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

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- 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 encouraged.
- 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 COVID-19 patients, should be identified and list should be available at work place all the times

Notes

- 1) The Bidder shall fully apprise himself of the prevailing conditions at both the sparing and receiving sites, climatic conditions including monsoon pattern, local conditions and site specific parameters and shall include for all such conditions and contingent measures in the bid, including

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those which may not have been specifically brought out in the specifications.

- 2) Bidder to quote lump sum rates for all the items after referring the Chapter –IX- Bill of Quantity of Technical Conditions of Contract (Volume-I Book-I).
- 3) **FOR FURTHER DETAILED SCOPE OF WORKS REFER RELEVANT SECTIONS IN THIS BOOK – TECHNICAL SPECIFICATION**

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SECTION-II FACILITIES IN THE SCOPE OF CONTRACTOR / BHEL (SCOPE MATRIX) (STORAGE SHED)

Sl.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:			
1.3.1.1.1.1	Open space for office	Yes		Free
1.3.1.1.1.2	Open space for storage	Yes		Free
1.3.1.1.1.3	Construction of bidder's office, canteen and storage building including supply of materials and other services		Yes	
1.3.1.1.1.4	Bidder's all office equipments, office / store / canteen consumables		Yes	
1.3.1.1.1.5	Canteen facilities for the bidder's staff, supervisors and engineers etc		Yes	
1.3.1.1.1.6	Fire fighting equipments like buckets, extinguishers etc		Yes	
1.3.1.1.1.7	Fencing of storage area, office, canteen etc of the bidder		Yes	
1.3.1.1.2	FOR LIVING PURPOSES OF THE BIDDER			
1.3.1.1.2.1	Open space		Yes	Contractor has to make his own arrangements for space, shelter and transportation of labors as per their requirement
1.3.1.1.2.2	Living accommodation		Yes	
1.3.1.2	ELECTRICITY			
1.3.1.2.1	Electricity (LT) For construction purposes		Yes	
1.3.1.2.1.1	Single point source		Yes	If Power supply at 400V, 3 Phase, 50HZ at single suitable point is

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				arranged by BHEL/customer, the electricity bill raised by power supplier is to be paid by bidder. The bill may include fixed charges, minimum consumption charges, taxes, duties etc.
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	
1.3.1.2.2.3	Duties and deposits including statutory clearances for the above		Yes	
1.3.1.2.2.4	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		Yes	
1.3.1.3.0	WATER SUPPLY			
1.3.1.3.1	For construction purposes:			
1.3.1.3.1.1	Making the water available at single point source		Yes	
1.3.1.3.1.2	Further distribution as per the requirement of work including supply of materials and execution		Yes	

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1.3.1.3.2	Water supply for bidder's office, stores, canteen etc		Yes	
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	
1.3.1.4.0	LIGHTING / ILLUMINATION			
1.3.1.4.1	For construction work (supply of all the necessary materials) 1. At office storage area 2. At the preassembly area 3. At the construction site /area		Yes	
1.3.1.4.2	For construction work (Execution of the lighting work / arrangements) 1. At office storage area 2. At the preassembly area 3. At the construction site /area		Yes	
1.3.1.5.0	COMMUNICATION FACILITIES for site operations of the bidder			
1.3.1.5.1	Telephone, Fax, internet, intranet, email etc		Yes	

Sl.No	Description	Scope to be taken care by		Remarks
		BHEL	Bidder	
1.3.2	ERECTION FACILITIES			
1.3.2.1.0	Engineering works for construction			
1.3.2.1.1	Providing the erection drawings covered under this scope		Yes	To be submitted to BHEL site for information/ approval prior to commencement of work.
1.3.2.1.2	Drawings for construction methods		Yes	In consultation with BHEL

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Sl.No	Description PART II	Scope to be taken care by		Remarks
		BHEL	Bidder	
1.3.2.1.3	As-built drawings – wherever deviations observed and executed and also based on the decisions taken at site		Yes	In consultation with BHEL
1.3.2.1.4	Preparation of site erection schedules and other input requirements		Yes	In consultation with BHEL
1.3.2.1.5	Review of performance and revision of site erection schedules in order to achieve the end dates and other commitments		Yes	To be jointly done on regular basis
1.3.2.1.6	Weekly erection schedules based on Sl No 1.3.2.1.5		Yes	
1.3.2.1.7	Daily erection / work plan based on Sl No 1.3.2.1.7		Yes	For daily monitoring meeting at site
1.3.2.1.8	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	

1.3.3 OPEN SPACE:

- 1.3.3.1 To establish a temporary site office, pre-assembly yard and storage area at the job site, minimum open space will be provided free of charges.
- 1.3.3.2 Location and area requirement for office / storage sheds / fabrication yard shall be discussed and mutually agreed to after award of work at site. Construction of necessary stores and storage of materials shall be in contractor's scope. Security of stores & work place shall be in Contractor's scope.
- 1.3.3.3 BHEL shall not provide to the contractor any residential accommodation to any of his staff and labourer and the contractor has to make his own arrangements at his cost.

1.3.4 WATER

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1.3.4.1 Contractor has to make his own arrangements for his water requirement for construction purposes as well as for his labour colony at his cost.

1.3.5 ELECTRICITY

1.3.5.1 Bidder has to make arrangement for Electricity for construction purpose at his cost. Any duty, deposit involved in getting the Electricity shall be borne by the Bidder. As regards to contractor's office shed also, all such expenditure shall be borne by the contractor. Contractor has to make his own arrangements for electricity requirement in the labour colony at his cost.

1.3.5.2 In case Electricity on chargeable basis is made available by customer then same shall be provided to contractor as per prevailing tariff. However, 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.

1.3.5.3 The bidder shall have to provide earth leakage circuit breaker at each point wherever human operated electrical drives / T&Ps are deployed

1.3.6 MATERIAL SUPPLY:

1.3.6.2 Supply / providing cement, aggregate (coarse and fine), Steel, and all other materials required for the scope of work are in the scope of the contractor.

1.3.7 CONSUMABLES

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 lamps 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 DEWATERING

Contractor shall ensure at all times that his work area & approach/ access roads are free from accumulation of water, so that the materials

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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 (except in floods) shall be considered by BHEL.

1.3.10 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.

1.3.11 BID DRAWINGS

Reference drawings as per Chapter-3 of Part-II are being provided only for guidance to the bidder.

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SECTION-III **T&PS and MMEs TO BE DEPLOYED BY CONTRACTOR** **(STORAGE SHED)**

- 1.4.1 All the tools & plants/vehicles and MMEs required for this scope of work are to be arranged by the contractor within the quoted rates. Necessary accessories for the tools & plants shall also be provided by the contractor.
- 1.4.2 Contractor shall deploy all necessary T&P to meet the schedules & as prescribed by BHEL engineer and required for completion of work in time without any delay.
- 1.4.3 In the event of non-mobilization of Tools, Plants, Machinery, Equipment, Material or non-availability of the same owing to breakdown and as a result progress of work suffered, BHEL reserves the right to make alternative arrangement (available or higher capacity) in line with SCC clause no. 4.2.1.7 and hire charges shall be applicable as under:

Case 1: BHEL provides its own Capital T&P: If BHEL provides owned T&P then BHEL, hire charges (as per BHEL norms) will be recovered from the contractor as per the prevailing BHEL Corporate hire charges applicable as per following cases:

- In case the T&P is specifically listed in “T&Ps to be deployed by Contractor”, ‘Rates of hire charges applicable to outside agencies other than contractors working for BHEL’ will apply.
- In case the T&P is not specifically listed in “T&Ps to be deployed by Contractor”, ‘Rates of hire charges applicable to contractors 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: BHEL provides hired T&P: In all cases other than that specified in Sl No. 1 above, actual expenses incurred by BHEL along with applicable overheads will be back-charged to the contractor.

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SECTION-IV

T&Ps AND MMEs TO BE DEPLOYED BY BHEL (STORAGE SHED)

- 1.5.1 BHEL will not provide any T & Ps for this scope of work.
- 1.5.2 All 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 as elaborated under **clause 1.4.3.**

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SECTION- V

TIME SCHEDULE (STORAGE SHED)

1.6.1 TIME SCHEDULE

1.6.1.1 Time period for completion of entire work is **3 (three) months** from mutually agreed start date as per the following schedule.

S.No.	Description	Days (from date of commencement of work)
1	Start of Civil foundation works	20
2	Start of Material Supply for shed	30
3	Completion of Civil foundation	50
4	Erection completion of shed including electrical works and punch points	90

1.6.1.2 During the total period of contract, the contractor has to carryout the activities in a phased manner as required by BHEL site.

1.6.1.3 The work shall be commenced on the mutually agreed date between the bidder and BHEL site-in-charge and shall be deemed as completed in all respect only when so certified by the site Engineer. The decision of BHEL in this regard shall be final and binding on the contractor. The scope of work under this contract is deemed to be completed only when so certified by the site Engineer.

1.6.1.4 Vendor shall submit foundation/ layout drawings duly attested by civil design agency/ chartered engineer/ consultant of good reputation/Civil engineering department of reputed engineering college within 10 days from award of contract.

1.6.1.5 After commencement of work at site, performance of successful bidder shall be monitored and evaluated on monthly basis in line with form-15 of Volume 1 – Book 2 (Refer forms & procedures).

1.6.1.6 There are no intermediate milestones.

1.6.2 MOBILISATION

1.6.2.1 The activities shall be started as per directions BHEL site-in-charge.

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1.6.2.2 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 into consideration of the COMPLETION SCHEDULE and submit for BHEL's approval.

1.6.2.3 In order to meet above schedule, contractor shall arrange & augment all necessary resources from time to time on the instructions of BHEL. No extra payment whatsoever shall be paid on this account.

1.6.3 **GUARANTEE PERIOD**

1.6.3.1 The guarantee period shall be 12 months for the design performance, quality of materials/items supplied by the bidder and also for the workmanship for works covered under the scope of the contract. The guarantee period shall commence from the date of completion of the entire work as certified by BHEL Engineer.

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SECTION - VI **GENERAL (STORAGE SHED)**

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

1.10.2 GENERAL

1.10.2.1 E way Bills to be arranged by contractor whenever required.

1.10.2.2 All works shall be carried out in proper workmen like manner. Items of works covered by the following specification shall be carried out as per the best practices and according to the direction of the Engineer In-charge / BHEL, Site Engineer and to his satisfaction. Unless otherwise specified in this section or in the description of item, the cost of stage of works mentioned here under shall be deemed to have been included in the rates of items provided in the schedule.

1.10.2.3 Scope of work covered under this specification requires quality workmanship, engineering and construction management. The contractor shall ensure timely completion of work. The contractor shall have adequate tools, measuring instruments, etc. in his possession. He shall also have adequate trained, qualified and experienced engineers, supervisory staff and skilled personnel. The manpower deployment identified by contractor shall match with above scope of works.

1.10.2.4 It is not the intent to specify herein all details of material. Any item related this work not covered by this but necessary to complete the system will be deemed to have been included in the scope of the work.

1.10.2.5 Site testing wherever required shall be carried out for all items / materials installed by the contractor to ensure proper installation and functioning in accordance with drawings, specifications and manufacturer's recommendations.

1.10.2.6 The work shall be executed under the usual conditions without affecting the plant construction and in conjunction with other operations and contracting agencies at site. The contractor and his personnel shall co-operate with the personnel of other agencies, co-ordinate his work with others and proceed in a manner that shall not delay or hinder the progress of work as a whole.

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- 1.10.2.7 The Contractor may have to execute work in such a place and condition where other agencies also will be under such circumstances. The contractor shall co-operate with other contractors and agencies so that various activities can be carried out simultaneously in order to achieve an early completion.
- 1.10.2.8 All the work shall be carried out as per instructions of BHEL engineer. BHEL engineer's decision regarding the correctness of the work and method of working shall be final and binding on the contractor.
- 1.10.2.9 The contractor will be responsible for the safe custody and proper accounting of all materials in connection with the work.
- 1.10.2.10 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.
- 1.10.2.11 Contractor shall retain all T&Ps, Material handling equipments etc at site as per advice of BHEL engineer and same shall be taken out from site only after getting the clearances from Engineer In charge.
- 1.10.2.12 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. Entry pass for materials shall be taken on returnable basis in the name of BHEL site.
- 1.10.2.13 The contractor at his cost shall arrange necessary security measures for adequate protection of his machinery, equipment, tools, materials etc. BHEL shall not be responsible for any loss or damage to the contractor's construction equipment and materials. The contractor may consult the Engineer-in-Charge on the arrangements made for general site security for protection of his machinery equipment tools etc.
- 1.10.2.14 Any wrong erection shall be removed and re-erected promptly to comply with the design requirements to the satisfaction of Site Engineer.
- 1.10.2.15 Contractor has to work in close co-ordination with other erection agency 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.
- 1.10.2.16 Contractor shall remove all scrap materials periodically generated from his working area in and around power station and collect the same at one place earmarked for the same. Failure to collect the

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scrap is likely to lead to accidents and as such BHEL reserves the right to collect and remove the scrap at contractor's risk and cost if there is any failure on the part of contractor in this respect. All the package materials, including special transporting frames, etc. shall be returned to the BHEL stores by the contractor.

- 1.10.2.17 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. 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.
- 1.10.2.18 No member of the already erected structure / platform, pipes, grills, platform, other component and auxiliaries should be cut without specific approval of BHEL engineer.
- 1.10.2.19 Contractors shall ensure that all their Staff / Employees are exposed to periodical training programme conducted by qualified agencies/ personnel on ISO 9001 – 2015 Standards.
- 1.10.2.20 Crane operators deployed by the contractor shall be tested by BHEL before he is allowed to operate the cranes.
- 1.10.2.21 On Completion of work, all the temporary buildings, structures, pipe lines, cable etc. shall be dismantled and leveled and debris shall be removed as per instruction of BHEL by the contractor at his cost. In the event of his failure to do so, the expenditure towards clearance of the same will be recovered from the contractor. The decision of BHEL Engineer in this regard is final.
- 1.10.2.22 It is the responsibility of the contractor to do the alignment, checking, etc. if necessary, repeatedly to satisfy BHEL Engineer with all the necessary tools and tackles, manpower etc. without any extra cost. Also the contractor should ensure that the alignment is not disturbed afterwards.
- 1.10.2.23 If any item or equipment not covered but requires being erected, same shall be carried out by the contractor. Equivalent or proportional unit rate shall be considered wherever possible from the BOQ. The rates quoted by the contractor shall be uniform as far as possible for similar items appearing in rate schedule / price bid.
- 1.10.2.24 The contractor shall ensure that his premises are always kept clean and tidy to the extent possible. Any untidiness noted on the part of the contractor shall be brought to the attention of the contractor's site representative who shall take immediate action to clean the surroundings to the satisfaction of the Engineer-in-Charge.

1.10.2.25 SITE INSPECTION

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- 1.10.2.25.1 BHEL or his authorized agents may inspect various stages of work during the currency of the contract awarded to him. The contractor shall make necessary arrangements for such inspection and carry out the rectification pointed out by the owner / employer without any extra cost to the owner / employer. No cost whatsoever such duplication of inspection of work be entertained.
- 1.10.2.25.2 BHEL will have full power and authority to inspect the works at any time, either on the site or at the contractor's premises. The contractor shall arrange every facility and assistance to carry out such inspection. On no account will the contractor be allowed to proceed with work of any type unless such work has been inspected and entries are made in the site inspection register by BHEL.
- 1.10.2.25.3 Wherever the performance of work by the contractor is not satisfactory in respect of workmanship, deployment of sufficient labour or equipment, delay in execution of work or any other matter, BHEL shall have the right to engage labour at normal ruling rates and get the work executed through other agency and debit the cost to the contractor and the contractor shall have no right to claim compensation thereof. In such a case, BHEL shall have the right to utilize the materials and tools brought by the contractors for the same work.
- 1.10.2.25.4 Contractor shall submit manufacturing quality plan as well as field quality plan for approval of BHEL site engineer.
- 1.10.2.26 DOCUMENTATION
- 1.10.2.26.1 As built drawings:
- After successful completion of installation work, drawings / documents shall be updated in line with the actual work carried out and as built drawings / documents shall be submitted by the contractor.
- 1.10.2.26.2 Other documents as specified in PROGRESS OF WORK (VOLUME-IA PART- II CHAPTER-XI)

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SECTION-VII PROGRESS OF WORK (STORAGE SHED)

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.)

- 1.11.1 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.
- 1.11.2 It is the responsibility of the contractor to provide all relevant information on a regular basis regarding erection progress, labour availability, equipment deployment, testing, etc.
- 1.11.3 Contractor is required to draw mutually agreed monthly erection programs in consultation with BHEL well in advance. Contractor shall ensure achievement of agreed program and shall also timely arrange additional resources considered necessary at no extra cost to BHEL.
- 1.11.4 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.
- 1.11.5 The contractor shall submit daily, weekly and monthly progress reports, manpower reports, materials reports and other reports as per Performa considered necessary by the Engineer as per the BHEL formats.
- 1.11.6 The manpower reports shall clearly indicate the manpower deployed, category wise specifying also the activities in which they are engaged.
- 1.11.7 The monthly report shall be submitted at the end of every month as a booklet and shall contain the following details: -
 - a. Safety implementation report in the format
 - b. Pending material and any other inputs required from BHEL for activities planned during the subsequent month.

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- 1.11.8 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.
- 1.11.9 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.

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SECTION-VIII

PAINTING (STORAGE SHED)

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.)

PAINTING

- 1.12.1 The quoted rate / price shall be inclusive of supply and application of painting of all the erected components as per instruction of BHEL Engineer.
- 1.12.2 In the case of steel fabricated items, raw steel after fabrication has to be cleaned and subsequent painting to be carried out.
- 1.12.3 All the exposed metal parts, wherever applicable after installation unless otherwise specified are to be first painted with at least one coat of suitable primer and required number of finish coats as specified by BHEL after thoroughly cleaning the dust, rust, scales, grease oil, and other foreign materials by wire brushing scrapping and chemical cleaning and the same being inspected and approved by BHEL engineers for painting. Afterwards the above parts shall be finished with as per the instructions of BHEL official.
- 1.12.4 Normally Paint shall be applied by brushing as per the instruction of BHEL Engineer. It shall be ensured that brush marks are minimum.
- 1.12.5 Paint used shall be stirred frequently to keep the pigment in suspension. Paint shall be of the ready mix type in original sealed containers as packed by the paint manufacturer. No thinners shall be permitted. Paint manufacturer's instructions shall be followed in method of application, handling, drying time etc.,
- 1.12.6 The scope of painting includes application of lettering the names of the systems, equipments, danger / warning signs and other data as required by BHEL within the quoted rate.
- 1.12.7 The actual colour to be applied shall be approved by BHEL before starting of actual painting work.
- 1.12.8 Primer & finish paint shall be of reputed paint supplier approved by BHEL site-in-charge. The quality of the finish paint shall be as per the standards of IS or equivalent as approved by BHEL. Before procurement of paint the contractor has to obtain the clearance from BHEL authorities.
- 1.12.9 No paint shall be applied when the surface temp is above 55 deg. Centigrade or below 10 deg. Centigrade, and when the humidity is greater than 90% to cause condensation on the surface or frost / foggy weather.

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- 1.12.10 Before commencement of final painting, contractor has to obtain written clearance from BHEL for effective completion of surface preparation.
- 1.12.11 Before applying the subsequent coats, the thickness of each coat shall be measured and recorded with BHEL.
- 1.12.12 Specification for Painting: 2 coats of Zinc Chromate primer (minimum 25 micron DFT at shop and 25 micron DFT after erection) followed by 2 coats of synthetic enamel paint (minimum 25 micron DFT of each coat) of approved make and shade to achieve an even shade over steel sections already having primer coats and keeping overall DFT with primer not less than 110 microns.

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SECTION-IX

ANNEXURES (STORAGE SHED)

Chapter	Description	No.of pages
1	General Technical Requirements Of Civil Works	04
2	Technical Specifications-For Closed Storage Shed and indicative drawings	06 + 05

**GENERAL TECHNICAL REQUIREMENTS OF CIVIL WORKS FOR STORAGE
SHED**

ANNEXURES (STORAGE SHED) CHAPTER-01



Bharat Heavy Electricals Limited

Project Management Department
Power Sector – Southern Region
690, Anna Salai, Nandanam
Chennai – 600 035

2.2.1 CLEANING OF WORK SITE

The area shall be cleared out of all trees, stumps, bushes, grasses, vegetation etc. with their roots, fences, logs, rubbish, water, slush etc. All debris from the above operation shall be removed from the site at location decided by BHEL Engineer.

2.2.2 Leveling and Grading

- 2.2.1.1 The area has to be levelled with excavated earth/ approved good quality soil/murum which has to be arranged by bidder. Bidders to locate and arrange for borrow earth and also to include all formalities like royalty, seigniorage charges etc. in the rate to be quoted. The material shall be free from lumps and clods, roots and vegetation, harmful salts and chemicals, organic materials, etc. The area shall be levelled and graded with proper slope as per the requirement of site to the satisfaction of the site engineer.
- 2.2.1.2 In few cases, the agency has to level the area with the approved excavated soil/earth available at site within the lead of 1km to 2km as per the instructions of BHEL engineer in charge under relevant item of price bid.

2.2.3 Earthwork

- 2.2.2.1 Earth work excavation shall be done as per IS standards in all types of soil for foundations, trenches including the shoring, strutting, dewatering, filling around foundations and to grade, compaction of fills etc.
- 2.2.2.2 Excavated material shall not be deposited within 1.5 M from the top edge of the excavation or within distance equal to the depth of excavation, whichever is higher.
- 2.2.2.3 If Contractor excavates beyond the specified depth, the over excavated portion shall be filled back only with 1:4:8 cement concrete and well compacted without any extra cost.
- 2.2.2.4 The excavated soil will be disposed off by using it for back filling or by either spreading at designated disposal area. All surplus materials from excavation shall be carried away from excavation side and dumped at dumping site as directed by BHEL Engineer.
- 2.2.2.5 The earth filling shall be carried out by cutting & removing by Mechanical means, transporting within Plant Building (or) from outside borrowed earth, Filling in layer, watering, compacting by Roller/Compactors to carry out construction works over the filling as per the direction of Engineer In charge.

2.2.4 Cement Concrete works

- 2.2.3.1 All the concrete works under the scope of Contract will be done in accordance with the enclosed BOQ, Drawings & relevant IS standards.
- 2.2.3.2 The reinforcement shall conform to the latest revisions of IS specification. The bars will be used of deformed bars conforming to IS 1786. The cutting, bending

and placing of the reinforcement will be as per the drawing and direction of Engineer-in-Charge.

- 2.2.3.3 The form work should be capable of carrying the dead load of the concrete, the reinforcements and the forces due to vibration.
- 2.2.3.4 The form work shall be designed by the Contractor and approved by the Engineer-in-Charge.
- 2.2.3.5 Curing shall be done for all the concrete works continuously. The form work will be removed after sufficient curing is done.

2.2.5 Masonry Work

- 2.2.4.1 Brick masonry shall be done by using best quality locally available burnt clay bricks/ Fly ash lime bricks of standard size or as directed by Engineer In charge. The brick work in cement mortar 1:6 shall be done for all the walls all around as shown in the drawing.
- 2.2.4.2 The plastering will be done over the brick masonry in cement mortar 1:6 of 12mm thick both for interior as well as external walls.

2.2.6 Structural Works

- 2.2.5.1 This specification covers the Roofing, structures for storage shed.
- 2.2.5.2 The roofing structures shall cover tubular trusses, purlins, bottom tie runners, anchor plates, base plates and fixing bolts for trusses, etc. Any other item not specifically mentioned but required for completion of the structure shall be deemed to have been included in this specification. The Tubular Trusses, purlins, Bottom tie runners will be fabricated from raw materials by the tenderer as per the drawing and as directed by Engineer In charge to complete the work. The required base plate, Anchor bolt, GI 'J' bolt etc., are to be arranged by the contractor at his cost.
- 2.2.5.3 The trusses shall be of tubular steel welded construction fabricated in places of convenient length for transportation by truck and speedy erection at site. The base plates will be welded to the trusses for fixing the same on pillars. Necessary cleats or fixing plates shall be provided on the trusses, for holding the purlins and the bottom tie runners, all as shown in the fabrication drawing.
- 2.2.5.4 The purlins and bottom tie runners shall be of steel tubes of sizes shown in the drawing. Corrugated GS sheets shall be used for the roofing. The sheets shall be fixed to purlins with GI "J" bolts, cap washers, bitumen washers. Flat iron wind ties 32 x 5 mm flat shall be provided over the GS sheets for additional protection against wind storms, for all rows within the Quoted Rates.

2.2.7 Painting and Finishing

- 2.2.6.1 All steel surfaces including ventilators, windows, grills, rolling shutter etc shall also be primed with approved steel primer (one coat) and two coats of approved enamel paint so as to achieve as even.
- 2.2.6.2 All the structural webbers shall be provided with two coats of anti-rust red oxide primer paint after proper cleaning of the surface.
- 2.2.6.3 Painting distemper two coats over a priming coat must be provided using best quality oil bound distemper of approved make and colour as per the IS specification Oil bound washable distemper shall be of oil emulsion type, containing suitable preservatives and shall conform to IS: 428.

2.2.8 RATES AND MEASUREMENTS

2.2.7.1 Rates

2.2.7.1.1 The item of work in the schedule of quantities describes 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.

2.2.7.1.2 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

2.2.7.1.3 The bidder's quoted rate shall be inclusive of supplying and providing all labour, men, materials, equipments, tools and plants, supervision, service, approaches, schemes etc.

2.2.7.2 Measurements

Mode of measurement shall be as per relevant IS 1200. 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.

NOTE: The above should not be concluded as final. They are meant for general guidelines. BHEL reserves the right to include or exclude any item which is required for completing the job as per rates indicated in rate schedule. Contractor should carry out all such jobs as per the instructions of BHEL, Engineer.

TECHNICAL SPECIFICATION FOR STORAGE SHED

ANNEXURES (STORAGE SHED) Chapter-02



Bharat Heavy Electricals Limited

Project Management Department

Power Sector – Southern Region

690, Anna Salai, Nandanam

Chennai – 600 035

2.3.1 SCOPE

Design, Procurement, Supply, Receipt at Site, Erection, Painting etc. and Handing over of Removable/Re-erectable type Pre-Engineered, Pre-fabricated Steel Storage Shed including associated Civil and Electrical works.

2.3.2 DESIGN CONSIDERATIONS FOR CLOSED STORAGE SHED

- 2.3.2.1 Size of Closed Shed – **15M c/c X 30M c/c X 6.0 M** (approximate).
- 2.3.2.2 Clear Height of closed Shed (between FFL & Bottom of truss/ Structural Member) – 6.0M.
- 2.3.2.3 Columns shall be spanning – 6.0M c/c long span & 5.0M c/c short span.
- 2.3.2.4 All design work of sheds shall be of pressed steel sections & have to be vetted by civil design agency/ chartered engineer/ consultant of good reputation/Civil engineering department of reputed engineering college.
- 2.3.2.5 All side cladding/ roof sheets shall be fitted in such a way that they can be removed at any point of time.
- 2.3.2.6 Steel Sliding doors (4.65 M Width x 5 M Height) shall be provided at front entrance of each covered shed at centre location. Suitable arrangement shall be made for easy operation of gates (gear operated).
- 2.3.2.7 One man-entry gate to be provided on at one side of each shed (front entrance by the side of sliding door).
- 2.3.2.8 The bidder should submit a guarantee for 12 months of operations for the design performance, materials supplied & erection works.
- 2.3.2.9 All designs have to be carried out as per relevant IS code.

2.3.3 CIVIL WORK

- 2.3.3.1 Design and execution of civil works shall be carried out as per latest IS codes, standard specification and drawings as per the instruction of Engineer In-charge.
- 2.3.3.2 Grade of RCC shall be confirming to min. M25.
- 2.3.3.3 Reinforcement Steel shall be confirming to min.Fe500.
- 2.3.3.4 Brick masonry using first class brick of strength 75kg/sq cm with masonry with CM 1:6 and plastering with CM 1:6 of min. 15mm thick
- 2.3.3.5 Flooring shall consist of reinforced concrete base of 100 mm thick PCC of grade M15 (1:2:4) over a layer of 150 mm thick compacted sand.
- 2.3.3.6 All the exposed face of Masonry & concrete should be painted with cement paint.
- 2.3.3.7 Civil works: Foundations, Flooring & 230mm thick Brick cladding up to 0.900m above finished floor level along periphery.
- 2.3.3.8 SBC of soil may be ascertained after site inspection for design of foundation of storage shed.

- 2.3.3.9 Foundation should never be laid on filled up soil. In case of filled up soil, the founding level has to reach virgin soil.
- 2.3.3.10 Height of RCC Column foundation shall be + 0.60 m above existing G.L. However, before starting the work the Vendor has to visit site to collect actual information. No extra cost shall be paid for rise in elevation due to site conditions.
- 2.3.3.11 RCC Ramp to be provided at the entrance of each shed.
- 2.3.3.12 HDPE Rain Water Down Pipe shall be provided with suitable gutters all around.

2.3.4 STRUCTURAL STEEL WORK

- 2.3.4.1 Design of structural steel work shall be carried out as per latest IS codes, standard Specification and drawings. All materials for structural steel works have to be supplied by the contractor and necessary test certificates of the materials procured for this work must be submitted for scrutiny of BHEL site. All fabrication and erection of structures must be executed according to the specification and drawings. Erection of trusses shall be true to line and level and aligned properly, as per drawing and instruction of Engineer In-charge.
- 2.3.4.2 Structural/ steel members will have 2 coat of Zinc Chromate primer -minimum 25 micron DFT at shop and 25 micron DFT after erection (surface preparation of the section as per the standards to suit the climatic conditions) followed by 2 coats of synthetic enamel paint (if not pre-coated)- minimum 25 micron (DFT) of each coat of approved make and shade to achieve an even shade over steel sections already having primer coats and keeping overall DFT with primer not less than 110 microns. The roof truss must have bolted joints at crown and at both ends.
- 2.3.4.3 All accessories like G.I. bolts, EPDM washers and nuts etc. all complete required for the work must be from reputed manufacturer. All bolts, nuts (IS 4759) shall be galvanised (hot dip) min. 270gm/m². Galvanised spring/ plain washer shall be as per IS 1573.
- 2.3.4.4 Since these are detachable sheds & to be in repetitive use at other locations, proper marking (permanent) shall be made for identification to ease re-erection. The stores shed shall be so designed that it can be dismantled at any time and may be transported to be re-erected at other location.
- 2.3.4.5 Cladding : Roof and Side Cladding with 0.63 mm thick corrugated /semi-corrugated G.I. sheet of minimum galvanisation of 275 gsm total on both sides with minimum 150mm overlapping, 8mm dia G.I. hook bolts or 'J' Bolts and nuts @305 mm c/c along with G.I. limpet and EPDM washers & nuts including cutting of sheets for opening etc. all complete. Translucent (Poly Carbonate) sheet of approved make shall be provided for alternative bays on roofs (min. 5% of the roof sheeting area). Both roof and side cladding are to be made "Water Tight. ". Purlins for wall & roof cladding shall be 'z' shape made-up with pressed steel.

2.3.4.6 Logo-1 no shall be painted in front of the entrance just above the sliding door.

2.3.5 MISCELLANEOUS WORK

2.3.5.1 Providing ventilators 900 mm (W) x 600 mm (H) – 5 no's should be at a height of 4.5m from FFL, made of suitable Aluminium section with wired glass fixed type for closed shed only.

2.3.5.2 Suitable long span shelf system shall be provided throughout the length of both opposite longitudinal spans of closed sheds. It should have two shelves with one shorter top & one wider middle rack at height of 600mm from floor adding to a total height of 1200mm. The shelves shall be design to with stand SKU loading (not less than 125 Kg/Sq.M) with suitable angle section. The width of top shelf shall be of 600mm & intermediate/middle shelf is 750mm.

2.3.6 ELECTRICAL WORK

2.3.6.1 Supply & installation of electrical items are to be carried out strictly as per approved drawings and executed through licensed electricians.

2.3.6.2 Bidder to supply & install electrical items like Main switch (30A TPN), ELCB, wires, conduit, tees, bends, clamps, JB's, Switch boards, earthing wires etc. for 18 nos. Medium Bay HPSV lamps preferably of 250 watts with fittings. The same will be as per BHEL site Engineer's approval. Exhaust fans of size 600mm of suitable capacity on both sides on the gable ends to be supplied and fitted.

2.3.6.3 Main wiring points - 2.5 Sq mm copper wire. Light, Fan & 5A points - 1.5 Sq mm copper wire. 15/20 A points - 2.5 Sq mm copper wire.

2.3.6.4 7 Nos. of 250 W HPSV Flood Lights light fitting to be provided. Flood light to be installed in each corner and centre of each side of storage shed except at entrance

2.3.6.5 Outside the shed 1nos sodium vapour lamp shall be provided at the entrance.

2.3.6.6 Outdoor Light distribution Board for outside lights to be provided at outside of the shed. Electrical cables shall confirm to Finolex / Havells / Universal / Delton / Polycab. Paramount and fixtures/fittings shall be of Havells / Crompton/ Bajaj / Philips or any other approved make (BIS certified).

2.3.7 GENERAL

2.3.7.1 All works shall be carried out in proper workmen like manner. Items of works covered by the following specification shall be carried out as per the best practices and according to the direction of the Engineer In-charge / BHEL, Site Engineer and to his satisfaction. Unless otherwise specified in this section or in the description of item, the cost of stage of works mentioned here under shall be deemed to have been included in the rates of items provided in the schedule.

2.3.7.2 Bidders may take note of the following points while sending their offers:

- i. Agency shall submit two sets of proposed drawings of the shed to BHEL site before commencement of work. Agency has to prepare detailed drgs for civil foundations & structural drg of Covered Shed. The design and drawing must be vetted by civil design agency/ chartered engineer/ consultant of good reputation/Civil engineering department of reputed engineering college and to be submitted to BHEL site for information/ approval prior to commencement of work. Five sets of final drawings, along with one soft copy in CD and one reproducible, shall be handed over to BHEL site immediately after finalization of design
- ii. The materials and workmanship must be of good quality and accepted standards and specifications. The site engineer reserves the right to reject any material not up to the specification. After completion of work, the building and areas around them should be cleared of all rubbish, debris etc. and handed over in fit condition for occupation.
- iii. While executing the work at site, if there is any increase or decrease in the depth of the foundation because of the soil condition at site, the new quantities will be reworked and submitted for approval to BHEL
- iv. The quoted prices shall be inclusive of all above and shall include transit freight, handling at site, assembly and erection.

2.3.8 PREFERABLE MAKE/BRANDS FOR VARIOUS ITEMS TO BE INSTALLED

Given below is only an indicative list, new supplies shall be purchased from any leading manufacturer, confirming to IS standards as approved by BHEL site.

ITEM	MANUFACTURER
Cladding/Roof Sheeting & Structural	JSW/ Tata Blue scope/SAIL
LT ACB	L&T/TM/SIEMENS/GEC ALSTOM/ GE POWER CONTROLS / SCHNEIDER / C&S / SPACEAGE HYUNDAI BIS certified manufacturer as approved by BHEL site.
Fuse Switch Unit	ALSTOM / SIEMENS / L&T / CGL / STANDARDS /HAVELS / SCHNEIDER / C&S / GE POWER BIS certified manufacturer as approved by BHEL site.
MCB	STANDARD / MDS / INDO KOPP / C&S / SIEMENS / ABB/HAVELLS BIS certified manufacturer as approved by BHEL site.
MCCB	STANDARD / MDS / INDO KOPP / C&S / SIEMENS / ABB/HAVELLS

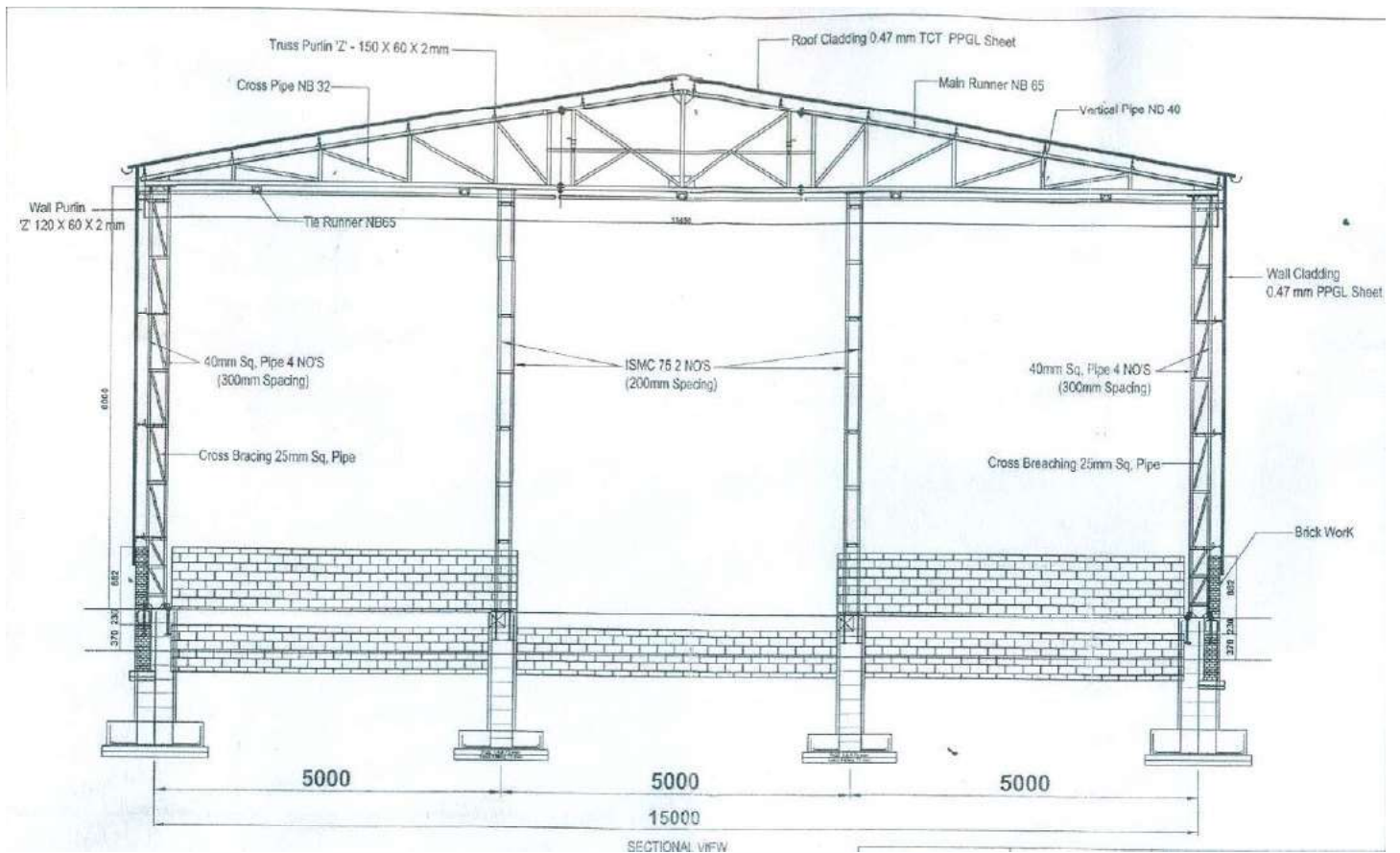
	BIS certified manufacturer as approved by BHEL site.
HRC Fuses	SIEMENS / L & T / ALSTOM / S & S / STANDARD / INDOASIAN / HAVELS / VERSATRIP / BUSMAN / GE POWER BIS certified manufacturer as approved by BHEL site.
Control switches	SIEMENS / ALSTOM / L & T / KAYCEE BIS certified manufacturer as approved by BHEL site.
Indicating lamps (LEDs)	SIEMENS / L & T / ALSTOM / TM / BINAY / TECKNIC / VAISHNO BIS certified manufacturer as approved by BHEL site.
Lighting Fittings	PHILIPS/BAJAJ/CROMPTON/CEMA/GE/HAVELLS/ MYSORE LAMPS BIS certified manufacturer as approved by BHEL site.
Switch Socket outlet	ALSTOM / CGL / BEST & CROMPTON / ESSEN BIS certified manufacturer as approved by BHEL site.
Piano switch	ANCHOR / ELLORA / MAK ELECTRIC / ALSTOM BIS certified manufacturer as approved by BHEL site.
LT Power & Control Cables	FORT GLOSTER / ASIAN CABLES / CCI / UNIVERSAL / NICCO / DELTON CABLES / FINOLEX / INDUSTRIAL CABLES / CMI / OMEGA / RADIANT CABLES / POLYCAB/ KEI/GOVIND / BRIMSON / PREMIER / PARAMOUNT /PLAZA BIS certified manufacturer as approved by BHEL site.
Terminal Blocks	ESSEN / CONNECT WELL / ELMEX / PHOENIX / WAGO BIS certified manufacturer as approved by BHEL site.

2.3.9 DRAWINGS & OTHER ENCLOSURES

Following drawings/documents are enclosed strictly for the guidance of the Bidders:

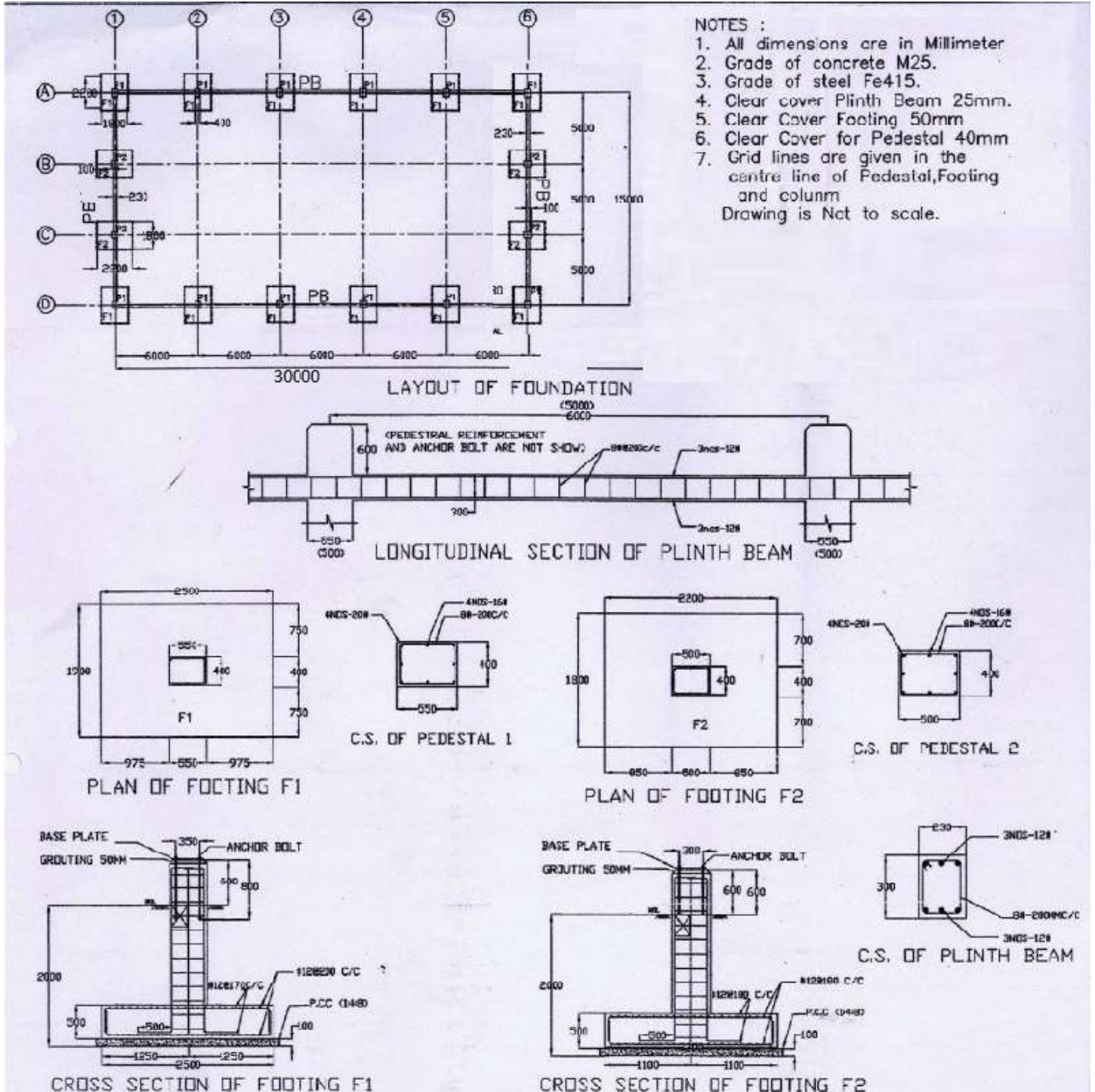
S.No.	Description	No. of pages
1.	Closed storage shed (Typical)	5

ANNEXURES (STORAGE SHED) CHAPTER-2
Technical Specifications-For Closed Storage Shed and indicative drawings

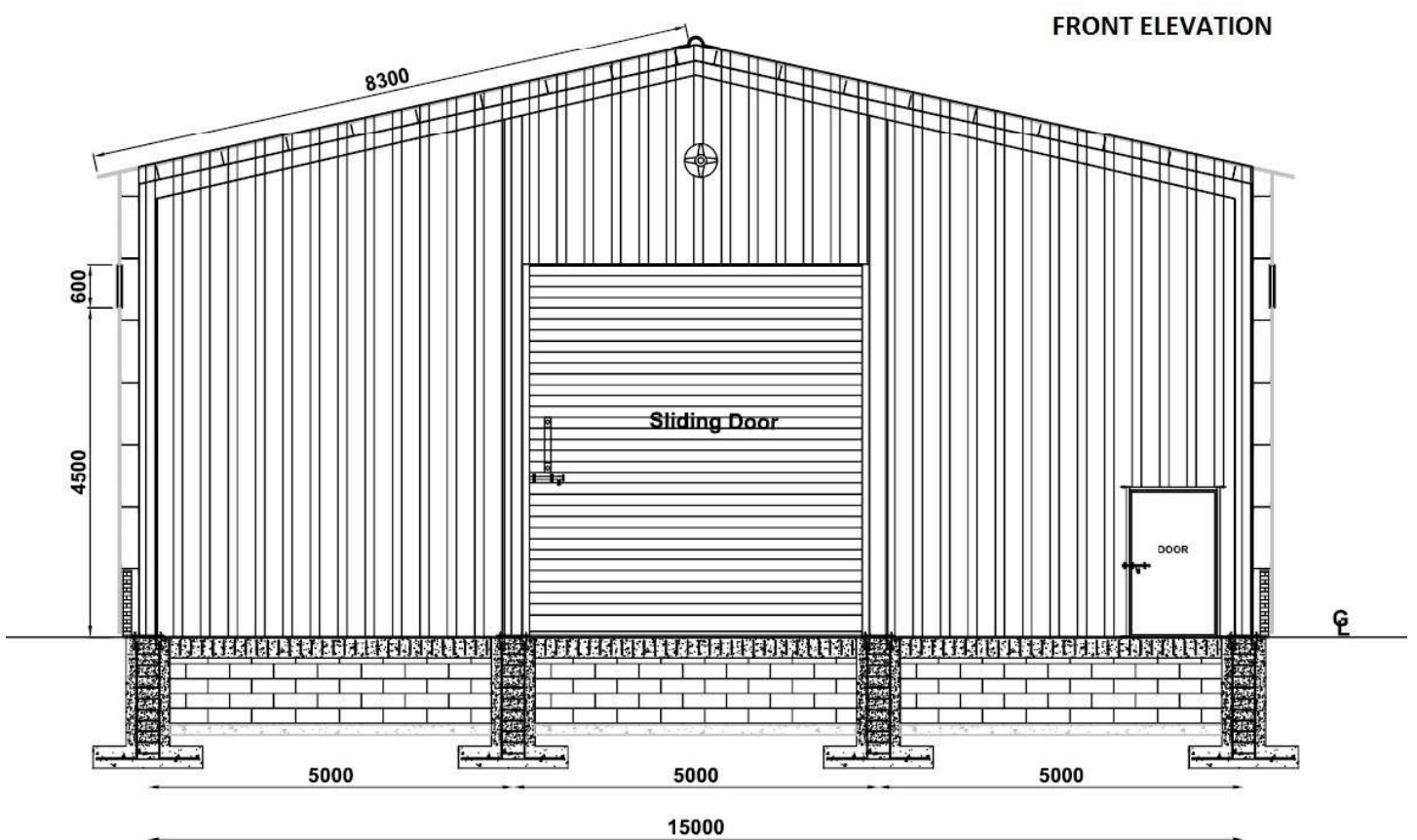


Note: Drawing is for indicative purpose only.

ANNEXURES (STORAGE SHED) CHAPTER-2
Technical Specifications-For Closed Storage Shed and indicative drawings



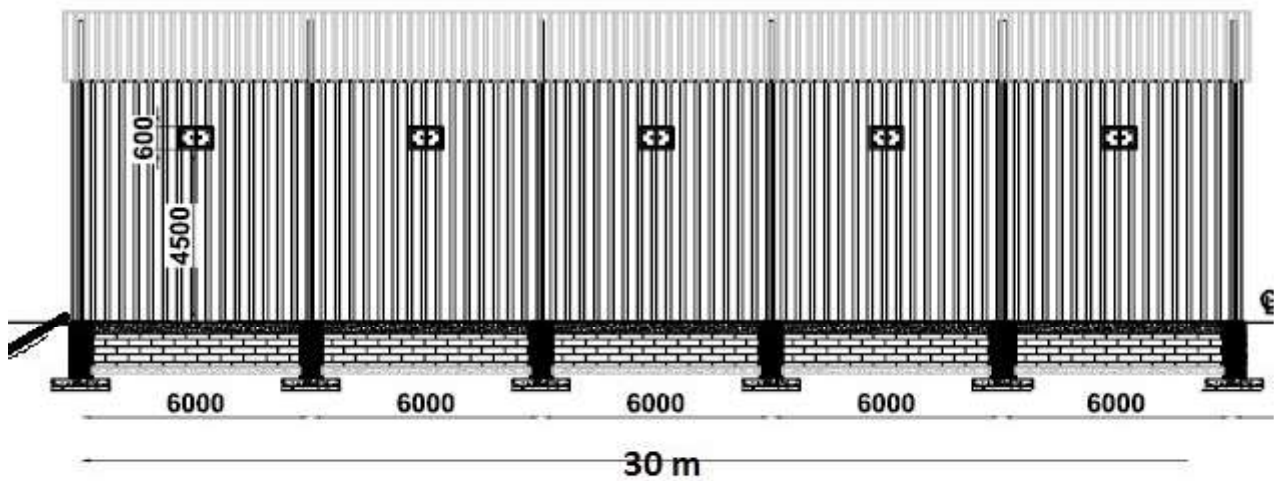
Note: Drawing is for indicative purpose only.



Note: Drawing is for indicative purpose only.

ANNEXURES (STORAGE SHED) CHAPTER-2
Technical Specifications-For Closed Storage Shed and indicative drawings

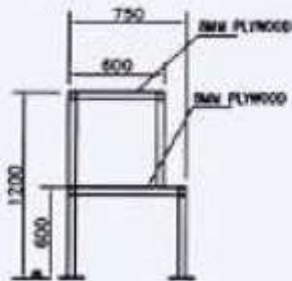
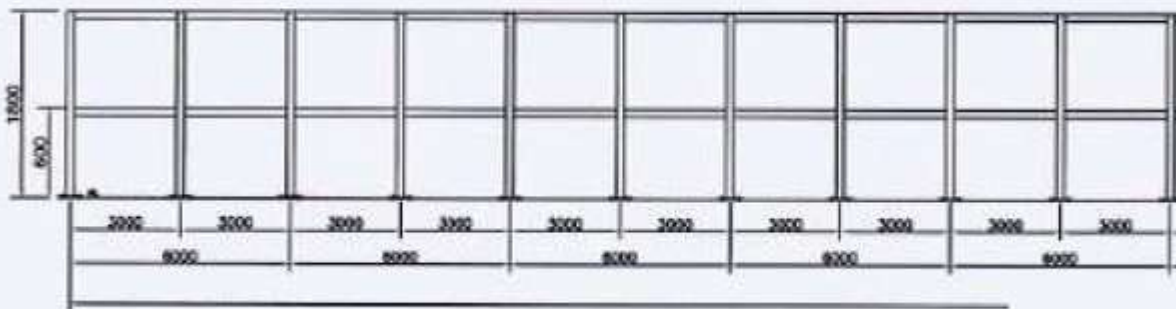
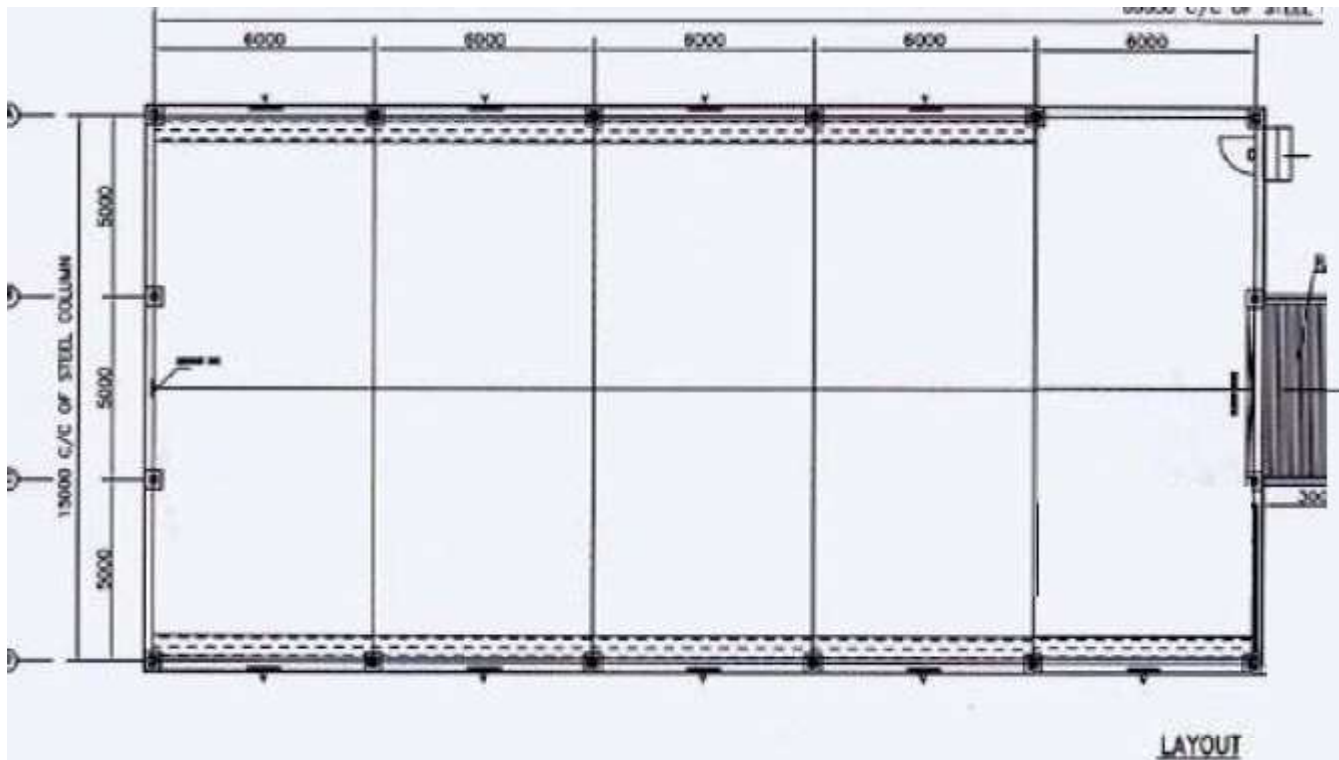
SIDE ELEVATION



Note: Drawing is for indicative purpose only.

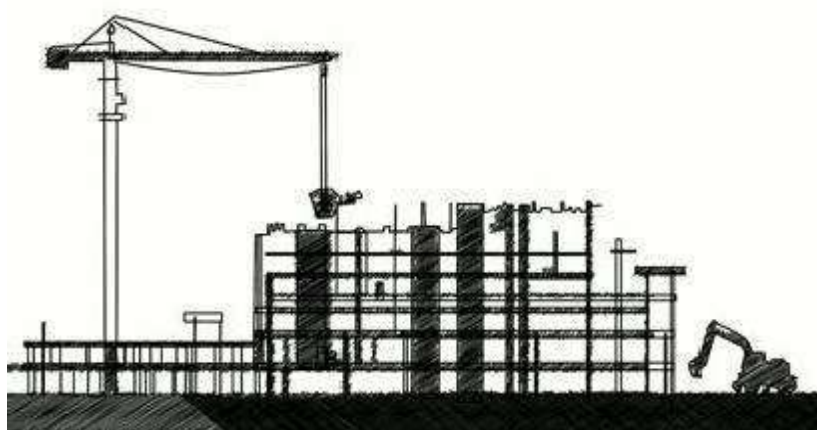
ANNEXURES (STORAGE SHED) CHAPTER-2

Technical Specifications-For Closed Storage Shed and indicative drawings



Longitudinal storage Rack

Note: Drawing is for indicative purpose only.



HEALTH, SAFETY and ENVIRONMENT PLAN

for

**SITE
OPERATIONS**

by

**SUB-
CONTRACTORS**

POWER SECTOR

HSE PLAN FOR SITE OPERATIONS BY BHEL'S SUBCONTRACTORS

AT A GLANCE

BEFORE START	SIGNING OF MOU	
	Agree to comply to HSE requirement- Statutory and BHEL’s	
PLAN	HSE ORGANISATION	
	Manpower 1 (one) safety officer for every 500 workers or part thereof 1(one) safety-steward/ supervisor for every 100 workers Qualification As per Cl. 7.1	HSE Roles and responsibilities - Site In-charge- As per clause 7.2.1 - Safety officer- As per clause 7.2.2
	HSE Planning for Man, Machinery/Equipment/Tools & Tackles	
PROVIDE	HSE INFRASTRUCTURE	
	- PPEs - Drinking Water - Washing Facilities - Latrines and Urinals - Provision of shelter for rest - Medical facilities	- Canteen facilities - Labour Colony - Emergency Vehicle - Pest Control - Scrapyard - Illumination
TRAIN	HSE TRAINING , AWARENESS & PROMOTION	
	Training - Induction training - Height work and other critical areas - Tool Box talk & Pep Talk	Awareness & Promotion - Signage - Poster - Banner - Competition - Awards
COMMUNICATE	HSE COMMUNICATION	
	Incident Reporting - Accident- Fatal & Major - Property damage - Near Miss	Event Reporting - Celebrations - Training - Medical camp

EXECUTE SAFELY

OPERATIONAL CONTROL PROCEDURES

PERMIT TO WORK

Height work (above 2 metres), Hot Work, Heavy Lifting, Confined Space, Radiography, excavation (More than 4 metres)

SAFETY DURING WORK EXECUTION

• Welding • Rigging • Cylinder- storage & Movement • Demolition work • T&Ps • Chemical Handling • Electrical works	• Fire • Scaffolding • Height work • Working Platform • Excavation • Ladder • Lifting • Hoisting appliance

HOUSE KEEPING

WASTE MANGEMENT

TRAFFIC MANAGEMENT

ENVIRONMENTAL CONTROL

EMERGENCY PREPAREDNESS AND RESPONSE PLAN

CHECKS

HSE AUDITS & INSPECTION

• Daily Checks • Inspection of PPEs • Inspection of T& Ps • Inspection of Cranes & Winches	• Inspection of Height work • Inspection of Welding and Gas cutting • Inspection of elevators etc.

HSE PERFORMANCE EVALUATION PARAMETERS

NON CONFORMANCE

PENALTY for NON CONFORMANCE

Refer Clause 16

Incremental penalty

For repeated violation by the same person, the penalty would be double of the previous penalty

For repeated fatal incident in the same Unit incremental penalty to be imposed. The subcontractor will pay 2 times the penalty compared to previously paid in case there are repeated cases of fatal incidents under the same subcontractor for the same package in the same unit.

	HEALTH, SAFETY AND ENVIRONMENT PLAN FOR SITE OPERATION by SUBCONTRACTORS		Doc no.: HSEP: 14
	POWER SECTOR		REV: 01
			Date: 20.01.2020

REVISION HISTORY SHEET

Date	Revision No.	Details of Changes	Reason	Prepared	Reviewed	Approved
12.08.2014	00	First Issue	First Issue	S. B. Jayant, Dy Manager- FQA & Safety	A. K. Sinha, GM-FQA & Safety	Anuj Bhatnagar, ED-FQA & Safety
20.01.2020	01	Formats added: HSEP:14-F30 – Monthly HSE Planning & Review (Page 11, Clause 8.0 - updated) HSEP:14-F13E-Excavation Inspection Format (part of F30)) HSEP:14-F32B – Job Safety Analysis Format (part of F30) HSEP:14-F31A – Daily HSE Reporting (Page 18, Clause 10.3 – added) HSEP:14-F33 – HSE Performance Evaluation (Page 31, Clause 13 – revised)	IOM No. PSHQHSE/M ONREP/02 Dated 08-Jan-2020	Rohit Kumar	Santosh Nair, GM (MSX & HSE)	



**HEALTH, SAFETY AND ENVIRONMENT
PLAN FOR
SITE OPERATION by SUBCONTRACTORS**

POWER SECTOR

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1.0 PURPOSE

- 1.1** The purpose of this HSE Plan is to provide for the systematic identification, evaluation, prevention and control of general workplace hazards, specific job hazards, potential hazards and environmental impacts that may arise from foreseeable conditions during installation and servicing of industrial projects and power plants.
- 1.2** This document shall be followed by BHEL's subcontractors at all installation and servicing sites. In case customer specific documents are to be implemented, this document will be followed in conjunction with customer specific documents.
- 1.3** Although every effort has been made to make the procedures and guidelines in line with statutory requirements, in case of any discrepancy relevant statutory guidelines must be followed.
- 1.4** In case the customer has any specific requirement, the same is to be fulfilled.

2.0 SCOPE

The document is applicable for BHEL's Subcontractors at all installation / servicing activities of BHEL Power Sector as per the relevant contractual obligations.

3.0 OBJECTIVES AND TARGETS

The HSE Plan reflects that BHEL places high priority upon the Occupational Health, Safety and Environment at workplaces.

- Ensure the Health and Safety of all persons at work site is not adversely affected by the work.
- Ensure protection of environment of the work site.
- Comply at all times with the relevant statutory and contractual HSE requirements.
- Provide trained, experienced and competent personnel. Ensure medically fit personnel only are engaged at work.
- Provide and maintain plant, places and systems of work that are safe and without risk to health and the environment.
- Provide all personnel with adequate information, instruction, training and supervision on the safety aspect of their work.
- Effectively control, co-ordinate and monitor the activities of all personnel on the Project sites including subcontractors in respects of HSE.
- Establish effective communication on HSE matters with all relevant parties involved in the Project works.
- Ensure that all work planning takes into account all persons that may be affected by the work.
- Ensure fitness testing of all T&Ps/Lifting appliances like cranes, chain pulley blocks etc. are to be certified by competent person.
- Ensure timely provision of resources to facilitate effective implementation of HSE requirements.
- Ensure continual improvements in HSE performance
- Ensure conservation of resources and reduction of wastage.
- Capture the data of all incidents including near misses, process deviation etc. Investigate and analyze the same to find out the root cause.
- Ensure timely implementation of correction, corrective action and preventive action.



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HSE TARGETS

EXPLOSION	ZERO
FATALITY	ZERO
LOST TIME INJURY	ZERO
FIRE	ZERO
VEHICLE INCIDENTS	ZERO
ENVIRONMENTAL INCIDENTS	ZERO

4.0 BHEL POWER SECTOR HEALTH, SAFETY & ENVIRONMENT POLICY

Health, Safety & Environment Policy of BHEL

In BHEL, Health, Safety and Environment (HSE) responsibilities are driven by our commitment to protect our employees and people we work with, community and environment. BHEL believes in zero tolerance for unsafe work/non-conformance to safety and in minimizing environmental footprint associated with all its business activities. We commit to continually improve our HSE performance by:

- Developing safety and sustainability culture through active leadership and by ensuring availability of required resources.
- Ensuring compliance with applicable legislation, regulations and BHEL systems.
- Taking up activities for conservation of resources and adopting sound waste management by following Reduce/Recycle/Reuse approach.
- Continually identifying, assessing and managing environmental impacts and Occupational Health & Safety risks of all activities, products and services adopting approach based on elimination/substitution/reduction/control.
- Incorporating appropriate Occupational Health, Safety and Environment criteria into business decisions, design of products & systems and for selection of plants, technologies and services.
- Imparting appropriate structured training to all persons at workplace and promoting awareness amongst customers, contractors and suppliers on HSE issues.
- Reviewing periodically this policy and HSE Management Systems to ensure its relevance, appropriateness and effectiveness.
- Communicating this policy within BHEL and making it available to interested parties.

sd/-

CMD, BHEL

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5.0 MEMORANDUM OF UNDERSTANDING:

After award of work, subcontractors are required to enter into a memorandum of understanding as given below:

Memorandum of Understanding

BHEL, Power Sector _____ Region is committed to Health, Safety and Environment Policy (HSE Policy).

M/s _____ do hereby also commit to comply with the same HSE Policy while executing the Contract Number _____

M/s _____ shall ensure that safe work practices as per the HSE plan. Spirit and content therein shall be reached to all workers and supervisors for compliance.

In addition to this, M/S _____ shall comply to all applicable statutory and regulatory requirements which are in force in the place of project and any special requirement specified in the contract document of the principal customer.

M/s _____ shall co-operate in HSE audits/inspections conducted by BHEL /customer/ third party and ensure to close any non-conformity observed/reported within prescribed time limit.

Signed by authorized representative of M/s -----

Name :

Place & Date:



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6.0 TERMS AND DEFINITIONS

6.1 DEFINITIONS

6.1.1 INCIDENT

Work- related or natural event(s) in which an injury, or ill health (regardless of severity), damage to property or fatality occurred, or could have occurred.

6.1.2 NEAR MISS

An incident where no ill health, injury, damage or other loss occurs, but it had a potential to cause, is referred to as "Near-Miss".

6.1.3 MAN-HOURS WORKED

The total number of man hours worked by all employees including subcontractors working in the premises. It includes managerial, supervisory, professional, technical, clerical and other workers including contract labours. Man-hours worked shall be calculated from the payroll or time clock recorded including overtime. When this is not feasible, the same shall be estimated by multiplying the total man-days worked for the period covered by the number of hours worked per day. The total number of workdays for a period is the sum of the number of men at work on each day of period. If the daily hours vary from department to department separate estimate shall be made for each department and the result added together.

6.1.4 FIRST AID CASES

First aids are not essentially all reportable cases, where the injured person is given medical treatment and discharged immediately for reporting on duty, without counting any lost time.

6.1.5 LOST TIME INJURY

Any work injury which renders the injured person unable to perform his regular job or an alternative restricted work assignment on the next scheduled work day after the day on which the injury occurred.

6.1.6 MEDICAL CASES

Medical cases come under non-reportable cases, where owing to illness or other reason the employee was absent from work and seeks Medical treatment.

6.1.7 TYPE OF INCIDENTS & THEIR REPORTING:

The three categories of Incident are as follows:

Non-Reportable Cases:

An incident, where the injured person is given medical help and discharged for work without counting any lost time.



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Reportable Cases:

In this case the injured person is disable for 48 hours or more and is not able to perform his duty.

Injury Cases:

These are covered under the heading of non-reportable cases. In these cases the incident caused injury to the person, but he still continues his duty.

6.1.8 TOTAL REPORTABLE FREQUENCY RATE

Frequency rate is the number of Reportable Lost Time Injury (LTI) per one Million Man hours worked. Mathematically, the formula read as:

$$\frac{\text{Number of Reportable LTI} \times 1,000,000}{\text{Total Man Hours Worked}}$$

6.1.9 SEVERITY RATE

Severity rate is the Number of days lost due to Lost Time Injury (LTI) per one Million Man hours worked. Mathematically, the formula reads as:

$$\frac{\text{Days lost due to LTI} \times 1,000,000}{\text{Total Man Hours Worked}}$$

6.1.10 INCIDENCE RATE

Incidence Rate is the Number of LTI per one thousand manpower deployed. Mathematically, the formula reads as:

$$\frac{\text{Number of LTI} \times 1000}{\text{Average number of manpower deployed}}$$

7.0 HSE ORGANISATION

Number of safety officers:

The subcontractor must deploy one safety officer for every 500 workers or part thereof in each package. In addition, there must be one safety-steward/safety-supervisor for every 100 workers.

Deployment: The subcontractor should deploy sufficient safety officers and safety-steward/Safety-supervisor, as per requirement given above, since initial stage and add more in proportion to the added strength in work force. Any delay in deployment will attract a penalty of Rs.30,000/- per man month for the delayed period.

7.1 QUALIFICATION FOR HSE PERSONNEL

Sl.no	Designation	Qualification	Experience
1	Safety officer (Construction Agency)	Degree or Diploma in Engineering with full time diploma in Industrial Safety with construction safety as one of the subjects	Minimum two years for degree holder and five years for diploma holder in the field of Construction of power plant/ major industries

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2	Safety-Steward/ Safety-Supervisor	Degree or diploma in any discipline with full time diploma in Industrial Safety with construction safety as one of the subjects	Minimum two years

7.2 RESPONSIBILITIES

7.2.1 SITE IN -CHARGE OF SUBCONTRACTOR

- Shall sign Memorandum of Understanding (MoU) for compliance to BHEL's HSE Plan for Site Operations as per clause 5.0
- Shall engage qualified safety officer(s) and steward (s) as per clause 7.0
- Shall adhere to the rules and regulations mentioned in this code, practice very strictly in his area of work in consultation with his concerned engineer and the safety coordinator.
- Shall screen all workmen for health and competence requirement before engaging for the job and periodically thereafter as required.
- Shall not engage any employee below 18 years.
- Shall arrange for all necessary PPEs like safety helmets, belts, full body harness, shoes, face shield, hand gloves etc. before starting the job. Shall ensure that no working men/women carry excessive weight more than stipulated in Factory Rule Regulation R57.
- Shall ensure that all T&Ps engaged are tested for fitness and have valid certificates from competent person.
- Shall ensure that provisions stipulated in contract Labour Regulation Act 1970, Chapter V C.9, canteen, rest rooms/washing facilities to contracted employees at site.
- Shall adhere to the instructions laid down in Operation Control Procedures (OCPs) available with the site management.
- Shall ensure that person working above 2.0 meter should use Safety Harness tied to a life line/stable structure.
- Shall ensure that materials are not thrown from height. Cautions to be exercised to prevent fall of material from height.
- Shall report all incidents (Fatal/Major/Minor/Near Miss) to the Site engineer /HSE officer of BHEL.
- Shall ensure that Horseplay is strictly forbidden.
- Shall ensure that adequate illumination is arranged during night work.
- Shall ensure that all personnel working under subcontractor are working safely and do not create any Hazard to self and to others.
- Shall ensure display of adequate signage/posters on HSE.
- Shall ensure that mobile phone is not used by workers while working.
- Shall ensure conductance of HSE audit, mockdrill, medical camps, induction training and training on HSE at site.
- Shall ensure full co-operation during HQ/External /Customer HSE audits.



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- ☐ Shall ensure submission of look-ahead plan for procurement of HSE equipment's and PPEs as per work schedule.
- Shall ensure good housekeeping.
- Shall ensure adequate valid fire extinguishers are provided at the worksite.
- Shall ensure availability of sufficient number of toilets /restrooms and adequate drinking water at work site and labour colony.
- Shall ensure adequate emergency preparedness.
- Shall be member of site HSE committee and attend all meetings of the committee
- Power source for hand lamps shall be maximum of 24 v.
- ☐ Temporary fencing should be done for open edges if Hand – railings and Toe-guards are not available.

7.2.2 HEALTH, SAFETY AND ENVIRONMENT OFFICER OF SUBCONTRACTOR

- Carry out safety inspection of Work Area, Work Method, Men, Machine & Material, P&M and other tools and tackles.
- Facilitate inclusion of safety elements into Work Method Statement.
- Highlight the requirements of safety through Tool-box / other meetings.
- Help concerned HOS to prepare Job Specific instructions for critical jobs.
- Conduct investigation of all incident/dangerous occurrences & recommend appropriate safety measures.
- Advice & co-ordinate for implementation of HSE permit systems, OCPs & MPs.
- Convene HSE meeting & minute the proceeding for circulation & follow-up action.
- Plan procurement of PPE & Safety devices and inspect their healthiness.
- Report to PS Region/HQ on all matters pertaining to status of safety and promotional program at site level.
- Facilitate administration of First Aid
- Facilitate screening of workmen and safety induction.
- Conduct fire Drill and facilitate emergency preparedness
- Design campaigns, competitions & other special emphasis programs to promote safety in the workplace.
- ☐ Apprise PS– Region on safety related problems.
- Notify site personnel non-conformance to safety norms observed during site visits / site inspections.
- Recommend to Site In charge, immediate discontinuance of work until rectification, of such situations warranting immediate action in view of imminent danger to life or property or environment.
- To decline acceptance of such PPE / safety equipment that do not conform to specified requirements.
- Encourage raising Near Miss Report on safety along with, improvement initiatives on safety.
- Shall work as interface between various agencies such customer, package-in-charges, subcontractors on HSE matters



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8.0 PLANNING BY SUBCONTRACTOR

Monthly planning and review of HSE activities shall be carried out by subcontractor as per format No. HSEP:14-F30 jointly along with BHEL.

8.1 MOBILISATION OF MACHINERY/EQUIPMENT/TOOLS BY SUBCONTRACTOR

- As a measure to ensure that machinery, equipment and tools being mobilized to the construction site are fit for purpose and are maintained in safe operating condition and complies with legislative and owner requirement, inspection shall be arranged by in-house competent authority for acceptance as applicable.
- The machinery and equipment to be embraced for this purpose shall include but not limited to the following:
 - o Mobile cranes.
 - o Side Booms.
 - o Forklifts.
 - o Grinding machine.
 - o Drilling machine.
 - o Air compressors.
 - o Welding machine.
 - o Generator sets.
 - o Dump Trucks.
 - o Excavators.
 - o Dozers
 - o Grit Blasting Equipment.
 - o Hand tools.
- Subcontractor shall notify the engineer, of his intention to bring on to site any equipment or any container, with liquid or gaseous fuel or other substance which may create a hazard. The Engineer shall have the right to prescribe the condition under which such equipment or container may be handled and used during the performance of the works and the subcontractor shall strictly adhere to such instructions. The Engineer shall have the right to inspect any construction tool and to forbid its use, if in his opinion it is unsafe. No claim due to such prohibition will be entertained.

8.2 MOBILISATION OF MANPOWER BY SUBCONTRACTOR

- The subcontractor shall arrange induction and regular health check of their employees as per schedule VII of BOCW rules by a registered medical practitioner.
- The subcontractor shall take special care of the employees affected with occupational diseases under rule 230 and schedule II of BOCW Rules. The employees not meeting the fitness requirement should not be engaged for such job.
- Ensure that the regulatory requirements of excessive weight limit (to carry/lift/ move weights beyond prescribed limits) for male and female workers are complied with.
- Appropriate accommodation to be arranged for all workmen in hygienic condition.



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8.3 PROVISION OF PPEs

- Personnel Protective Equipment (PPEs), in adequate numbers, will be made available at site & their regular use by all concerned will be ensured
- The following matrix recommends usage of minimum PPEs against the respective job.

Sl. No	Type of work	PPEs
1	Concrete and asphalt mixing	Nose mask, hand glove, apron and gum boot
2	Welders/Grinders/ Gas cutters	Welding/face screen, apron, hand gloves, nose mask and ear muffs if noise level exceeds 90dB. Helmet fitted with welding shield is preferred for welders
3	Stone/ concrete breakers	Ear muffs, safety goggles, hand gloves
4	Electrical Work	Rubber hand glove, Electrical Resistance shoes
5	Insulation Work	Respiratory mask, Hand gloves, safety goggles
6	Work at height	Double lanyard full body harness, Fall arrestor (specific cases)
7	Grit/Sand blasting	Blast suit, blast helmet, respirator, leather gloves
8	Painting	Plastic gloves, Respirators (particularly for spray painting)
9	Radiography	As per BARC guidelines

- The PPEs shall conform to the relevant standards as below and bear ISI mark.

Relevant is-codes for personal protection

IS: 2925 – 1984	Industrial Safety Helmets.
IS: 4770 – 1968	Rubber gloves for electrical purposes.
IS: 6994 – 1973 (Part-I)	Industrial Safety Gloves (Leather & Cotton Gloves).
IS: 1989 – 1986 (Part-I-II)	Leather safety boots and shoes.
IS: 5557 – 1969	Industrial and Safety rubber knee boots.
IS: 6519 – 1971	Code of practice for selections care and repair of Safety footwear.
IS: 11226 – 1985	Leather Safety footwear having direct molding sole.
IS: 5983 – 1978	Eye protectors.
IS: 9167 – 1979	Ear protectors.
IS: 1179-1967	Eye & Face protection during welding
IS: 3521 – 1983	Industrial Safety Belts and Harness
IS: 8519 -1977	Guide for selection of industrial Safety equipment for body protection
IS: 9473-2002, 14166-1994, 14746-1999	Respiratory Protective Devices

The list is not exhaustive. The safety officer may demand additional PPEs based on specific requirement.



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- Where workers are employed in sewers and manholes, which are in use, the subcontractor shall ensure that the manhole covers are opened and ventilated at least for an hour before the workers are allowed to get into manhole, and the manholes so opened shall be cordoned off with suitable railing and provided with warning signals or boards to prevent incident to the public
- Besides the PPEs mentioned above, the persons shall use helmet and safety shoe. The visitors shall use Helmet and any other PPEs as deemed appropriate for the area of work.

Colour scheme for Helmets:

- Workmen: Yellow
 - Safety staff: Green or white with green band
 - Electrician: Red
 - Others including visitors: White
- All the PPEs shall be checked for its quality before issue and the same shall be periodically checked. The users shall be advised to check the PPEs themselves for any defect before putting on. The defective ones shall be repaired/ replaced.
 - The issuing agency shall maintain register for issue and receipt of PPEs.
 - The Helmets shall have logo or name (abbreviation of agency name permitted) affixed or printed on the front.
 - The body harnesses shall be serial numbered.

8.4 ARRANGEMENT OF INFRASTRUCTURE

8.4.1 DRINKING WATER

- Drinking water shall be provided and maintained at suitable places at different elevations.
- Container should be labeled as "Drinking Water"
- Cleaning of the storage tank shall be ensured atleast once in 3 months indicating date of cleaning and next due date.
- Potability of water should be tested as per IS10500 at least once in a year.

8.4.2 WASHING FACILITIES

- In every workplace, adequate and suitable facilities for washing shall be provided and maintained.
- Separate and adequate cleaning facilities shall be provided for the use of male and female workers. Such facilities shall be conveniently accessible and shall be kept in clean and hygienic condition and dully illuminated for night use.
- Overalls shall be supplied by the subcontractor to the workmen and adequate facilities shall be provided to enable the painters and other workers to wash during the cessation of work.

8.4.3 LATRINES AND URINALS

- Latrines and urinals shall be provided in every work place.
- Urinals shall also be provided at different elevations.
- They shall be adequately lighted and shall be maintained in a clean and sanitary condition at all times, by appointing designated person.
- Separate facilities shall be provided for the use of male and female worker if any.



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8.4.4 PROVISION OF SHELTER DURING REST

Proper Shed & Shelter shall be provided for rest during break

8.4.5 MEDICAL FACILITIES

8.4.5.1 MEDICAL CENTRE (As per Schedule V, X and XI of BOCW central Rules, 1998)

- A medical centre shall be ensured/identified at site with basic facilities for handling medical emergencies. The medical center can be jointly developed on proportionate sharing basis with permission from BHEL
- A qualified medical professional, not less than MBBS, shall be deployed at the medical centre
- The medical centre shall be equipped with one ambulance, with trained driver and oxygen cylinder.
- Medical waste shall be disposed as per prevailing legislation (Bio-Medical Waste –Management and Handling Rules, 1998)

8.4.5.2 FIRST AIDER

- Ensure availability of Qualified First-aider throughout the working hours.
- Every injury shall be treated, recorded and reported.
- Refresher course on first aid shall be conducted as necessary.
- List of Qualified first aiders and their contact numbers should be displayed at conspicuous places.

8.4.5.3 FIRST AID BOX (as per schedule III of BOCW)

- The subcontractor shall provide necessary first aid facilities as per schedule III of BOCW. At every work place first aid facilities shall be provided and maintained.
- The first aid box shall be kept by first aider who shall always be readily available during the working hours of the work place. His name and contact no to be displayed on the box.
- The first aid boxes should be placed at various elevations so as to make them available within the reach and at the quickest possible time.
- The first aid box shall be distinctly marked with a Green Cross on white background.
- Details of contents of first aid box is given in Annexure No. 01
- Monthly inspection of First Aid Box shall be carried out by the owner as per format no. HSEP:14-F01
- The subcontractor should conduct periodical first –aid classes to keep his supervisor and Engineers properly trained for attending to any emergency.

8.4.5.4 HEALTH CHECK UP (As per schedule VII and Form XI)

The persons engaged at the site shall undergo health checkup as per the format no. HSEP:14-F02 before induction. The persons engaged in the following works shall undergo health checkup at least once in a year:

- a. Height workers
- b. Drivers/crane operators/riggers



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- c. Confined space workers
- d. Shot/sand blaster
- e. Welding and NDE personnel

8.4.6 PROVISION OF CANTEEN FACILITY

- Canteen facilities shall be provided for the workmen of the project inside the project site.
- Proper cleaning and hygienic condition shall be maintained.
- Proper care should be taken to prevent biological contamination.
- Adequate drinking water should be available at canteen.
- Fire extinguisher shall be provided inside canteen.
- Regular health check-up and medication to the canteen workers shall be ensured.

8.4.7 PROVISION OF ACCOMODATION/LABOUR COLONY

- || The subcontractor shall arrange for the accommodation of workmen at nearby localities or by making a labour colony.
- || Regular housekeeping of the labour colony shall be ensured.
- || Proper sanitation and hygienic conditions to be maintained.
- || Drinking water and electricity to be provided at the labour colony.
- || Bathing/ washing bay
- || Room ventilation and electrification.

8.4.8 PROVISION OF EMERGENCY VEHICLE

- Dedicated emergency vehicle shall be made available at workplace by each subcontractor to handle any emergency

8.4.9 PEST CONTROL

Regular pest control should be carried out at all offices, mainly laboratories, canteen, labour colony and stores.

8.4.10 SCRAPYARD

- In consultation with customer, scrapyard shall be developed to store metal scrap, wooden scrap, waste, hazardous waste.
- Scrap/Waste shall be segregated as Bio-degradable and non-bio-degradable and stored separately.

8.4.11 ILLUMINATION

- The subcontractor shall arrange at his cost adequate lighting facilities e.g. flood lighting, hand lamps, area lighting etc. at various levels for safe and proper working operations at dark places and during night hours at the work spot as well as at the pre-assembly area.
- Adequate and suitable light shall be provided at all work places & their approaches including passage ways as per IS: 3646 (Part-II). Some recommended values are given below:



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S. No.	Location	Illumination (Lux)
A. Construction Area		
1.	Outdoor areas like store yards, entrance and exit roads	20
2.	Platforms	50
3.	Entrances, corridors and stairs	100
4.	General illumination of work area	150
5.	Rough work like fabrication, assembly of major items	150
6.	Medium work like assembly of small machined parts	300
	rough measurements etc.	
7.	Fine work like precision assembly, precision measurements etc.	700
8.	Sheet metal works	200
9.	Electrical and instrument labs	450
B. Office		
1.	Outdoor area like entrance and exit roads	20
2.	Entrance halls	150
3.	Corridors and lift cars	70
4.	Lift landing	150
5.	Stairs	100
6.	Office rooms, conference rooms, library reading tables	300
7.	Drawing table	450
8.	Manual telephone exchange	200

- Lamp (hand held) shall not be powered by mains supply but either by 24V or dry cells.
- Lamps shall be protected by suitable guards where necessary to prevent danger, in case of breakage of lamp.
- Emergency lighting provision for night work shall be made to minimise danger in case of main supply failure.

If the subcontractor fails to take appropriate safety precautions or to provide necessary safety devices and equipment or to carry out instructions issued by the authorized BHEL official, BHEL shall have the right to take corrective steps at the risk and cost of the subcontractor

9.0 HSE TRAINING& AWARENESS

9.1 HSE INDUCTION TRAINING

All persons entering into project site shall be given HSE induction training by the HSE officer of BHEL /subcontractor before being assigned to work.

In-house induction training subjects shall include but not limited to:

- Briefing of the Project details.
- Safety objectives and targets.
- Site HSE rules.
- Site HSE hazards and aspects.
- First aid facility.
- Emergency Contact No.
- Incident reporting.
- Fire prevention and emergency response.
- Rules to be followed in the labour colony (if applicable)



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- Proper safety wear & gear must be issued to all the workers being registered for the induction (i.e., Shoes/Helmets/Goggles/Leg guard/Apron etc.)
- They must arrive fully dressed in safety wear & gear to attend the induction.
- Any one failing to conform to this safety wear& gear requirement shall not qualify to attend.
- On completing attending subcontractor's in-house HSE induction, each employee shall sign an induction training form (format no. HSEP:14-F03) to declare that he had understood the content and shall abide to follow and comply with safe work practices. They may only then be qualified to be issued with a personal I.D. card, for access to the work site.

9.2 HSE TOOLBOX TALK

- HSE tool Box talk shall be conducted by frontline foreman/supervisor of subcontractor to specific work groups prior to the start of work. The agenda shall consist of the followings:
 - o Details of the job being intended for immediate execution.
 - o The relevant hazards and risks involved in executing the job and their control and mitigating measures.
 - o Specific site condition to be considered while executing the job like high temperature, humidity, unfavorable weather etc.
 - o Recent non-compliances observed.
 - o Appreciation of good work done by any person.
 - o Any doubt clearing session at the end.
- Record of Tool box talk shall be maintained as per format no. HSEP:14-F04
- Tool box talk to be conducted at least once a week for the specific work.

9.3 TRAINING ON HEIGHT WORK

Training on height work shall be imparted to all workers working at height by in-house/external faculty at least twice in a year. The training shall include following topics:

- Use of PPEs
- Use of fall arrester, retractable fall arrester, life line, safety nets etc.
- Safe climbing through monkey ladders.
- Inspection of PPEs.
- Medical fitness requirements.
- Mock drill on rescue at height.
- Dos & Don'ts during height work.

9.4 HSE TRAINING DURING PROJECT EXECUTION

- Other HSE training shall be arranged by BHEL/ subcontractor as per the need of the project execution and recommendation of HSE committee of site.
- The topics of the HSE training shall be as follows but not limited to:
 - o Hazards identification and risk analysis (HIRA)
 - o Work Permit System
 - o Incident investigation and reporting
 - o Fire fighting
 - o First aid
 - o Fire-warden training
 - o EMS and OHSMS
 - o T & Ps fitness and operation



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- o Electrical safety
- o Welding, NDE & Radiological safety
- o Storage, preservation & material handling.
- A matrix shall be maintained to keep an up-to-date record of attendance of training sessions carried out.

9.5 HSE PROMOTION-SIGNAGE, POSTERS, COMPETITION, AWARDS ETC

9.5.1 Display of HSE posters and banners

- Site shall arrange appropriate posters, banners, slogans in local/Hindi/English languages at work place

9.5.2 Display of HSE signage

- Appropriate HSE signage shall be displayed at the work area to aware workmen and passersby about the work going on and do's and don'ts to be followed

9.5.3 Competition on HSE and award

- Site will arrange different competition (slogan, poster, essay etc.) on HSE time to time (Safety day, BHEL day, World Environment Day etc.) and winners will be suitably awarded.

9.5.4 HSE awareness programme

- Subcontractor shall arrange HSE awareness programme periodically on different topics including medical awareness for all personnel working at site

10.0 HSE COMMUNICATION

10.1 INCIDENT REPORTING

- The subcontractor shall submit report of all incidents, fires and property damage etc to the Engineer immediately after such occurrence, but in any case not later than 24 hours of the occurrence. Such reports shall be furnished in the manner prescribed by BHEL. (Refer HSE procedure for incident investigation, analysis and reporting for details)
- In addition, periodic reports on safety shall also be submitted by the subcontractor to BHEL from time to time as prescribed by the Engineer. Compiled monthly reports of all kinds of incidents, fire and property damage to be submitted to BHEL safety officer as per prescribed formats.
- HSE incidents of site shall be reported to BHEL site Management as per Procedure for Incident Investigation and Reporting in format no. HSEP:14-F15. Corrective action shall be immediately implemented at the work place and compliance shall be verified by BHEL HSE officer and until then, work shall be put on hold by Construction Manager.

10.2 HSE EVENT REPORTING

- Important HSE events like HSE training, Medical camp etc. organized at site shall be reported to BHEL site management in detail with photographs for publication in different in-house magazines
- Celebration of important days like National Safety Day, World Environment Day etc. shall also be reported as mentioned above.

10.3 DAILY HSE ACTIVITY REPORTING

Daily HSE activities shall be reported by subcontractor to BHEL as per Format No. HSEP:14-F31A



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11.0 OPERATIONAL CONTROL

All applicable OCPs (Operational control procedures) will be followed by subcontractor as per BHEL instructions. This will be done as part of normal scope of work. List of such OCPs is given below. In case any other OCP is found to be applicable during the execution of work at site, then subcontractor will follow this as well, within quoted rate. These OCPs (applicable ones) will be made available to subcontractor during work execution at site. However for reference purpose, these are kept with Safety Officer of BHEL at the Power Sector Regional HQ, or available in downloadable format in the website, which may be refereed by subcontractor, if they so desire.

LIST OF OCPs

Safe handling of chemicals	Safety in use of cranes	Hydraulic test
Electrical safety	Storage and handling of gas cylinders	Spray insulation
Energy conservation	Manual arc welding	Trial run of rotary equipment
Safe welding and gas cutting operation	Safe use of helmets	Stress relieving
Fire safety	Good house keeping	Material preservation
Safety in use of hand tools	Working at height	Cable laying/tray work
First aid	Safe excavation	Transformer charging
Food safety at canteen	Safe filling of hydrogen in cylinder	Electrical maintenance
Illumination	Vehicle maintenance	Safe handling of battery system
Handling and erection of heavy metals	Safe radiography	Computer operation
Safe acid cleaning	Waste disposal	Storage in open yard
Safe alkali boil out	Working at night	For sanitary maintenance
Safe oil flushing	Blasting	Batching
Steam blowing	DG set	Piling rig operation
Safe working in confined area	Handling & storage of mineral wool	Gas distribution test
Safe operation of passenger lift, material hoists & cages	Drilling, reaming and grinding(machining)	Cleaning of hotwell / deaerator
Electro-resistance heating	Compressor operation	O&M of control of AC plant & system
Air compressor	Passivation	Safe Loading of Unit
Safe EDTA Cleaning	Safe Chemical cleaning of Pre boiler system	Safe Boiler Light up
Safe Rolling and Synchronization		

11.1 HSE ACTIVITIES

HSE activities shall be conducted at site based on the HSEMSM developed by Power Sector and issued to site by Regions.

While planning for any activity the following documents shall be referred for infrastructural requirements to establish control measures:

- 1) HSE Procedure for Register of OHS Hazards and Risks
- 2) HSE Procedure for Register of Environmental Aspects and Impacts
- 3) HSE Procedure for Register of Regulations



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- 4) Operational Control Procedures
- 5) HSE Procedure for Emergency Preparedness and Response Plan
- 6) Contract documents

11.2 WORK PERMIT SYSTEM

- 11 The following activities shall come under Work Permit System
 - a. Height working above 2 metres
 - b. Hot working at height
 - c. Confined space
 - d. Radiography
 - e. Excavation more than 4 meter depth
 - f. Heavy lifting above 50 tonRefer Annexure 05 for Work permit formats.
- "HSE Procedure for Work Permit System" shall be followed while implementing permit system. Where customer is having separate Work Permit System the same shall be followed.
- 11 Permit applicant shall apply for work permit of particular work activity at particular location before starting of the work with Job Hazard Analysis.
- 11 Permit signatory shall check that all the control measures necessary for the activity are in place and issue the permit to the permit holder.
- 11 Permit holder shall implement and maintain all control measures during the period of permit .He will close the permit after completion of the work. The closed permit shall be archived in HSE Department of site.

11.3 SAFETY DURING WORK EXECUTION

Respective OCPS are to be followed and adherence to the same would be contractually binding

11.3.1 WELDING SAFETY

All safety precautions shall be taken for welding and cutting operations as per IS-818. All safety precautions shall be taken for foundation and other excavation marks as per IS-3764.

11.3.2 RIGGING

Rigging equipment shall not be loaded in excess of its recommended safe working load. Rigging equipment, when not in use, shall be removed from the original work area so as not to present a hazard to employees.

11.3.3 CYLINDERS STORAGE AND MOVEMENT

All gas cylinders shall be stored in upright position. Suitable trolley shall be used. There shall be flash-back arrestors conforming to IS-11006 at both cylinder and burner ends. Damaged tube and regulators must be immediately replaced. No of cylinders shall not exceed the specified quantity as per OCP

Cylinders shall be moved by tilting and rolling them on their bottom edges. They shall not be intentionally dragged, struck or permitted to strike each other violently.

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When cylinders are transported by powered vehicle they shall be secured in a vertical position.

11.3.4 DEMOLITION WORK

Before any demolition work is commenced and also during the process of the work the following shall be ensured:

- All roads and open areas adjacent to the work site shall either be closed or suitably protected.
- No electric cable or apparatus which is liable to be a source of danger nor a cable or an apparatus used by the operator shall remain electrically charged.
- All practical steps shall be taken to prevent danger to persons employed from the risks of fire or explosion or flooding. No floor, roof or other part of the building shall be so overloaded with debris or materials as to render them unsafe.

11.3.5 T&Ps

All T&Ps/ MMEs should be of reputed brand/appropriate quality & must have valid test/calibration certificates bearing endorsement from competent authority of BHEL..Subcontractor to also submit monthly reports of T&Ps deployed and validity test certificates to BHEL safety Officer as per the format/procedure of BHEL.

11.3.6 CHEMICAL HANDLING

Displaying safe handling procedures for all chemicals such as lube oil, acid, alkali, sealing compounds etc , at work place.Where it is necessary to provide and/or store petroleum products or petroleum mixture & explosives, the subcontractor shall be responsible for carrying out such provision / storage in accordance with the rules & regulations laid down in the relevant petroleum act, explosive act and petroleum and carbide of calcium manual, published by the chief inspector of explosives of India. All such storage shall have prior approval if necessary from the chief inspector of explosives or any other statutory authority. The subcontractor shall be responsible for obtaining the same.

11.3.7 ELECTRICAL SAFETY

- Providing adequate no. of 24 V sources and ensure that no hand lamps are operating at voltage level above 24 Volts.
- Fulfilling safety requirements at all power tapping points.
- High/ Low pressure welders to be identified with separate colour clothings. No welders will be deployed without passing appropriate tests and holding valid welding certificates. Approved welding procedure should be displayed at work place.
- The subcontractor shall not use any hand lamp energized by Electric power with supply voltage of more than 24 volts in confined spaces like inside water boxes, turbine casings, condensers etc.
- All portable electric tools used by the subcontractor shall have safe plugging system to source of power and be appropriately earthed. Only electricians licensed by appropriate statutory authority shall be employed by the subcontractor to carry out all types of electrical works. Details of earth resource and their test date to be given to BHEL safety officer as per the prescribed formats of BHEL
- The subcontractor shall use only properly insulated and armored cables which conform to the requirement of Indian Electricity Act and Rules for all wiring, electrical applications at site.



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- BHEL reserves the right to replace any unsafe electrical installations, wiring, cabling etc. at the cost of the subcontractor.
- All electrical appliances used in the work shall be in good working condition and shall be properly earthed.
- No maintenance work shall be carried out on live equipment.
- The subcontractor shall maintain adequate number of qualified electricians to maintain his temporary electrical installations.
- Area wise Electrical safety inspection is to be carried out on monthly basis as per "Electrical Safety Inspection checklist" and the report is to be submitted to BHEL safety officer
- Adequate precautions shall be taken to prevent danger for electrical equipment. No materials on any of the sites of work shall be so stacked or placed as to cause danger or inconvenience to any person or the public
- The subcontractor shall carefully follow the safety requirement of BHEL/ the purchaser with the regard to voltages used in critical areas.

11.3.8 FIRE SAFETY

- Providing appropriate fire fighting equipment at designated work place and nominate a fire officer/warden adequately trained for his job.
- Subcontractor shall provide enough fire protecting equipment of the types and numbers at his office, stores, temporary structure in labor colony etc. Such fire protection equipment shall be easy and kept open at all times.
- The fire extinguishers shall be properly refilled and kept ready which should be certified at periodic intervals. The date of changing should be marked on the Cylinders.
- All other fire safety measures as laid down in the "codes for fire safety at construction site" issued by safety coordinator of BHEL shall be followed.
- Non-compliance of the above requirement under fire protection shall in no way relieve the subcontractor of any of his responsibility and liabilities to fire incident occurring either to his materials or equipment or those of others.
- Emergency contacts nos must be displayed at prominent locations
- Tarpaulin being inflammable should not be used (instead, only non-infusible covering materials shall be used) as protective cover while preheating, welding, stress relieving etc. at site.

11.3.9 SCAFFOLDING

- Suitable scaffolds shall be provided for workman for all works that cannot safely be done from the ground, or from solid construction except in the case of short duration of work which can be done safely from ladders.
- When a ladder is used, it shall be of rigid construction made of steel. The steps shall have a minimum width of 45 cm and a maximum rise of 30 cm. Suitable handholds of good quality wood or steel shall be provided and the ladder shall be given an inclination not steeper than $\frac{1}{4}$ horizontal and 1 vertical.
- Scaffolding or staging more than 3.6 m above the ground floor, swung or suspended from an overhead support or erected with stationery support shall have a guard rail properly bolted, braced or otherwise secured, at least 90 cm above the floor or platform of such scaffolding or staging and extending along the entire length of the outside and ends thereof with only such openings as may be necessary for the delivery of materials. Such scaffolding or staging shall be so fastened as to prevent it from savor, from swaying, from the building or structure.

11.3.10 WORK AT HEIGHT:

- Guardrails and toe-board/barricades and sound platform conforming to IS:4912-1978 should be provided.



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- Wherever necessary, life-line (pp or metallic) and fall arrestor along with Polyamide rope or Retractable lifeline should be provided.
- Safety Net as per IS:11057:1984 should be used extensively for prevention/ arrest of men and materials falling from height. The safety nets shall be fire resistant, duly tested and shall be of ISI marked and the nets shall be located as per site requirements to arrest or to reduce the consequences of a possible fall of persons working at different heights.
- Reaching beyond barricaded area without lifeline support, moving with support of bracings, walking on beams without support, jumping from one level to another, throwing objects and taking shortcut must be discouraged.
- Use of Rebar steel for making Jhoola and monkey-ladder (Rods welded to vertical or inclined structural members), temporary platform etc. must be avoided.
- Monkey Ladder should be properly made and fitted with cages.
- Jhoola should be made with angles and flats and tested like any lifting tools before use.
- Lanyard must be anchored always and in case of double lanyard, each should be anchored separately.
- In case of pipe-rack, persons should not walk on pipes and walk on platforms only.
- In case of roof work, walking ladder/ platform should be provided along with lifeline and/ or fall arrestor.
- Empty drums must not be used.
- For chimney or structure painting, both hanging platform and men should be anchored separately to a firm structure along with separate fall arrestor. Rope ladder should be discouraged.

11.3.11 WORKING PLATFORM

Working platforms, gangways and stairways shall be so constructed that they do not sag unduly or unequally and if the height of the platform gangways provided is more than 3.6 m above ground level or floor level, they shall be closely boarded and shall have adequate width which shall not be less than 750 mm and be suitably fenced as described above. Every opening in the floor or a building or in a working platform shall be provided with suitable means to prevent the fall of persons or materials by providing suitable fencing or railing whose minimum height shall be 90 cm.

11.3.12 EXCAVATION

Wherever there are open excavation in ground, they shall be fenced off by suitable railing and danger signals installed at night so as to prevent persons slipping into the excavations.

11.3.13 LADDER SAFETY

Safe means of access shall be provided to all working places. Every ladder shall be securely fixed. No portable single ladder shall be over 9 m in the length while the width between side rails in rung ladder shall in no case be less than app. 29.2 cm for ladder upto and including 3 m in length. For longer ladders this width shall be increased at least ¼" for each additional foot of length.

A sketch of the ladders and scaffolds proposed to be used shall be prepared and approval of the Engineer obtained prior to Construction.

11.3.14 LIFTING SAFETY

- It will be the responsibility of the subcontractor to ensure safe lifting of the equipment, taking due precaution to avoid any incident and damage to other equipment and personnel.



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- All requisite tests and inspection of handling equipment, tools & tackle shall be periodically done by the subcontractor by engaging only the Competent Persons as per law.
- Defective equipment or uncertified shall be removed from service.
- Any equipment shall not be loaded in excess of its recommended safe working load.

11.3.15 HOISTING APPLIANCE

- Motors, gearing, transmission, electric wiring and other dangerous parts of hoisting appliances should be provided with efficient safe guards.
- Hoisting appliance should be provided with such means as will reduce to the minimum the risk of any part of a suspended load becoming incidentally displaced.
- When workers employed on electrical installations which are already energized, insulating mats, wearing apparel, such as gloves, sleeves and boots as may be necessary should be provided.
- The worker should not wear any rings, watches and carry keys or other materials which are good conductor of electricity.

11.4 ENVIRONMENTAL CONTROL

Environment protection has always been given prime importance by BHEL. Environmental damage is a major concern of the principal subcontractor and every effort shall be made, to have effective control measures in place to avoid pollution of Air, Water and Land and associated life. Chlorofluorocarbons such as carbon tetrachloride and trichloroethylene shall not be used. Waste disposal shall be done in accordance with the guidelines laid down in the project specification.

Any chemical including solvents and paints, required for construction shall be stored in designated bonded areas around the site as per Material Safety Data Sheet (MSDS).

In the event of any spillage, the principle is to recover as much material as possible before it enters drainage system and to take all possible action to prevent spilled materials from running off the site. The subcontractor shall use appropriate MSDS for clean-up technique

All subcontractors shall be responsible for the cleanliness of their own areas.

The subcontractors shall ensure that noise levels generated by plant or machinery are as low as reasonably practicable. Where the subcontractor anticipates the generation of excessive noise levels from his operations the subcontractor shall inform to Construction Manager of BHEL accordingly so that reasonable & practicable precautions can be taken to protect other persons who may be affected.

It is imperative on the part of the subcontractor to join and effectively contribute in joint measures such as tree plantation, environment protection, contributing towards social upliftment, conversion of packing woods to school furniture, keeping good relation with local populace etc.

The subcontractor shall carry out periodic air and water quality check and illumination level checking in his area of work place and take suitable control measure.

11.5 HOUSEKEEPING

- Keeping the work area clean/ free from debris, removed scaffoldings, scraps, insulation/sheeting wastage /cut pieces, temporary structures, packing woods etc. will be in the scope of the subcontractor. Such cleanings has to be done by



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subcontractor within quoted rate, on daily basis by an identified group. If such activity is not carried out by subcontractor / BHEL is not satisfied, then BHEL may get it done by other agency and actual cost along with BHEL overheads will be deducted from contractor's bill. Such decisions of BHEL shall be binding on the subcontractor

- Proper housekeeping to be maintained at work place and the following are to be taken care of on daily basis.
- All surplus earth and debris are removed/disposed off from the working areas to identified locations.
- Unused/Surplus cables, steel items and steel scrap lying scattered at different places/elevation within the working areas are removed to identified locations.
- All wooden scrap, empty wooden cable drums and other combustible packing materials, shall be removed from workplace to identified locations. Sufficient waste bins shall be provided at
- Different work places for easy collection of scrap/waste. Scrap chute shall be installed to remove scrap from high location.
- Access and egress (stair case, gangways, ladders etc.) path should be free from all scrap and other hindrances.
- Workmen shall be educated through tool box talk about the importance of housekeeping and encourage not to litter.
- Labour camp area shall be kept clear and materials like pipes, steel, sand, concrete, chips and bricks, etc. shall not be allowed in the camp to obstruct free movement of men and machineries.
- Fabricated steel structures, pipes & piping materials shall be stacked properly.
- No parking of trucks/trolleys, cranes and trailers etc. shall be allowed in the camp, which may obstruct the traffic movement as well as below LT/HT power line.
- Utmost care shall be taken to ensure over all cleanliness and proper upkeep of the working areas

11.6 WASTE MANAGEMENT

Take suitable measures for waste management and environment related laws/legislation as a part of normal construction activities. Compliance with the legal requirements on storage/ disposal of paint drums (including the empty ones), Lubricant containers, Chemical Containers, and transportation and storage of hazardous chemicals will be strictly maintained.

11.6.1 BINS AT WORK PLACE

- Sufficient rubbish bins shall be provided close to workplaces.
- Bins should be painted yellow and numbered.
- Sufficient nos. of drip trays shall be provided to collect oil and grease.
- Sufficient qty. of broomsticks with handle shall be provided.
- Adequate strength of employees should be deployed to ensure daily monitoring and service for waste management.

11.6.2 STORAGE AND COLLECTION

- Different types of rubbish/waste should be collected and stored separately.
- Paper, oily rags, smoking material, flammable, metal pieces should be collected in separate bins with close fitting lids.
- Rubbish should not be left or allowed to accumulate on construction and other work places.
- Do not burn construction rubbish near working site.

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11.6.3 SEGREGATION

- Earmark the scrap area for different types of waste.
- Store wastes away from building.
- Oil spill absorbed by non-combustible absorbent should be kept in separate bin.
- Clinical and first aid waste stored and incinerated separately.

11.6.4 DISPOSAL

- Sufficient containers and scrap disposal area should be allocated.
- All scrap bin and containers should be conveniently located.
- Provide self-closing containers for flammable/spontaneously combustible material.
- Keep drainage channels free from choking.
- Make schedule for collection and disposal of waste.

11.6.5 WARNING AND SIGNS

- Appropriate sign to be displayed at scrap storage area
- No toxic, corrosive or flammable substance to be discarded into public sewage system.
- Waste disposal shall be in accordance with best practice.
- Comply with all the requirements of Pollution Control Board (PCB) for storage and disposal of hazardous waste.

11.7 TRAFFIC MANAGEMENT SYSTEM

11.7.1 SAFE WORKPLACE TRANSPORT SYSTEM

- Traffic routes in a work place shall be suitable for the persons or vehicles using them. This shall be sufficient in number and of sufficient size. This shall reflect the suitability of traffic routes for vehicles and pedestrians.
- Where vehicles and pedestrians use the same traffic routes there shall be sufficient space between them. Where necessary all traffic routes must be suitably indicated. Pedestrians or vehicles must be able to use traffic routes without endangering those at work. There must be sufficient separation of traffic routes from doors, gates and pedestrian traffic routes.
- For internal traffic, lines marked on roads / access routes and between buildings shall clearly indicate where vehicles are to pass.
- Temporary obstacles shall be brought to the attention of drivers by warning signs or hazard cones.
- Speed limits shall be clearly displayed. Speed ramps preceded by a warning signs or marker are necessary.
- The traffic route should be wide enough to allow vehicles to pass and re-pass oncoming or parked traffic and it may be advisable to introduce on-way system or parking restrictions.
- Safest route shall be provided between places where vehicles have to call or deliver.
- Avoid vulnerable areas/items such as fuel or chemicals tanks or pipes, open or unprotected edges and structures likely to collapse



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- Safe areas shall be provided for loading and unloading.
- Avoid sharp or blind bends. If this is not possible hazards should be indicated e.g. blind corner.
- Ensure road crossings are minimum and clearly signed.
- Entrance and gateways shall be wide enough to accommodate a second vehicle without causing obstruction.
- Set sensible speed limits which are clearly sign posted.
- Where necessary ramps should be used to retard speed. This shall be preceded by a warning sign or mark on the road.
- Forklift trucks shall not pass over road hump unless of a type capable of doing so.
- Overhead electric cable, pipes containing flammable hazardous chemical shall be shielded by using goal posts height gauge posts or barriers.
- Road traffic signs shall be provided on prominent locations for prevention of incidents and hazards and for quick guidance and warning to employees and public. Safety signs shall be displayed as per the project working requirement and guideline of the state in which project is done. Vehicles hired or used shall not be parked within the 15m radius of any working area. Any vehicle, that is required to be at the immediate/near the vicinity, shall be approved by the person in-charge of the site.

11.7.2 TRAFFIC ROUTE FOR PEDESTRIANS

- Where traffic routes are used by both pedestrians and vehicles road shall be wide enough to allow vehicles and pedestrians safely.
- Separate routes shall be provided for pedestrians to keep them away from vehicles. Provide suitable barriers/guard at entrances/exit and the corners or buildings.
- Where pedestrian and vehicle routes cross, appropriate crossing shall be provided.
- Where crowd is likely to use roadway e.g. at the end of shift, stop vehicles from using them at such times.
- Provide high visibility clothing for people permitted in delivery area.

11.7.3 WORK VEHICLE

Work vehicle shall be as safe stable efficient and roadworthy as private vehicles on public roads. Site management shall ensure that drivers are suitably trained. All vehicle e.g. heavy motor vehicle forklift trucks dump trucks mobile cranes shall ensure that the work equipment conforms to the following:

- o A high level of stability.
- o A safe means of access/egress.
- o Suitable and effective service and parking brakes.
- o Windscreens with wipers and external mirrors giving optimum all round visibility.
- o Provision of horn, vehicle lights, reflectors, reversing lights, reversing alarms.
- o Provision of seat belts.
- o Guards on dangerous parts.
- o Driver protection - to prevent injury from overturning and from falling objects/materials.
- o Driver protection from adverse weather.
- o No vehicle shall be parked below HT/LT power lines.
- o Valid Pollution Under Control certification for all vehicles



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11.7.4 DAILY CHECK BY DRIVER

- There should also be daily safety checks containing below mentioned points by the driver before the vehicle is used.
 - o Brakes.
 - o Tires.
 - o Steering.
 - o Mirrors.
 - o Windscreen waters.
 - o Wipers.
 - o Warning signals.
 - o Specific safety system i.e. control interlocks
- Management should ensure that drivers carry out these checks.

11.7.5 TRANSPORTATION OF PERSONNEL AND MATERIALS BY VEHICLES

- All drivers shall hold a valid driving License for the class of vehicle to be driven and be registered as an authorized BHEL driver with the Administration Department.
 - Securing of the load shall be by established and approved methods, i.e. chains with patented tightening equipment for steel/heavy loads. Sharp corners on loads shall be avoided when employing ropes for securing.
 - All overhangs shall be made clearly visible and restricted to acceptable limits
 - Load shall be checked before moving off and after traveling a suitable distance.
 - On no account is construction site to be blocked by parked vehicles Drivers of vehicles shall only stop or park in the areas designate by the stringing foreman.
 - Warning signs shall be displayed during transportation of material.
- All vehicles used by BHEL shall be in worthy condition and in conformance to the Land Transport requirement.

11.7.6 MAINTENANCE

All Vehicles used for transportation of man and material shall undergo scheduled inspections on frequent intervals to secure safe operation. Such inspections shall be conducted in particular for steering, brakes, lights, horn, doors etc. Site management shall ensure that work equipment is maintained in an efficient, working order and in good repair. Inspections and services carried out at regular intervals of time and or mileage. No maintenance shall be carried below HT/LT power lines.

11.8 EMERGENCY PREPAREDNESS AND RESPONSE

- Emergency preparedness and response capability of site shall be developed as per Emergency Preparedness and Response plan issued by Regional HQ
- Availability of adequate number of first aiders and fire warden shall be ensured with BHEL and its subcontractors
- All the subcontractor's supervisory personnel and sufficient number of workers shall be trained for fire protection systems. Enough number of such trained personnel must be available during the tenure of contract. Subcontractor should nominate his supervisor to coordinate and implement the safety measures.
- Assembly point shall be earmarked and access to the same from different location shall be shown
- Fire exit shall be identified and pathway shall be clear for emergency escape.



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- Appropriate type and number of fire extinguisher shall be deployed as per Fire extinguisher deployment plan and validity shall be ensured periodically through inspection
- Adequate number of first aid boxes shall be strategically placed at different work places to cater emergency need. Holder of the first aid box shall be identified on the box itself who will have the responsibility to maintain the same.
- First aid center shall be developed at site with trained medical personnel and ambulance
- Emergency contact numbers (format given in EPRP) of the site shall be displayed at prominent locations.
- Tie up with fire brigade shall be done in case customer is not having fire station.
- Tie up with hospital shall be done in case customer is not having hospital.
- Disaster Management group shall be formed at site
- Mock drill shall be arranged at regular intervals. Monthly report of the above to be given to BHEL safety Officer as per prescribed BHEL formats
- Mock drill shall be conducted on different emergencies periodically to find out gaps in emergency preparedness and taking necessary corrective action

12.0 HSE INSPECTION

Inspection on HSE for different activities being carried out at site shall be done to ensure compliance to HSEMS requirements. The subcontractor shall maintain and ensure necessary safety measures as required for inspection and tests HV test, Pneumatic test, Hydraulic test, Spring test, Bend test etc. as applicable, to enable inspection agency for performing Inspection. If any test equipment is found not complying with proper safety requirements then the Inspection Agency may withhold inspection, till such time the desired safety requirements are met.

12.1 DAILY HSE CHECKS

Both the Site Supervisors and safety officer of Subcontractor are to conduct daily site Safety inspection around work activities and premises to ensure that work methods and the sites are maintained to an acceptable standard. The following are to form the common subjects of a daily safety inspection:

- Personal Safety wears & gear compliance.
- Complying with site safety rules and permit-to-work (PTW).
- Positions and postures of workers.
- Use of tools and equipment etc. by the workers.

The inspection should be carried out just when work starts in beginning of the day, during peak activities period of the day and just before the day's work ends.

12.2 INSPECTION OF PPE

- PPEs shall be inspected by HSE officer at random once in a week as per format no. HSEP:14-F06 for its compliance to standard and compliance to use and any adverse observation shall be recorded in the PPE register.
- The applicable PPEs for carrying out particular activities are listed below.

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12.3 INSPECTION OF T&Ps

- A master list of T&Ps shall be maintained by each subcontractor.
- All T&Ps being used at site shall be inspected by HSE officer once in a month as per format no. HSEP:14-F07 for its healthiness and maintenance.
- The T&Ps which require third party inspection shall be checked for its validity during inspection. The third party test certificate should be accompanied with a copy of the concerned competent person's valid qualification record.
- The validity of T&P shall be monitored as per "Status of T&Ps" format no. HSEP:14-F08

12.4 INSPECTION OF CRANES AND WINCHES

- Cranes and winches shall be inspected by the operator through a daily checklist for its safe condition (as provided by the equipment manufacturer) before first use of the day.
- Cranes and Winches shall be inspected by HSE officer once in a month as per format no. HSEP:14-F09 for healthiness, maintenance and validity of third party inspection.
- The date of third party inspection and next due date shall be painted on cranes and winches.
- The operators/drivers shall be authorized by sub-contractor based on their competency and experience and shall carry the I-card.
- The operator should be above 18 years of age and should be in possession of driving license of HMV man & goods), vision test certificate and should have minimum qualification so that he can read the instructions and check list.

12.5 INSPECTION ON HEIGHT WORKING

- Inspection on height working shall be conducted daily by supervisors before start of work to ensure safe working condition including provision of
 - o Fall arrestor
 - o Lifelines
 - o Safety nets
 - o Fencing and barricading
 - o Warning signage
 - o Covering of opening
 - o Proper scaffolding with access and egress.
 - o Illumination
- Inspection on height working shall be conducted once in a week by HSE officer as per format no. HSEP:14-F10.
- Medical fitness of height worker shall be ensured.
- Height working shall not be allowed during adverse weather.

12.6 INSPECTION ON WELDING AND GAS CUTTING OPERATION

- Supervisor shall ensure that no flammable items are available in near vicinity during welding and gas cutting activity.
- Gas cylinders shall be kept upright.
- Use of Flash back arrestor shall be ensured at both ends.



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- Inspection during welding and gas cutting operations shall be carried out by HSE officer once a month as per format no. HSEP:14-F11.
- Use of fire blanket to be ensured to avoid falling of splatters during welding or gas cutting operation at height.
- Availability of fire extinguisher at vicinity shall be ensured.

12.7 INSPECTION ON ELECTRICAL INSTALLATION / APPLIANCES

- Ensure proper earthing in electrical installation
- Use ELCB at electrical booth
- Electrical installation shall be properly covered at top where required
- Use appropriate PPEs while working
- Use portable electrical light < 24 V in confined space and potentially wet area.
- Monthly inspection shall be carried out as per format no. HSEP:14-F12.

12.8 INSPECTION OF ELEVATOR

- Elevators shall be inspected by concerned supervisors once in a week as per format no. HSEP:14-F13.
- All elevators shall be inspected by competent person and validity shall be ensured.
- The date of third party inspection and next due date shall be painted on elevator.

12.9 INSPECTION OF EXCAVATION

Excavation activities shall be inspected as per Format HSEP:14-F13A

13.0 HSE PERFORMANCE

- Contractor shall be assessed on monthly basis for HSE Compliance by BHEL Safety In-charge at site. The HSE compliance shall be based on Online HSE Evaluation System of BHEL as per Format No. HSEP:14-F33.
- BHEL shall reserve the right to use this assessment for evaluating bidder's capacity for future tenders
- Suitable HSE reward system shall be developed at site level to promote HSE compliance amongst workmen by the subcontractor.
To decide HSE reward, performance towards HSE shall be evaluated for workmen and it shall be awarded regularly in public gathering.
- If safety record of the subcontractor in execution of the awarded job is to the satisfaction of safety department of BHEL, issue of an appropriate certificate to recognize the safety performance of the subcontractor may be considered by BHEL after completion of the job.

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14.0 HSE PENALTIES

- As per contractual provision HSE penalties shall be imposed on subcontractors for non-compliance on HSE requirement as per format no. HSEP:14-F14. The list in the format is only indicative. For any other violation, not listed in the format, the minimum penalty amount is to be decided as per BOCW act.
- If principal customer/statutory and regulatory bodies impose some penalty on HSE due to the non-compliance of the subcontractor the same shall be passed on to them.
- The penalty amount shall be recovered by Site Finance department from subcontractors from the RA/Final bill.

15.0 OTHER REQUIREMENTS

- In case of any delay in completion of a job due to mishaps attributable to lapses by the subcontractor, BHEL shall have the right to recover cost of such delay from the payments due to the subcontractor, after notifying the subcontractor suitably.
- If the subcontractor fails to improve the standards of safety in its operation to the satisfaction of BHEL after being given reasonable opportunity to do so and/or if the subcontractor fails to take appropriate safety precautions or to provide necessary safety devices and equipment or to carry out instruction regarding safety issued by BHEL, BHEL shall have the right to take corrective steps at the risk and cost of the subcontractor after giving a notice of not less than 7 days indicating the steps that would be taken by BHEL.
- If the subcontractor succeeds in carrying out its job in time without any fatal or disabling injury incident and without any damage to property BHEL may, at its sole discretion, favorably consider to reward the subcontractor suitably for the performance.
- In case of any damage to property due to lapses by the subcontractor, BHEL shall have the right to recover the cost of such damages from the subcontractor after holding an appropriate enquiry.
- The subcontractor shall take all measures at the sites of the work to protect all persons from incidents and shall be bound to bear the expenses of defense of every suit, action or other proceeding of law that may be brought by any persons for injury sustained or death owing to neglect of the above precautions and to pay any such persons such compensation or which may with the consent of the subcontractor be paid to compromise any claim by any such person, should such claim proceeding be filed against BHEL, the subcontractor hereby agrees to indemnify BHEL against the same.
- The subcontractor shall not employ men below the age of 18 years and women on the work of painting with products containing lead in any form. Wherever men above the age of 18 are employed on the work of lead painting, overalls shall be supplied by the subcontractor to the workmen and adequate facilities shall be provided to enable the working painters to wash during the cessation of work.
- The subcontractor shall notify BHEL of his intention to bring to site any equipment or material which may create hazard.
- BHEL shall have the right to prescribe the conditions under which such equipment or materials may be handled and the subcontractor shall adhere to such instructions.



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- BHEL may prohibit the use of any construction machinery, which according to the organization is unsafe. No claim for compensation due to such prohibition will be entertained by BHEL.

16. NON COMPLIANCE

NONCONFORMITY OF SAFETY RULES AND SAFETY APPLIANCES WILL BE VIEWED SERIOUSLY AND BHEL HAS RIGHT TO IMPOSE FINES ON THE SUBCONTRACTOR AS UNDER FOR EVERY INSTANCE OF VIOLATION NOTICED:

SN	Violation of Safety Norms	Fine (in Rs)
01	Not Wearing Safety Helmet	200/- *
02.	Not wearing Safety Belt or not anchoring life line	500/-*
03	Not wearing safety shoe	200/-*
04	Not keeping gas cylinders vertically	200/-
05	Not using flash back arrestors	100/-
06	Not wearing gloves	50/- *
07.	Grinding Without Goggles	50/- *
08.	Not using 24 V Supply For Internal Work	500/-
09.	Electrical Plugs Not used for hand Machine	100/-
10.	Not Slings properly	200/-
11.	Using Damaged Sling	200/-
12.	Lifting Cylinders Without Cage	500/-
13.	Not Using Proper Welding Cable With Lot of Joints And Not Insulated Property.	200/-
14.	Not Removing Small Scrap From Platforms	500/-
15.	Gas Cutting Without Taking Proper Precaution or Not Using Sheet Below Gas Cutting	500/-
16.	Not Maintaining Electric Winches Which are Operated Dangerously	500/-
17.	Improper Earthing Of Electrical T&P	500/-
18	No or improper barricading	500/-
19.	Activity carried out without Safety work permit (Height work, Lifting activity, Hot work-each person/case)	1000/-
20.	Incident Resulting in Partial Loss in Earning Capacity	25,000/- per victim
21.	Fatal Incident Resulting in total loss in Earning Capacity	1,00,000/- per victim for first instance #

• Legend:-

*: per head. For repeated violation by the same person, the penalty would be double of the previous penalty. Date of "Repeated violation" will be counted from subsequent days.

#: or as deducted by customer, whichever is higher. For repeated fatal incident in the same Unit incremental penalty to be imposed. The subcontractor will pay 2 times the penalty compared to previously paid in case there are repeated cases of fatal incidents under the same subcontractor for the same package in the same unit.

Any other non-conformity noticed not listed above will also be fined as deemed fit by BHEL. The decision of BHEL engineer is final on the above. The amount will be deducted from running bills of the subcontractor. The amount collected above will be utilized for giving award to the employees who could avoid incident by following safety rules. Also the amount will be spent for purchasing the safety appliances and supporting the safety activity at site.



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17.0 HSE AUDIT/INSPECTION

- Regular HSE Audit/inspection shall be carried out by Subcontractor as per Site HSE audit calendar.
- HSE checklist (**Annexure 02**) shall be used for carrying out audit/inspection and report shall be submitted to BHEL site management
- All non-conformities and observations on HSE identified during internal or external HSE audit shall be disposed off by site in a time bound manner and reported back the implementation status
- Corrective action and Preventive action on HSE issues raised by certification body issued by Regional HQs shall be implemented by site and reported to Site management.

18.0 MONTHLY HSE REVIEW MEETING

- II Site shall hold HSE review meeting every month to discuss and resolve HSE issues of site and improve HSE performance. It will also discuss the incidents occurred since previous meeting, its root cause and Corrective action and Preventive action. The agenda is given below:
 - o Implementation of earlier MOM
 - o HSE performance
 - o HSE inspection
 - o HSE audit and CAPA
 - o HSE training
 - o Health check-up camp
 - o HSE planning for the erection and commissioning and installation activities in the coming month
 - o HSE reward and promotional activities
- II The meeting shall be chaired by Construction Manager, convened by HSE coordinator and attended by all HOS, Site Incharge of Subcontractors and HSE officer of Subcontractors.
- MOM on the discussion will be circulated to the concerned for implementation.

19.0 FORMATS USED (Details available in Annexure-04)

SL. No.	Format Name	Format No.	Rev No.
01	Inspection of First Aid Box	HSEP:14-F01	00
02	Health Check Up	HSEP:14-F02	00
03	HSE Induction Training	HSEP:14-F03	00
04	Tool Box Talk	HSEP:14-F04	00
05	Monthly Site HSE Report	As specified by BHEL	00
06	Inspection of PPE	HSEP:14-F06	00



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07	Inspection of T&Ps	HSEP:14-F07	00
08	Status of T&Ps	HSEP:14-F08	00
09	Inspection of Cranes and Winches	HSEP:14-F09	00
10	Inspection on Height Working	HSEP:14-F10	00
11	Inspection on Welding & Gas Cutting	HSEP:14-F11	00
12	Inspection on Electrical Installation	HSEP:14-F12	00
13	Inspection on Elevator	HSEP:14-F13	00
14	HSE Penalty	HSEP:14-F14	00
15	Accident /incident / property damage /fire incident report	HSEP:14-F15	00



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20.0 ANNEXURES

ANNEXURE 01

As per Contract Labour (Regulation & Abolition Act), Central Rules, 1971,

- (1) The first-aid box shall be distinctively marked with a Red Cross on a white background and shall contain the following items, namely:

(a) For establishments in which the number of contract labour employed does not exceed fifty, each first aid box shall contain the following equipment:

(i)	6 small sterilized dressings
(ii)	3 medium size sterilized dressings
(iii)	3 large size sterilized dressings
(iv)	6 pieces of sterilized eye pads in separate sealed packets.
(v)	6 roller bandages 10 cm wide.
(vi)	6 roller bandages 5 cm wide.
(vii)	One tourniquet
(viii)	A supply of suitable splints
(ix)	Three packets of safety pins.
(x)	Kidney tray.
(xi)	3 large sterilized burn dressings.
(xii)	1 (30ml) bottle containing a two percent alcoholic solution of iodine
(xiii)	1 (30 ml) bottle containing Sal volatile having the dose and mode of administration indicated on the label
(xiv)	1 snake bite lancet
(xv)	1 (30gms) bottle of potassium permanganate crystals.
(xvi)	1 pair scissors
(xvii)	1 copy of the First-Aid leaflet issued by the Director General, Factory Advice Service and Labour Institutes, Government of India.
(xviii)	A bottle containing 100 tablets (each of 5 grains) of aspirin
(xix)	Ointment for burns
(xx)	A bottle of suitable surgical anti-septic solution

(b) For establishment in which the number of contract labour exceeds fifty each first-aid box shall contain the following equipment:

(i)	12 small sterilized dressings
(ii)	6 medium size sterilized dressings
(iii)	6 large size sterilized dressings.
(iv)	6 large size sterilized burn dressings
(v)	6 (15 grams) packets sterilized cotton wool
(vi)	12 pieces of sterilized eye pads in separate sealed packets.



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(vii)	12 roller bandages 10 cm wide.
(viii)	12 roller bandages 5 cm wide.
(ix)	One tourniquet.
(x)	A supply of suitable splints.
(xi)	Three packets of safety pins.
(xii)	Kidney tray.
(xiii)	Sufficient number of eye washes bottles filled with distilled water or suitable liquid clearly indicated by a distinctive sign which shall be visible at all times.
(xiv)	4 per cent Xylocaine eye drops, and boric acid eye drops and soda by carbonate eye drops.
(xv)	1 (60ml) bottle containing a two percent alcoholic solution of iodine
(xvi)	One (two hundred ml) bottle of mercurochrome (2 per cent) solution in water.
(xvii)	1 (120ml) bottle containing Sal volatile having the dose and mode of administration indicated on the label.
(xviii)	1 roll of adhesive plaster (6 cmX1 meter)
(xix)	2 rolls of adhesive plaster (2 cmX1 meter)
(xx)	A snake bite lancet.
(xxi)	1 (30 grams) bottle of potassium permanganate crystals.
(xxii)	1 pair scissors
(xxiii)	1 copy of the First-Aid leaflet issued by the Director-General, Factory Advice service and labour Institutes, Government of India.
(xxiv)	a bottle containing 100 tablets (each of 5 grains) of aspirin
(xxv)	Ointment for burns
(xxvi)	A bottle of a suitable surgical anti septic solution.

(2) Adequate arrangement shall be made for immediate recoupment of the equipment when necessary.



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ANNEXURE 02

HSE AUDIT/INSPECTION CHECKLIST CUM COMPLIANCE REPORT

PROJECT: _____

SUBCONTRACTOR: _____

DATE : _____

OWNER : _____

INSPECTION BY: _____

Note : write 'NA' wherever the items is not applicable

Item	Y e s	N o	Remarks	Action
HOUSEKEEPING				
Waste containers provided and used				
Passageways and walkways clear				
General neatness of working area				
Other				
PERSONNEL PROTECTIVE EQUIPMENTS				
Goggles; shields				
Face protection				
Hearing protection				
Respiratory masks etc.				
Safety belts				
Other				
EXCAVATIONS / OPENINGS				
Openings properly covered or barricaded				
Excavations shored				
Excavations barricaded				
Overnight lighting provided				
Other				
WELDING, CUTTING				
Gas cylinders chained upright				
Cable and hoses not obstructing				
Fire extinguisher (s) accessible				
Others				
SCAFFOLDING				
Fully decked platforms				
Guard and intermediate rails in place				
Toe boards in place				
Adequate shoring				
Adequate access				
Others				
LADDER				
Extension side rails 1 m above				
Top of landing				
Properly secured				



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Angle + 70° from horizontal				
Other				
HOISTS, CRANES AND DERRICKS				
Condition of cables and sheaf OK				
Condition of slings, chains, hooks OK				
Inspection & maintenance log maintained				
Outriggers used				
Signals observed and understood				
Qualified operators				
Others				
MACHINERY, TOOLS & EQUIPMENT				
Proper instruction				
Safety devices				
Proper cords				
Inspection and maintenance				
Other				
VEHICLE AND TRAFFIC				
Rules and regulations observed				
Inspection and maintenance				
Licensed drivers				
Other				
TEMPORARY FACILITIES				
Emergency instructions posted				
Fire extinguishers provided				
Fire-aid equipment available				
General neatness				
Others				
FIRE PREVENTION				
Personnel instructed				
Fire extinguishers checked				
No smoking in prohibited areas.				
Hydrants				
Clearance				
Others				
ELECTRICAL				
Proper wiring				
ELCB's provided				
Ground fault circuit interrupters				
Protection against damage				
Prevention of tripping hazards				
Other				
HANDLING & STORAGE OF MATERIALS				
Properly stored or stacked				
Passageways clear				
Other				
FLAMMABLE GASES AND LIQUIDS				
Containers clearly identified				
Proper storage				
Fire extinguisher nearby				



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Other				
WORKING AT HEIGHT				
Safety nets				
Safety belts				
Safety helmets				
Anchoring of safety belt to the life line rope				
ENVIRONMENT				
Lubricant waste/engine oils properly dispose.				
Waste from Canteen, offices, sanitation etc. disposed properly.				
Disposal of surplus earth, stripping materials, expired batteries, oily rags and combustible materials done properly.				
HEALTH CHECKS				
Hygienic conditions at labor camps O.K.				
Availability of first-aid facilities				
Proper sanitation at site, office & labor camps.				
Arrangement of medical facilities.				
Measures for dealing with illness.				
Availability of potable drinking water for workmen & staff.				
Provision of crèches for children.				



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ANNEXURE 03

REFERENCES

- Contract documents
- Relevant legislations
- HSEMSM
- Relevant Indian standards as listed below (illustrative only):

SL NO	CODE NAME	TITLE
(1)	IS : 818-1888 (Reaffirmed 2003)	Code of Practice for safety and health requirements in Electric and Gas Welding and Cutting operations.
(2)	IS: 1179-1967 (Reaffirmed 2003)	Specification for Equipment for Eye & Face protection during welding.
(3)	IS : 1989 (Part 2):1986 (Reaffirmed 1997)	Specification for Leather Safety Boots & Shoes
(4)	IS:2925 – 1984 (Reaffirmed 2010)	Specification for Industrial Safety Helmets
(5)	IS:3521 : 1999 (Reaffirmed 2002)	Industrial Safety Belts & Harnesses-Specification
(6)	IS:3646(Part II) – 1966 (Reaffirmed 2003)	Code of Practice for Interior Illumination
(7)	IS:3696 (Part I) – 1987 (Reaffirmed 2002)	Safety Code for Scaffolds and Ladders
(8)	IS: 3696(Part 2) : 1991 (Reaffirmed 2002)	Scaffolds and Ladders-Code of Safety
(9)	IS:3786 – 1983 (Reaffirmed 2002)	Method for Computation of Frequency and Severity Rates for Industrial Injuries and Classification of Industrial Incidents
(10)	IS:4770 : 1991 (Reaffirmed 2006)	Rubber Gloves – Electricals purposes-Specification
(11)	IS:4912 : 1978 (Reaffirmed 2002)	Safety Requirements for Floor and Wall Openings, Railings and Toe Boards
(12)	IS: 5983 – 1980 (Reaffirmed 2002)	Specification for Eye-Protectors
(13)	IS:6519 – 1971 (Reaffirmed 1997)	Code of Practice for Selection, Care and Repair of Safety Footwear
(14)	IS:9167:1979	Specification for Ear-Protectors
(15)	IS:6994(Part I)-1973 (Re affirmed 1996)	Specification for Industrial Safety Gloves Leather and Cotton Gloves
(16)	IS:8519 – 1977 (Reaffirmed 1983)	Guide for Selection of Industrial Safety Equipment for Body Protection.
(17)	IS 11006 : 2011	Flash Back(Flame Arrestor) Specification



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(18)	IS:8520 – 1977 (Reaffirmed 2002)	Guide for Selection of Industrial Safety Equipment for Eye, Face and Ear Protection.
(19)	IS:9473:2002	Respiratory Protective Devices-Filtering Half Masks to protect against Particles-Specification.
(20)	IS:9944:1992 (Reaffirmed 2003)	Natural and Man-made Fiber Rope Slings-Recommendations on Safe working loads.
(21)	IS:11057 – 1884 (Reaffirmed 2001)	Specification for Industrial Safety Nets
(22)	IS:12254:1993 (Reaffirmed 2002)	Polyvinyl Chloride (PVC) Industrial Boots-Specification
(23)	IS:13367(Part 1):1992 (Reaffirmed 2003)	Safe Use of Cranes-Code of Practice
(24)	IS:14166:1994 (Reaffirmed 2002)	Respiratory Protective Devices-Full Face Masks Specification
(25)	IS:14746 : 1999 (Reaffirmed 2003)	Respiratory Protective Devices-Half Masks and Quarter Masks - Specification
(26)	IS : 15397 :2003 (Reaffirmed 2008)	Portable Extinguisher Mechanical Foam Type(Stored Pressure)-Specification
(27)	IS: 19011:2002	Guidelines for Quality and/or Environmental Management Systems Auditing



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**ANNEXURE 04 : SAFETY FORMATS
&
ANNEXURE 05 : WORK PERMIT FORMATS**

**POWER SECTOR****INSPECTION OF FIRST AID BOX**

FORMAT NO: HSEP:14-F01

REV NO.: 00

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Name of Site :	
Name of Sub-Contractor :	
Inspected by :	
Date of Inspection :	

Number of employees on the site: - _____

Sl.No.	Item	No. Available	Remarks
1	No. of small sterilized dressings		
2	No of medium sized sterilized dressings		
3	No of large sized sterilized dressings.		
4	No of large sized sterilized burn dressings		
5	No of (15 grams) packets sterilized cotton wool		
6	No of pieces of sterilized eye pads in separate sealed packets.		
7	No of roller bandages 10 cm wide.		
8	No of roller bandages 5 cm wide.		
9	Whether tourniquet available		
10	Whether supply of Suitable splints available.		
11	No of packets of safety pins.		
12	Whether kidney tray available		
13	Whether sufficient number of eye wash bottles, filled with distilled water or suitable liquid, clearly indicated by a distinctive sign which shall be visible at all times, available.		
14	Whether 4%-xylocaine eye drops, and boric acid eye drops and soda by carbonate eye drops available.		
15	Whether (60ml) bottle containing a two percent alcoholic solution of iodine available		
16	Whether (two hundred ml) bottle of mercurochrome (2 per cent) solution in water available.		

**POWER SECTOR****INSPECTION OF FIRST AID BOX**

FORMAT NO: HSEP:14-F01

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Sl.No.	Item	No. Available	Remarks
17	Whether 120ml bottle containing Sal volatile having the dose and mode of administration indicated on the label, available.		
18	Whether roll of adhesive plaster (6 cmX1 meter) available		
19	No of rolls of adhesive plaster (2 cmX1 meter)		
20	Whether snake bite lancet available.		
21	Whether (30 grams) bottle of potassium permanganate crystals available.		
22	Whether a pair scissors available		
23	Whether copy of the First-Aid leaflet issued by the Director-General, Factory Advice service and labour Institutes, Government of India available.		
24	Whether bottle containing 100 tablets (each of 5 grains) of aspirin available		
25	Whether Ointment for burns available		
26	Whether bottle of a suitable surgical anti-septic solution available		

Signature of Subcontractor's Site I/C:

**POWER SECTOR****HEALTH CHECK UP**

FORMAT NO: HSEP:14-F02

REV NO.: 00

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Name of Site :	
Name of Sub-Contractor :	
Name of Employee :	

NAME:

History Of Past Illness	H/O Epilepsy
	H/O Drug Allergy
	H/O Diabetics/ Hypertension
	H/O Unconsciousness
Personal History	
EXAMINATION	
OBSERVATION	
<u>General Physical Examination</u>	
Height	:
Weight	:
BMI	:
Built And nourishment	:
Pallor	:
Temperature	:
Chest Expansion	: Inspiration Expansion
Lymph Node Enlargement	:
<u>Ear, Nose, Throat</u>	:
Ear	:
Nose	:
Throat	:

**POWER SECTOR****HEALTH CHECK UP**

FORMAT NO: HSEP:14-F02

REV NO.: 00

PAGE NO. 2 OF 02

EXAMINATION	OBSERVATION
<u>Cardiovascular System Examination :</u>	
Inspection :	
Palpation :	Pulse BP
Auscultation (Heart Sounds) :	
<u>Respiratory System :</u>	
Inspection :	Respiratory Rate
Palpation:	
Percussion :	
Auscultation (Breath Sounds) :	
<u>Examination of Abdomen :</u>	
Inspection :	
Palpation :	
Auscultation (Bowel Sounds) :	
Any Other :	
Clinical Impression	

Signature of the examining doctor

	POWER SECTOR	FORMAT NO: HSEP:14-F03 REV NO.: 00 PAGE NO. 01 OF 01
	HSE INDUCTION TRAINING	

Name of Site :	
Name of Sub-Contractor :	
Date :	
Name of Training Co-ordinator	

Sl No.	Name	Designation	Organisation	Signature

Signature of Training co-ordinator :

	POWER SECTOR	FORMAT NO: HSEP:14-F04 REV NO.: 00 PAGE NO. 01 OF 01
	TOOL-BOX TALK	

Name of Site :	
Sub-Contractors Name :	
Date :	

Topic	Name of person delivered Tool Box Talk	No. of Participants attended	Remarks

Signature of Site I/C of Subcontractor :

	POWER SECTOR	FORMAT NO: HSEP:14-F06 REV NO.: 00 PAGE NO. 01 OF 01
	PERSONAL PROTECTIVE EQUIPMENTS	

Name of Site :	
Name of Sub-Contractor :	
Inspected by :	
Date of Inspection :	

Item	Issued this Month	Nos. Issued up to the Month	Percentage of usage at site
Safety Helmet			
Safety Shoes			
Full Body Harness			
Fall Arrestor			
Safety Nets			
Other PPEs.			

Signature of Site I/C of Subcontractor :

	POWER SECTOR	FORMAT NO: HSEP:14-F07 REV NO.: 00 PAGE NO. 01 OF 01
	INSPECTION OF T&Ps	

Name of Site :	
Name of Sub-Contractor :	
Date of Inspection :	

Sl.No.	Description	Remarks
1.0	Name of equipment	
2.0	Basic Information of equipment	
2.1	Specification	
2.2	Sr. No. of equipment	
2.3	Make	
2.4	Year of manufacture	
3.0	Major repairs / overhauls(Furnish details of work carried out)	Date(s) of major repair/overhaul
3.1		
3.2		
3.3	Repairs carried out at site	
4.0	Any performance test conducted	Yes/No
5.0	Document Submitted	Yes/No
6.0	Manufacturer's test / guarantee certificate	Available/ Not available
7.0	Performance test	Done/ Not Done
8.0	Acceptance Norms	
9.0	Committee Observations	
10.0	Date of next review (if accepted)	

Signature-Site Safety Officer (BHEL)	Signature-Subcontractor/ Subcontractor's Safety Officer

	POWER SECTOR	FORMAT NO: HSEP:14-F08 REV NO.: 00 PAGE NO. 01 OF 01
	STATUS OF T&Ps	

Name of Site	
Name of Sub-Contractor	
Date of Inspection	

Item	Nos. Deployed	Identification No.	Nos. Tested by competent person	Validity of Test Certificate
Winches				
Chain Blocks				
Wire Rope Slings				
Man Cages				
D-Shackles				
Air Compressors				
Crawler Cranes				
Mobile Cranes				
Hydra Cranes				
Others				

Signature of Site I/C of subcontractor:

**POWER SECTOR****INSPECTION OF CRANES AND WINCHES**

FORMAT NO: HSEP:14-F09

REV NO.: 00

PAGE NO. 01 OF 03

Name of Site :	
Name of Sub-Contractor :	
Inspected by :	
Date of Inspection:	

Crane Reg. No (Make/Model)

Name of Driver/Operator

Sl.no.	Description	Observation	Measures
1	Valid Driving license		
2	Hook & Hook Latch		
3	Over Hoist limit switch		
4	Boom limit switch		
5	Boom Angle Indicator		
6	Boom limit cutoff switch		
7	Condition of Boom		
8	Condition of ropes		
9	Number of load lines		
10	Size and condition of the slings		
11	Stability of the cranes		
12	Soil Condition		
13	Swing Break And Lock		
14	Proper Break And Lock		
15	Hoist Break And Lock		
16	Boom Break And Lock		
17	Main Clutch		
18	Leakage in Hydraulic Cylinders		
19	Out riggers fully extendable		
20	Tyre pressure		
21	Condition of Battery And Lamps		

**POWER SECTOR****INSPECTION OF CRANES AND WINCHES**

FORMAT NO: HSEP:14-F09

REV NO.: 00

PAGE NO. 2 OF 03

Sl.no.	Description	Observation	Measures
22	Guards of moving and rotating parts		
23	Load chart provided		
24	Number and position of pedant ropes		
25	Reverse Horn		
26	Load Test Details		
27	Operator's fitness		
28	Pollution under control certificate		
29	Fire extinguisher of appropriate type.		
30	Training of the operator		

WINCH

Sl. No.	Description	YES	NO	NA	Remarks
1	Has the copy of Third Party Inspection certificate been provided in winch machine shed?				
2	Is winch machine operator experienced enough to operate the winch machine?				
3	Is the winch machine operated by someone other than the winch machine operator?				
4	Is there guard provided in all moving parts like wheel and motor's shaft?				
5	Will it protect against unforeseen operational contingencies?				
6	Are brakes, clutch and locking arrangement working properly?				
7	Has it been ensured that the guard does not constitute a hazard by itself?				
8	Are the cranks and the connecting rods protected by guardrails?				
9	Is there provision for fully covered shed with wooden plank roof?				

**POWER SECTOR****INSPECTION OF CRANES AND WINCHES**

FORMAT NO: HSEP:14-F09
REV NO.: 00
PAGE NO. 3 OF 03

Sl. No.	Description	YES	NO	NA	Remarks
10	Is wire rope free from any kind of damage or wear and tear?				
11	Is split pin provided for the protection of clutch and brake locking arrangement?				
12	Is pulley inspected by competent person and certified before use?				
13	Is pulley free from any wear and tear visually?				
14	Is winch rope barricaded with clipsheet for the protection of rope and person?				
15	Is the wire rope lubricated by cardium oil?				
16	Is there any friction in wire rope which may damage the wire rope rather than the rolling parts?				
17	Is there any oil leakage in the hydraulic system of the winch machine?				
18	Has it been ensured that the guard will not cause discomfort or inconvenience to operator?				
	Total Number of NO:				
	Total Number of NA:				
	% Compliance :				

Signature of Site I/C of subcontractor :

	POWER SECTOR	FORMAT NO: HSEP:14-F10 REV NO.: 00 PAGE NO. 01 OF 02
	INSPECTION OF HEIGHT WORKING	

Name of Site :	
Name of Sub-Contractor :	
Inspected by :	
Date of Inspection:	

Sl. No.	Descriptions	Observation (Yes/No)	Remarks
1	All the workers have been explained safe work method?		
2	An established communication system has been established and explained to the workers.		
3	Adequate illumination has been ensured.		
4	Work area inspected prior to the start of the work.		
5	Area below the work place barricaded, particularly below hot work.		
6	Workers provided with bags /box to carry bolts, nuts and hand tools		
7	Arrangement for fastening hand tools made.		
8	All work platforms ensured to be of adequate strength and ergonomically suitable.		
9	Fabricated makeshift arrangements are checked for quality and type of material welding, anchoring etc.		
10.	Work at more than one elevation at the same segment is restricted.		
	ACCESS/EGRESS		
1	Walkways provided with handrail, mid-rail and toe guard?		
2	All checkered plates, gratings properly welded/ bolted?		
3	Are ladders inspected and they are in good condition?		
4	Are ladders spliced?		
5	Are ladders properly secured to prevent slipping, sliding or falling?		
6	Do side rails extend 36" above top landing?		
7	Are built up ladders constructed of sound materials?		



POWER SECTOR

INSPECTION OF HEIGHT WORKING

FORMAT NO: HSEP:14-F10

REV NO.: 00

PAGE NO. 02 OF 02

Sl. No.	Descriptions	Observation (Yes/No)	Remarks
8	Are rugs and cleats not over 12" on center?		
9	Metal ladders not used around electrical hazards.		
10	Proper maintenance and storage.		
11	Ladders placed at right slope.		
12	Ladders / staircases welded/ bolted properly.		
13	Any obstruction in the stairs.		
14	Are landing provided with handrails, knee rails, toe boards etc.?		
15	Whether ramp is provided with proper slope.		
16	Proper hand rails / guards provided in ramps.		
	Housekeeping		
1	Walkways, aisles & all overhead workplaces cleared of loose material.		
2	Flammable materials, if any, are cleared.		
3	All the de shuttering materials are removed after de shuttering is done.		
4	Platforms and walkways free from oil/grease or other slippery material.		
5	Collected scrap are brought down or lowered down and not dropped from height.		
	PPE And Safety Devices		
1	Use of safety helmet, safety belts ensured for all workers		
2	Anchoring points provided at all places of work.		
3	Common lifeline provided wherever linear movement at height is required.		
4	Safety nets are use wherever required.		
5	Proper fall arrest system is deployed at critical workplaces.		
6	Crawler boards/Safety system or works on fragile roof are used.		

Signature of Site I/C of subcontractor :

**POWER SECTOR****INSPECTION OF WELDING AND GAS
CUTTING**

FORMAT NO: HSEP:14-F11
REV NO.: 00
PAGE NO. 1 OF 02

Name of Site	
Name of Sub-Contractor	
Inspected by	
Date of Inspection	

Welding				
Sl.no.	Description	Y e s	N o	Remarks
1	Is electric connection given through 30 mA ELCB/RCCB to welding m/c?			
2	Is electric cable fitted properly in junction box on m/c?			
3	Is electrical cable free from joints?			
4	Are the joints attached firmly & insulated with tape?			
5	Is double earthing given to body of m/c?			
6	Is the physical condition of the m/c good?			
7	Is ON/OFF switch connected to the m/c is working and in good condition?			
8	Are indication lamps on m/c working?			
9	Is the electrode holder in good condition?			
10	Are the cables of the welding m/c lugged & tight properly?			
11	Are return lead connected properly (Rod, Angle, Channels shall not be used)			
	Total No of NO			
	Total No of YES			

**POWER SECTOR****INSPECTION OF WELDING AND GAS
CUTTING**

FORMAT NO: HSEP:14-F11
REV NO.: 00
PAGE NO. 2 OF 02

Gas Cutting				
Sl. no	Description	Yes	No	Remarks
1	Are Cylinders kept on trolleys?			
2	Physical condition of Gas cylinders Good?			
3	Is there Oil/Grease on valve of the cylinder?			
4	Are pressure regulators in good condition?			
5	Condition of hose pipe OK?			
6	Are hose pipe clamped with hose clip?			
7	Is flash back arrestor & NRV fitted on torch both for O2 and LPG cylinder?			
8	Is nozzle of the torch cleaned?			
	Total Number of NO			
	Total No of YES			
	% Compliance			

Signature of Site I/C of subcontractor :

	POWER SECTOR	FORMAT NO: HSEP:14-F12 REV NO.: 00 PAGE NO. 01 OF 02
	INSPECTION OF ELECTRICAL INSTALLATION	

Name of Site	
Name of Sub-Contractor	
Inspected by	
Date of Inspection:	

Sr. No.	Contents	Yes/No	Remarks
A	Cable		
1.	Whether the condition of cable is checked?		
2.	Are cables received from other sites checked for insulation resistance before putting them into use?		
3.	Are all main cables taken either underground / overhead?		
4.	Are welding cables routed properly above the ground?		
5.	Are welding and electrical cables overlapping?		
6.	Is any improper joining of cables/wires prevailing at site?		
B	DBs/SDBs		
1.	Is earth conductor continued up to DB / SDB?		
2.	Whether DBs and extension boards are protected from rain / water?		
3.	Is there any overloading of DBs / SDBs?		
4.	Are correct / proper fuses & CBs provided at main boards and sub-boards?		
5.	Is energized wiring in junction boxes, CB panels & similar places covered all times?		
C	ELCB		
1.	Whether the connections are routed through ELCB?		
2.	Is ELCB sensitivity maintained at 30 mA?		

**POWER SECTOR****INSPECTION OF ELECTRICAL INSTALLATION**

FORMAT NO: HSEP:14-F12

REV NO.: 00

PAGE NO. 02 OF 02

Sr. No.	Contents	Yes/No	Remarks
3.	Are the ELCB numbered and tested periodically & test results recorded in a logbook countersigned by a competent person?		
D	Grounding		
1.	Is natural earthing ensured at the source of power (main DB at Generator or Transformer)?		
2.	Whether the continuity and tightness of the earth conductor are checked?		
3.	Mention the gauge of the earth conductor used at the site.		
4.	Mention the value of Earth Resistance.		
E	Electrically operated Machines or Accessories.		
1.	Whether the plug top is provided everywhere.		
2.	Are all metal parts of electrical equipment and light fittings / accessories grounded?		
3.	Is there any shed or cover for welding machines?		
4.	Are halogen lamps fixed at proper places?		
5.	Are portable power tools maintained as per norms?		
6.	Any other information:		

Signature of Site I/C of subcontractor :

**POWER SECTOR****INSPECTION OF ELEVATOR**

FORMAT NO: HSEP:14-F13

REV NO.: 00

PAGE NO. 01 OF 01

Name of Site	
Name of Sub-Contractor	
Inspected by	
Date of Inspection	

Sr. No.	Description	Remarks
1.0	Name of equipment	
2.0	Basic Information of equipment	
2.1	Specification	
2.2	Sr. No. of equipment	
2.3	Make	
2.4	Year of manufacture	
3.0	Major repairs/overhauls(Furnish details of work carried out)	Date(s) of major repair/overhaul
3.1		
3.2		
3.3	Repairs carried out at site	
4.0	Any performance test conducted	Yes/No
5.0	Document Submitted	Yes/No
6.0	Manufacturer's test / guarantee certificate	Available/ Not available
7.0	Performance test	Done/ Not Done
8.0	Acceptance Norms	
9.0	Committee Observations	
10.0	Date of next review (if accepted)	

Signature-Subcontractor/ Subcontractor's
Safety Officer

Signature-Site Safety Officer (BHEL)

	POWER SECTOR	FORMAT NO: HSEP:14-F13E REV NO.: 00 PAGE NO. 01 OF 01
	Inspection of Excavation	

Name of Site :	
Name of Sub-Contractor :	
Inspected by :	
Date of Inspection :	

Sl.no.	Description	Yes	No	Remarks
1	Precautions taken for Underground Electrical Cable			
2	Precautions taken for Under / Above ground sewer/ Drinking Water Line			
3	Precautions taken for Underground Telecommunication Line			
4	Precautions taken for Underground Product/Utility Line			
5	Precautions taken for Underground Fire Water Line			
6	Shoring / Shuttering / Sheet piling done to prevent collapse of excavation walls. Strength of Excavation wall ensured at all times			
7	Slope Cutting / Angle Maintained			
8	Hard Barricading & Edge Protection provided			
9	Separate Safe Access for Man and Vehicle			
10	Lighting arrangement			
11	Banksman Provided			
12	Required basic PPEs provided			
13	Excavated soil / Construction Material / equipment kept away from the edge.			
14	First aid in attendance.			
15	Other:			
	Total No of YES			

Signature-Subcontractor/ Subcontractor's Safety Officer

Signature-Site Safety Officer (BHEL)

**POWER SECTOR****HSE PENALTY**

FORMAT NO: HSEP:14-F14

REV NO.: 00

PAGE NO. 1 OF 02

Sub: MEMO for Penalty for non-compliances in Safety

Following lapse (tick marked) was observed and penalty is imposed as stated at the bottom of this memo. It is requested that such occurrences be please avoided in future.

Safety Area

SN	Violation of Safety Norms	Fine (in Rs)
01.	Not Wearing Safety Helmet	200/- *
02.	Not wearing Safety Belt or not anchoring life line	500/-*
03.	Not wearing safety shoe	200/-*
04.	Not keeping gas cylinders vertically	200/-
05.	Not using flash back arrestors	100/-
06.	Not wearing gloves	50/- *
07.	Grinding Without Goggles	50/- *
08.	Not using 24 V Supply For Internal Work	500/-
09.	Electrical Plugs Not used for hand Machine	100/-
10.	Not Slings properly	200/-
11.	Using Damaged Sling	200/-
12.	Lifting Cylinders Without Cage	500/-
13.	Not Using Proper Welding Cable With Lot of Joints And Not Insulated Property.	200/-
14.	Not Removing Small Scrap From Platforms	500/-
15.	Gas Cutting Without Taking Proper Precaution or Not Using Sheet Below Gas Cutting	500/-
16.	Not Maintaining Electric Winches Which are Operated Dangerously	500/-
17.	Improper Earthing Of Electrical T&P	500/-
18.	No or improper barricading	500/-
19.	Activity carried out without Safety work permit (Height work, Lifting activity, Hot work-each person/case)	1000/-
20.	Incident Resulting in Partial Loss in Earning Capacity	25,000/- per victim
21.	Fatal Incident Resulting in total loss in Earning Capacity	1,00,000/- per victim for first instance #

Legend: -

*: per head. For repeated violation by the same person, the penalty would be double of the previous penalty. Date of "Repeated violation" will be counted from subsequent days.

#: or as deducted by customer, whichever is higher. For repeated fatal incident in the same Unit incremental penalty to be imposed. The subcontractor will pay 2 times the penalty compared to previously paid in case there are repeated cases of fatal incidents under the same subcontractor for the same package in the same unit.

1 Copy to Site Construction Manager (BHEL)

	POWER SECTOR- HQ	FORMAT NO: HSEP:14-F15 REV NO.: 00 PAGE NO. 01 OF 01
	Incident Report (To be submitted within 24 hours of time of incident)	

Type of incident: Fatal/Major/ Minor/Fire/Property Damage/Near-miss

1	NAME OF SITE		3	ACTIVITY AREA	
2	SCOPE OF WORK		4	NAME OF CONTRACTOR	
			5	NAME & DESIGNATION OF BHEL ACTIVITY I/C	
6	DATE & TIME OF ACCIDENT		7	DATE RESUMED	
8	NO. OF WORK-DAYS LOST BY VICTIM (If duty not resumed, give estimated figure)				
9	NO. OF MANHOURS LOST BY OTHERS				
10	PERSONAL DETAILS OF INJURED AND / OR DETAILS OF MATERIALS / EQUIPMENT / PROPERTY DAMAGED				
NAME			NAME OF MATERIAL / EQUIPMENT / PROPERTY		
PERIOD OF EMPLOYMENT					
AGE	YRS	SEX	MALE/ FEMALE	ESTIMATED COST	ACTUAL COST
MARITAL STATUS		SINGLE / MARRIED			
OCCUPATION		NATURE OF DAMAGE			
PART OF BODY INJURED					
NATURE OF INJURY					
AGENCY (OBJECT / EQUIPMENT / SUBSTANCE) MOST RESPONSIBLE FOR CAUSING ACCIDENT / INJURY / DAMAGE					
12	PERSON (NAME & DESIGNATION) WITH MOST CONTROL OVER AGENCY (OBJECT / EQUIPMENT / SUBSTANCE) CAUSING ACCIDENT INJURY / DAMAGE				
13	DESCRIBE CLEARLY HOW THE ACCIDENT OCCURRED (USE ADDITIONAL SHEET, IF REQUIRED)				
ANALYSIS					
14	WHAT ACTS AND / OR CONDITIONS CONTRIBUTED MOST DIRECTLY TO THIS ACCIDENT				
15	WHAT ARE THE BASIC REASON FOR THE EXISTENCE OF THESE ACTS AND / OR CONDITION ?				
16	WHAT CORRECTIVE ACTIONS HAVE BEEN TAKEN TO PREVENT ACCIDENT RECURRENCE ?				
	DATE :		SIGNATURE OF SITE HSE COORDINATOR		
17	COMMENTS OF HEAD / SOX				
	DATE:		SIGNATURE OF HEAD/SOX		



POWER SECTOR

Format for Monthly HSE Planning & Review

FORMAT NO: HSEP:14-F30

REV NO.: 00

PAGE NO. 01 OF 3

Note: This is a template and can be modified in consultation with BHEL

Name of the Site		Name of the Subcontractor	
Scope of Work		Date	
PART- A: PLAN OF HSE ACTIVITIES FOR THE MONTH OF.....		PART-B: REVIEW ON	
SN.	Description of HSE Activity & Formats	Plan & Targets for the month	Review
1	Availability of First Aid Box at Required Places and Inspection thereof as per Format: Fo1	Areas 1.	
2	Health check-up as per Format: Fo2	Health check-up for Nos 1. New inductees 2. Drivers & Operators 3. Workers in following high risk areas: a. ...	
3	Induction training of newly joined workers as per Format: Fo3	Minimum No. of workers:	
4	Toolbox talks (TBT) conducted before start of work as per Format: Fo4	Locations of TBTs & No. of workers 1. ...	
5	PPE usage and issue as per Format: Fo6		
6	Inspection of T&Ps as per Format: Fo7	List of T&Ps to be inspected 1.	
7	Identification & Inspection Status of T&Ps as per Format: Fo8		
8	Inspection of Cranes & Winches as per Format: Fo9	List of Cranes & Winches & Nos. 1. ...	
9	Inspection of Height Working as per Format: F10	Areas: 1. ...	
10	Inspection of Welding & Gas Cutting operations as per Format: F11	Areas: 1. ...	
11	Inspection of Electrical Installations as per Format: F12	Locations: 1. ...	
12	Inspection of Elevators (as applicable) as per Format: F13	Locations: 1. ...	
13	Inspection of Excavation as per Format: F13E	Locations: 1. ...	



POWER SECTOR

Format for Monthly HSE Planning & Review

FORMAT NO: HSEP:14-F30

REV NO.: 00

PAGE NO. 02 OF 3

SN.	Description of HSE Activity & Formats	Plan & Targets for the month	Review
14	Job Safety Analysis as per Format F32B	Activities: 1. ...	
15	Regular Job Specific Training (Re-training) for workers involved in hazardous activities	Topics/ Hazards & No. of workers 1. ...	
16	Mass housekeeping (HK) drive in work areas	Areas 1. ...	
17	Vertigo Test of Height workers	Minimum No. of workers:	
18	Deployment of qualified HSE Officers as per contract	Location(s) & Nos. 1. ...	
19	Deployment of qualified HSE Stewards as per contract	Location(s) & Nos. 1. ...	
20	Deployment of Safety tools & Equipment (Safety Nets, Lifelines, Fall arrestors, Man-cages, flashback arrestors, scaffolding etc.)	Tool/ Equipment & Location 1. ...	
21	Safety Walks by site in charge of agency (4 -Weekly once)	Dates:	
22	Safety walks by departmental head (8-Weekly twice)	Dates:	
23	Availability/ deployment of Safety posters/ placards/ signage at strategic locations	Locations: Nos. 1. ...	
24	Provision of clean drinking water sources for workers	Locations: Nos. 1. ...	
25	Provision of toilets for workers (separate for male & female workers)	Locations: Nos. 1. ...	
26	Rest sheds for workers during lunchtime, rain, dust storm etc.	Locations: Nos. 1. ...	
27	Availability of following in Labor colony	1. Clean drinking water 2. Toilets 3. Cleanliness & Hygiene 4. Grass cutting, 5. Fogging 6. Electrical Inspection ...	

	POWER SECTOR		FORMAT NO: HSEP:14-F30 REV NO.: 00 PAGE NO. 03 OF 3
	Format for Monthly HSE Planning & Review		
SN.	Description of HSE Activity & Formats	Plan & Targets for the month	Review
28	Availability of dust/ waste bins at various locations	Locations: 1. ...	
29	Availability of Ambulance (individual/ joint) in each shift	Ambulance No.	
30	Availability of emergency vehicle in each shift	Emergency vehicle	
31	Deployment/ Availability of tested Fire Extinguishers	Locations & Nos. 1. ...	
32	Tree plantation	Locations & Nos. 1. ...	
33	Waste disposal & Scrap Bins	Locations 1. ...	
34	Illumination checks	Locations 1. ...	
35	Safety award function: 1. Display of good practices Award presentation	Minimum 1 per month	
36	Submission of Daily Reports as per Format No.F31A	Daily Reports (Night & Day Shifts)	

PLAN		REVIEW	
<u>Agency</u> Name:	<u>BHEL</u> Name:	<u>Agency</u> Name:	<u>BHEL</u> Name:
Sign:	Sign:	Sign:	Sign:
Date:	Date:	Date:	Date:



	POWER SECTOR	FORMAT NO: HSEP:14-F31 A REV NO.: 00 PAGE NO. 01 OF 1
	Format for Daily HSE Reporting	

	POWER SECTOR	FORMAT NO: HSEP:14-F31 A REV NO.: 00 PAGE NO. 01 OF 1
	Format for Daily HSE Reporting	

	POWER SECTOR	FORMAT NO: HSEP:14-F31 A REV NO.: 00 PAGE NO. 01 OF 1
	Format for Daily HSE Reporting	

	POWER SECTOR	FORMAT NO: HSEP:14-F31 A REV NO.: 00 PAGE NO. 01 OF 1
	Format for Daily HSE Reporting	

	POWER SECTOR	FORMAT NO: HSEP:14-F31 A REV NO.: 00 PAGE NO. 01 OF 1
	Format for Daily HSE Reporting	

	POWER SECTOR	FORMAT NO: HSEP:14-F31 A REV NO.: 00 PAGE NO. 01 OF 1
	Format for Daily HSE Reporting	

Night		Day	SHIFT	Year	Site
			Submitted By		
			Work Area(s)		
			Staff		
			Man-Power		
			Safety Officers		
			Safety Stewards		
			Tool Box (Topics and No. of Participants)		
			Induction Training (No. of Participants)		
			Vertigo Test (Numbers Tested)		
			On-the-Job Training (Topic & participants)		
			Work Permits		
			Job Safety Analyses conducted		
			Height Work Inspection		
			Other Hazardous Activities Inspection		
NA			T&P Inspection (Names & Nos. Inspected)		
			Safety Walk (Designation, Areas)		
NA			HSE Meeting		
NA			Safety Reward (Details)		
NA			Housekeeping/ Dust Suppression/ Tree Plantation Activities (Locations/Details)		
			Lost time Accident		
			Restricted Work Case		
			Medical Treatment Case		
			First Aid Case		
			Near miss		
			Property Damage/ Fire		
			Non-Compliances Submitted by BHEL		
			Complied by Agency		
			Any other Remarks/ Inputs		



POWER SECTOR

Job Safety Analysis Format

FORMAT NO: HSEP:14-F32B

REV NO.: 00

PAGE NO. 01 OF 1

Name of the Site	
Name of the Subcontractor	
Activity, Area	

HAZARDS				PRECAUTIONS	

(Name)	Submitted By (Agency HSE)		Reviewed By (BHEL Execution)		Approved By (BHEL HSE)	
(Sign)						
(Date)						

**POWER SECTOR- HQ**

FORMAT NO: HSEP:14-F33

REV NO.: 00

PAGE NO. 01 OF 3

Checklist for Evaluation of HSE Performance

SL	Parameter for Measurement	M/ O	Wt	Supporting Documents
1a	Induction training for new workers conducted through audio-visual medium & documented ?	M	1	Induction Training Records
1b	Tool box talk conducted regularly as per plan, and documented?	M	1	Toolbox Talk Records
1c	Contractor in charge and safety in charge attended safety meetings?	M	2	Minutes of Meeting
1d	Whether observations in safety meetings are complied before next meeting?	M	2	-do-
1e	Preparation and submission of Monthly HSE report within stipulated time	M	1	Report submission date
1f	Preparation and submission of Incident/near-miss report and RCA Report (as applicable) within stipulated time	M	1	Incident/ Near Miss Records
1g	Carrying out Inspections and submission of Inspection reports within stipulated time	M	1	Inspection Records
1h	Regular Job Specific Training ensured for High Risk Workers (through audio-visual medium) as per plan	M	1	Training & Attendance Records
2a	Whether the contractor is registered under BOCW	M	2	BOCW Registration Certificate
2b	Availability of Qualified safety officer (1 for every 500 labour)	M	2	Safety Officer qualification & experience records
2c	Availability of Qualified safety supervisor (1 for every 100 labour)	M	2	Safety Officer qualification & experience records
2d	All the workers are provided and using safety helmets and safety shoes/gum boots	M	2	PPE Issue Records, Inspection/ non-conformity records
2e	Housekeeping done on regular basis and scrap removal at site	M	1	Housekeeping records, Inspection/ non-conformity records
2f	Usage of Goggles/Face shields and Hand gloves for gas cutter and grinders		1	PPE Issue Records, Inspection/ non-conformity records
2g	Wall openings & floor openings are guarded?		1	Inspection/ non-conformity records
2h	Adequate illumination provided in all working area?		1	Inspection/ non-conformity records
2i	Safety posters, sign boards and emergency contact numbers in all prominent location are displayed?		1	Inspection/ non-conformity records
2j	Availability of automatic reverse horns, Main horn, hook latches for Vehicles, mobile cranes, Hydras		1	Inspection/ non-conformity records
2k	Ban of carrying mobile phones to work place is implemented for workers		1	Inspection/ non-conformity records
2l	Availability of Tags & Inspection Certificates for Cranes of all capacities		1	Master T&P List with internal & external test details
2l.2	Availability of Tags & Inspection Certificates for Winches of all capacities		1	Master T&P List with internal & external test details
2l.3	Availability of Tags & Inspection Certificates, color coding for Chain pulley blocks		1	Master T&P List with internal & external test details
2l.4	Availability of Tags & Inspection Certificates for Vehicles - Trailers, Dozers, Dumpers, Excavators. Mixers etc.		1	Master T&P List with internal & external test details
2l.5	Availability of Tags & Inspection Certificates for Welding machines, grinders, Drilling machines, etc.		1	Master T&P List with internal & external test details
2l.6	Availability of Tags & Inspection Certificates, colour coding for Wire rope slings etc.		1	Master T&P List with internal & external test details
2l.7	Availability of Tags & Inspection Certificates for Batching plants		1	Master T&P List with internal & external test details

**POWER SECTOR- HQ**

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Checklist for Evaluation of HSE Performance

SL	Parameter for Measurement	M/ O	Wt	Supporting Documents
2m.1	Use of Lifting Permit as per requirement		1	Permit Records
2m.2	Use of Height Permit as per requirement		1	Permit Records
2m.3	Use of Hot Work Permit as per requirement		1	Permit Records
2m.4	Use of Excavation permit as per requirement		1	Permit Records
2m.5	Use of Confined space work permit as per requirement		1	Permit Records
2m.6	Use of Grating removal and safety net removal permit as per requirement		1	Permit Records
2m.7	Use of Lockout-Tag out permit as per requirement		1	Permit Records
2m.8	Use of Radiography permit as per requirement		1	Permit Records
2m.9	Use of Night/ Holiday Work Permit as per requirement		1	Permit Records
2m.10	Use of Any other Applicable Permit as per requirement		1	Permit Records
3a	Material safety data sheet(MSDS) available for all chemicals and displayed in usage and storage area?		1	Inspection/ non-conformity records
3b	Spillages of oil/concrete and other chemical is controlled and cleaned by proper method in case of spill?		1	Inspection/ non-conformity records
3c	Availability of adequate number of urinals in workplace and in elevations and maintained	M	1	
3d	Availability of rest rooms for workers at site	M	1	
3e	Availability of Drinking water facility at work spot		1	
3f	Hygienic Labour colony is provided for workers.		1	
4a	Is heavy/complex critical lifting permit obtained for heavy, complex materials before handling/erection activity?		1	Work Permit records
4b	Whether area below lifting activities barricaded		1	Inspection/ non-conformity records
4c	Availability of experienced rigging foreman		1	Experience details of rigging foreman
4d	Is agency is following proper storage and handling procedure as per manufacturer standard for all hazardous material?		1	Procedure for storage & handling
4e	Are oxygen and acetylene cylinders are transported to work place from storage area in trolleys		1	
5a	Whether all deep excavation has been protected by barrier		1	Inspection/ non-conformity records
5b	Sloping/benching & shoring provided for excavation as per requirement?		1	-do-
5c	Proper access and egress provided for excavations?		1	-do-
5d	Blasting is done in controlled manner?		2	-do-
6a	Whether Electrical booth is equipped with Co ₂ fire extinguishers and fire buckets filled with sand?		2	Inspection/ non-conformity records
6b	Availability of Illumination lamp in electric booth?		1	-do-
6c	whether Caution Boards have been displayed?		1	-do-
6d	Usage of Metal Plug top for all hand power tools ?		1	-do-
6e	Usage of Insulated welding cables.		1	-do-
6f	Electrical Booth/Distribution Board to be covered by proper Canopy.		1	-do-
6g	Availability of functional & individual 30mA ELCB / RCCB and MCB for protection and conducting periodical check-up?		1	-do-
6h	Double earthing for panel boards and all machinery & proper earth pit with regular inspection available?		1	-do-
6i	Whether Electrician is qualified and experienced		1	Qualification & Experience records of electrician
6j	Availability and usage of Rubber hand gloves by electrician?		1	Inspection/ non-conformity records

**POWER SECTOR- HQ****Checklist for Evaluation of HSE Performance**

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SL	Parameter for Measurement	M/ O	Wt	Supporting Documents
7a	Whether Scaffolding pipes made with steel or aluminum, are being used and checked periodically by experienced/ certified scaffolder?		2	Inspection/ non-conformity records
7b	8mm Stainless Steel wire rope with plastic cladding is provided for life line (Vertical / Horizontal) during height work?		2	-do-
7c	Availability of emergency lighting in case of power failure		1	-do-
7d	Whether all the openings are covered with Safety Nets made of fire proof Nylon?		1	-do-
7e	Whether MS pipe rails around staircases & platforms in usage are provided with top, middle rails and toe guard ?		1	-do-
7f	Whether Ladder with vertical life line /Fall arrestor is available to climb?		1	-do-
7g	Whether all workers deployed for working at height have been issued height pass after undergoing vertigo test?		1	Height Pass records
7h	Whether all workers deployed for height work / climbing ladder are provided and using Double lanyard safety belt?		1	PPE Issue records, inspection/ non-conformity reports
7i	Is all hand tools/Small material used by height workers is tied firmly to prevent fall?		1	-do-
8a	Flash back arrestors for all gas cutting sets is available on Torch side and cylinder side		1	Inspection/ non-conformity records
8b	Oxygen/Acetylene/LPG cylinders not in use have caps in place and stored separately?		1	-do-
8c	Availability of Face screen, Hand gloves, and Apron, for welders		1	-do-
8d	Protection from falling hot molten metal during metal cutting / welding at height by providing GI sheet below the cutting area especially in fire prone areas		1	-do-
9a	Pre-employment medical check-up done for all workers and submitted?		1	Medical check records
9b	Availability of first aid center, with MBBS doctor(Own or Sharing basis)	M	2	Attendance records
9c	Availability of Ambulance facility 24 hours (Own or sharing basis)	M	2	-do-
9d	Is First aid trained personnel's are available and their names are displayed at site?	M	1	-do-
9e	Availability of Emergency vehicle at site		1	
9f	Periodical medical check-up is conducted for all the workers and submitted?		1	Medical check records
9g	Availability of sufficient number of first aid box as per standard list and maintaining record		1	Inspection records
10a	Availability of Fire extinguishers, buckets at all vulnerable points		2	Fire extinguisher records
10b	Periodic fire mock drill conducted?		1	Fire, Mock drill records
10c	Are all flammable materials are stored separately?		1	
10d	Periodic grass cutting is done in material storage area?		1	
10e	Availability of 24V DC lighting in confined space work area		1	
10f	Availability of exhaust fan in confined space work area		1	

Note:

- **M: Mandatory; O: Optional.** Points other than mandatory can be excluded with appropriate justification (scope etc.) by BHEL
- Additionally: 30 Marks for each Fatal Accident and 10 mark for each major accident shall be deducted.



SAFETY WORK CLEARANCE

Permit no. _____

Project: _____

Emergency Contact Nos: _____

Subcontractor: _____

BURNING/WELDING /HOT WORK PERMIT

Area : _____ Date: _____ Time: _____

Name of Site Engineer (Permit Requesting Authority): _____ Sign: _____

Name of Work Performing Contractor: _____

Name of Package In charge: _____ Sign: _____ Date: _____

Description of Work: _____

Work Execution Date: _____ Time Valid from: _____ to _____

The above signing person(s) will be responsible to ensure that the above described work will be done under all the safety precautions mentioned on the permit to work.

The following precautions are to be taken:

No.	Item	Yes	Not required
1.	Proper Access/Exit available		
2.	Proper ventilation and /or lighting provided.		
3.	Proper and safe scaffolding, platform, ladder provided.		
4.	Welding machine located in a clean and dry area.		
5.	Welding machine grounded at the equipment and proper leakage current protection device (ELCB) provided for welding machine.		
6.	Emergency STOP buttons are in working condition. Welder /Helper knows how to operate it.		
7.	Welding machine input/output cables, welding holder and weld return clamp (Holder) are insulated and in good condition.		
8.	Welder & Fitter trained to connect ground/work return clamps (Holder) to work place prior to energization of welding machine.		
9.	Gas cylinders are stacked vertically and not below the welding / cutting area. Regulator key is available with cylinder.		
10.	Pressure gauges/Flash back arrestor provided and in working condition.		
11.	Personal Protective equipment Minimum applicable: safety helmet, safety goggles, welding helmet, safety shoes, leather gloves, long sleeve and nose mask -provided		
12.	In case of pits, water removed from the pit and wood/rubber insulation provided.		
13.	Safety signboards are in place.		
14.	Adequate and Suitable nos. of fire fighting extinguisher provided.		
15.	Nearby combustible material removed. Housekeeping done.		
16.	Other		

Name of Contractor Safety Officer: _____ Sign: _____ Date: _____ Time: _____

Reviewed and approved by BHEL Site Engineer (Permit Issuing Authority):

Name: _____ Sign: _____ Date: _____ Time: _____

Name of BHEL Safety Representative: _____ Sign: _____

I understand the precaution to be taken as described above and as per project requirement and hereby confirm that work will be executed under my supervision by following all precaution and Safety Rules.

Name of Work Performing Authority: _____ **Sign:** _____ **Date:** _____ **Time:** _____**Permit Cancellation:**

I hereby declare that the work is complete, all workers under my control have been withdrawn and the site restored to safe tidy condition.

Name of Work performing Authority: _____ Sign: _____ Date: _____ Time: _____

Name of Site Engr. (Permit Requesting Authority): _____ Sign: _____ Date: _____ Time: _____

Name of BHEL Site Engr. (Permit Issuing Authority): _____ Sign: _____ Date: _____ Time: _____

(This permit is valid only for the date it is issued)

Original at BHEL site

Second Copy – BHEL SAFETY

Third Copy : Contractor



SAFETY WORK CLEARANCE

Permit no. _____

Project: _____

Emergency Contact Nos: _____

Subcontractor: _____

LIFTING ACTIVITY PERMIT

Area : _____ Date: _____ Time: _____

Name of Site Engineer (Permit Requesting Authority): _____ Sign: _____ Name of Work

Performing Contractor: _____

Name of Package In charge: _____ Sign: _____ Date: _____

Description of Work: _____

Work Execution Date: _____ Time Valid from: _____ to _____

The above signing person(s) will be responsible to ensure that the above described work will be done under all the safety precautions mentioned on the permit to work.

The following precautions are to be taken:

No.	Item	Yes	Not required
1.	Crane used for lifting activity tested, certified and approved for rated lifting		
2.	All lifting tackles, gears/appliances are tested and certified for lifting works.		
3.	Crane operator is trained and competent for lifting operation.		
4.	Lifting sling/ belt is protected against sharp edge of the jobs to be lifted.		
5.	Access and exit marked and without obstruction.		
6.	Lifting arrangement adequate.		
7.	Unwanted rubbish material removed from work platform.		
8.	Minimum 2 guidelines have been provided for balancing and guiding jobs to be lifted.		
9.	Periphery area of crane booms as well as lifting job is barricaded and unauthorized/no-entry sign board posted.		
10.	Rigger and signal man is trained and competent for lifting work.		
11.	No lifting activity to be carried out during lightening, heavy wind/rain.		
12.	If scaffolding to be used during lift, scaffolding with valid tag available for use.		
13.	Double lanyards safety harness/belt checked and in working condition.		
14.	Safety shoes (non-slip), helmet with chin strap available with employees.		
15.	Others.		

Name of Contractor Safety Officer: _____ Sign: _____ Date: _____ Time: _____

Reviewed and approved by BHEL Site Engineer (Permit Issuing Authority):

Name: _____ Sign: _____ Date: _____ Time: _____

Name of BHEL Safety Representative: _____ Sign: _____

I understand the precaution to be taken as described above and as per project requirement and hereby confirm that work will be executed under my supervision by following all precaution and Safety Rules.

Name of Work Performing Authority: _____ **Sign:** _____ **Date:** _____ **Time:** _____**Permit Cancellation:**

I hereby declare that the work is complete, all workers under my control have been withdrawn and the site restored to safe tidy condition.

Name of Work performing Authority: _____ Sign: _____ Date: _____ Time: _____

Name of Site Engr. (Permit Requesting Authority): _____ Sign: _____ Date: _____ Time: _____

Name of BHEL Site Engr. (Permit Issuing Authority): _____ Sign: _____ Date: _____ Time: _____

(This permit is valid only for the date it is issued)

Original at BHEL site**Second Copy – BHEL SAFETY****Third Copy : Contractor**



SAFETY WORK CLEARANCE

Permit no. _____

Project: _____

Emergency Contact Nos: _____

Subcontractor: _____

WORKING AT HEIGHT PERMIT

Area : _____ Date: _____ Time: _____

Name of Site Engineer (Permit Requesting Authority): _____ Sign: _____ Name of Work

Performing Contractor: _____

Name of Package In charge: _____ Sign: _____ Date: _____

Description of Work: _____

Work Execution Date: _____ Time Valid from: _____ to _____

The above signing person(s) will be responsible to ensure that the above described work will be done under all the safety precautions mentioned on the permit to work.

The following precautions are to be taken:

No.	Item	Yes	Not required
1.	All workers on job are medically fit for working at height (Person should not have vertigo)		
2.	Scaffolding with valid tag available for use		
3.	Safety harness with life line support/ fall arrester are checked and in working condition		
4.	Safety shoes (non-slip), Helmet with chin strip available with employees		
5.	Safety nets are provided as per design and provided 25 ft. below working area & extending 8 ft beyond.		
6.	Horizontal life lines are provided to cater to design specification of 2300kg per person.		
7.	Ladders have been inspected and provided as per BHEL standard/contract.		
8.	All lifting / tightening tools, hand tools/equipment checked and in good condition		
9.	Access and exit marked and without obstruction.		
10.	Lighting arrangement adequate.		
11.	Unwanted and rubbish material removed from working platform.		
12.	Electrical cable, welding Hose/Compressed air hose properly secured and lay down without obstruction.		
13.	Signboards provided on working platforms		
14.	Hazards in the vicinity are identified and communicated to the worker.		
15.	Other		

Name of Contractor Safety Officer: _____ Sign: _____ Date: _____ Time: _____

Reviewed and approved by BHEL Site Engineer (Permit Issuing Authority):

Name: _____ Sign: _____ Date: _____ Time: _____

Name of BHEL Safety Representative: _____ Sign: _____

I understand the precaution to be taken as described above and as per project requirement and hereby confirm that work will be executed under my supervision by following all precaution and Safety Rules.

Name of Work Performing Authority: _____ **Sign:** _____ **Date:** _____ **Time:** _____**Permit Cancellation:**

I hereby declare that the work is complete, all workers under my control have been withdrawn and the site restored to safe tidy condition.

Name of Work performing Authority: _____ Sign: _____ Date: _____ Time: _____

Name of Site Engr. (Permit Requesting Authority): _____ Sign: _____ Date: _____ Time: _____

Name of BHEL Site Engr. (Permit Issuing Authority): _____ Sign: _____ Date: _____ Time: _____

(This permit is valid only for the date it is issued)

Original at BHEL site**Second Copy – BHEL SAFETY****Third Copy : Contractor**



MONTHLY PLAN REVIEW WITH CONTRACTOR

Form No: F-14 (Rev 01)

PS-

Page 1 of 5

Name of Project		Contract No.	
Name of Work		Name of Contractor	

PART- A: PLAN/ REVIEW OF WORK FOR THE MONTH OF

Date of Plan/ Review

SN.	Description of work	Unit of Measur- ement	Unit Rate	Planned		Cumulative Shortfall attributable to contractor upto last month (Refer Note 1)		Achieved		Shortfall attributable to BHEL w.r.t Plan (as per Col. 3 of Part- D)		Cumulative Shortfall attributable to Contractor upto & including this month		REMARKS (Reasons for Shortfall attributable to Contractor. Supporting documents to be kept as record.)	
				(QTY Planned for the month as per Part –C of last month)											
(a)	(b)	(c)	(d)	A		B		C		D		E=A+B-C-D			
				Phy.	Financial	Phy.	Financial	Phy.	Financial	Phy.	Financial	Phy.	Financial		
	Value of Other Items not mentioned above but planned to be executed in this month														
Total					ΣA		ΣB		ΣC		ΣD		ΣE		

Note 1: In addition to the work planned as per Col. 'A', Contractor shall also make full efforts to minimize the 'Cumulative shortfall attributable to contractor upto the month' as mentioned in Col. 'B' by enhancing its resources, so as to achieve the completion of activities as per agreed schedule. In case contractor is not able to execute the entire shortfall, then BHEL 'Engineer in-charge', shall decide the priority of work to be executed and it shall be binding on the contractor.

Note 2: Percentage Shortfall attributable to contractor w.r.t. "Plan - Shortfall attributable to BHEL" for the month = $[(\Sigma E - \Sigma B) / (\Sigma A - \Sigma D)] \times 100$
In case, $(\Sigma E - \Sigma B)$ is negative, then it shall be treated as zero percent."

Note 3: Form 14 should include all items being planned in the current month, and all items against which shortfall was attributable to contractor till previous month. However, for practical reason, if it is not possible to mention some of the items in Form-14 being planned to be executed in this month, then also value of such items shall necessarily be included in calculation of Total Value.

Note 4: In case reason for shortfall attributable to contractor is w.r.t. T&P and Manpower, it should be in conformity with Part B1 and B2.

BHEL
(Sign with name, designation and date)

CONTRACTOR
(Sign with name, designation and date)



MONTHLY PLAN REVIEW WITH CONTRACTOR

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Name of Project		Contract No.	
Name of Work		Name of Contractor	

PART – B-1: PLAN/REVIEW OF DEPLOYMENT OF MAJOR T&Ps FOR THE MONTH OF Date of Plan/ Review

CONTRACTOR'S SCOPE:-

SN.	PLAN				DEPLOYMENT STATUS			
	Major T&P to be deployed as per work planned for the month	QTY.	Deployment Period (in days)	Weightage assigned to planned T&P (in fraction such that $\Sigma C = 1$)	Actual Deployed Quantity	Actual Deployment Period (in days)	Weighted T&P Deployed	REMARKS (Works affected due to non-deployment of T&Ps)
		A	B	C	D	E	$F = (C \times D \times E) / (A \times B)$	

Note: In case, $E > B$, it shall be considered as $E = B$. Similarly, in case $D > A$, it shall be considered as $D = A$.

Percentage of T&P Deployed = $\Sigma F \times 100$

BHEL SCOPE:-

SN.	PLAN			DEPLOYMENT STATUS		
	Major T&P to be deployed as per work planned for the month	QTY.	Deployment Period (in days)	Actual Deployed Quantity	Actual Deployment Period (in days)	REMARKS (Works affected due to non-deployment of T&Ps)

BHEL
(Sign with name, designation and date)

CONTRACTOR
(Sign with name, designation and date)



MONTHLY PLAN REVIEW WITH CONTRACTOR

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Name of Project		Contract No.	
Name of Work		Name of Contractor	

PART – B-2: PLAN/ REVIEW OF DEPLOYMENT OF MANPOWER FOR THE MONTH OF Date of Plan/ Review

CONTRACTOR'S SCOPE:-

SN.	Area of Work	Category of Labour	No. of Labour required as per category	Deployment Period (in days)	No. of Labour actually deployed	Actual Deployment Period (in days)	REMARKS (Works affected due to non-availability of labour)
			A	B	C	D	

Percentage of Manpower Deployed= $100 \times \frac{\sum(C \times D)}{\sum(A \times B)}$

BHEL
(Sign with name, designation and date)

CONTRACTOR
(Sign with name, designation and date)



MONTHLY PLAN REVIEW WITH CONTRACTOR

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Name of Project		Contract No.	
Name of Work		Name of Contractor	

PART – C: PLAN(PHYSICAL) FOR THE NEXT MONTH i.e.

Date of Plan

SN.	Description of work	Original Planned Quantity	Planned Quantity (excluding shortfalls attributable to contractor till date)	Unit of Measu- rement	T&Ps Required				Manpower Required		REMARKS (Reasons for difference in Original Planned Quantity w.r.t. Planned quantity to be given)
					Contractor Scope		BHEL Scope		Category of Labour	No. of Labour required as per Category	
					Major T&P to be deployed as per work planned for the month	Quantity	Major T&P to be deployed as per work planned for the month	Quantity			

Note 1: Planned quantity should be based on available/ expected fronts/ inputs in the next month

Note 2: “Original Planned Quantity” shall be as per latest jointly agreed programme between BHEL and Contractor before commencement of work or at the time of latest Time Extension, as the case may be.

BHEL
(Sign with name, designation and date)

CONTRACTOR
(Sign with name, designation and date)



MONTHLY PLAN REVIEW WITH CONTRACTOR

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Name of Project		Contract No.	
Name of Work		Name of Contractor	

PART – D: REASONS FOR SHORTFALL ATTRIBUTABLE TO BHEL IN RESPECT OF PLAN FOR THE MONTH

SN.	Description of Work (from Part-A)	Quantities Affected		Reasons for Shortfall attributable to BHEL	Agency responsible for reasons for shortfall	Remarks (Supporting Documents in respect of agency responsible)
		Physical Quantity	Unit of Measu- rement			
1	2	3		4	5	6

Note1: Reasons for shortfall shall include non-availability of fronts/ drawings/ materials/ T&P (BHEL Scope)/ clearances etc. and other hindrances for which contractor is not responsible.

Note2: Agency responsible may be BHEL Site/ MUs/ Design Centre/ BHEL Customer etc.

BHEL
(Sign with name, designation and date)

CONTRACTOR
(Sign with name, designation and date)

Project		Vendor			Package/Unit	
Sl. No.	Parameter for Measurement	Classification	Max Score	Score Obtained	Measurement Key/Scheduled date	Supporting Documents
#1.01	Cumulative number of days in the month, the nominated Quality Officer or his authorised nominee was not available	QUALITY	1.5		Quality Officer or his authorised nominee should be available for all the days of working at site	Daily Log Book entry/Incident Registers/letter references
#1.02	Number of instances of non- compliance wrt FQP, Standard Drawings, Specifications, E&C Manuals etc.	QUALITY	1.5		No deviation from FQP, Standard Drawings, Specifications, E&C Manuals etc. is allowed without BHEL Engineer's approval.	Daily Log Book entry/Incident Registers/letter references
#1.03	Percentage submission of test certificates for batches of welding electrodes, cement, sand, aggregate, consumable, Paints etc. as applicable for this month OR In case of MM & MH package, monthly checks for Storage/Preservation of material.	QUALITY	1		Submission of 100% Test certificates for materials as per FQP is mandatory. MM & MH package: Storage/Preservation as per manual/procedure.	Daily Log Book entry/Incident Registers/letter references
#1.04	Number of incidences of improper storage & preservation (not in accordance to the guidelines of BHEL MUs or approved FQP) of materials, consumables (viz. gases, welding electrodes & fluxes, fuel etc.) & bought-out items (paints, fasteners etc.) under the custody of the contractor	QUALITY	1		Total number of non-compliances	Daily Log Book entry/Incident Registers/letter references
#1.05	Rework/ Rejection instances in a month necessitated due to deviation from Standard Drawings /Specifications /Manuals /E&C procedures /FQPs or due to Poor Workmanship by contractor	QUALITY	2		Reworks/ Rejection should be as minimum as possible. Total number of reworks/ rejections due to reasons attributable to contractor.	Daily Log Book entry/Incident Registers/letter references
#1.06	Delay in preparation & submission of signed protocols / log sheets / site register / NDT test reports as per approved FQP/ Qualified Welder List along with photocopies of Welder ID cards / Welder Performance Evaluation records etc. in the month OR in case of MM / MH package reconciliation statement / verification report.	QUALITY	1		Within 2 days of measurements taken or within first 3 working days of next month, as advised by BHEL Engineer	Daily Log Book entry/Incident Registers/letter references
#1.07	Number of instances for Major equipment/product failure due to negligence/improper work/poor workmanship by contractor	QUALITY	1		No such event should happen	Daily Log Book entry/Incident Registers/letter references
#1.08	Total number of complaints received in the month on the quality of finish / aesthetics	QUALITY	1		Total number of non-compliances	Daily Log Book entry/Incident Registers/letter references

Name and Signature of BHEL Package In-charge

Name and Signature of Contractor

Project		Vendor			Package/Unit	
Sl. No.	Parameter for Measurement	Classification	Max Score	Score Obtained	Measurement Key/Scheduled date	Supporting Documents
#2.01	Cumulative number of days of delay in submission of Plan FOR THE MONTH supported by deployment plan of Major T&Ps and Manpower (as per Form F-14) and relevant construction/layout drawings - like A4 plan / elevation views of plan status for structures / pressure parts/Civil Works, Piping isometrics for piping, Layout / PID / System reference sketch, Unloading / storage plans etc.as applicable.	PERFORMANCE	5		Number of days delayed from second working day of the month	Daily Log Book entry/Incident Registers/letter references
#2.02	Percentage of timely submission of Daily Reports for Progress of work, Resources, Consumables etc.	PERFORMANCE	1.5		Percentage of timely submission of daily reports/ Scheduled date is successive next day for each day	Daily Log Book entry/Incident Registers/letter references
#2.03	Number of days delayed for submission of FQP log sheets / protocols / Monthly Progress Reports for the work executed during the month under measurement	PERFORMANCE	1.5		Number of days delayed/Scheduled date is first 2 working days of next month	Daily Log Book entry/Incident Registers/letter references
#2.04	Percentage Shortfall attributable to contractor w.r.t. "Plan - Shortfall attributable to BHEL" for the month as per Form-14	PERFORMANCE	35		As per Part-A of Form-14	Progress review formats
#2.05	Number of days delayed in submission of Running bills with complete supporting documents (including updated reconciliation statement of BHEL issued material) for the month	PERFORMANCE	2		Number of days delayed / Scheduled date is 7th day of next month	Daily Log Book entry/Incident Registers/letter references
#2.06	Number of times the Top Management of contractor did not respond to critical issues of site, for the month	PERFORMANCE	1		Total number of instances	Daily Log Book entry/Incident Registers/letter references
#2.07	Cumulative number of days in the month the works were stopped / refused on interpretation of contract clauses/scope due to tendency of taking undue advantage by interpreting contract clauses in their favour	PERFORMANCE	2		Cumulative number of days lost	Daily Log Book entry/Incident Registers/letter references
#2.08	Number of times rework was refused by contractor	PERFORMANCE	1		Total number of non-compliances	Daily Log Book entry/Incident Registers/letter references

Name and Signature of BHEL Package In-charge

Name and Signature of Contractor

Project		Vendor			Package/Unit	
Sl. No.	Parameter for Measurement	Classification	Max Score	Score Obtained	Measurement Key/Scheduled date	Supporting Documents
#2.09	Cumulative number of days in the month recording / logging was not done in daily log / history register / hindrance register / soft form in a PC maintained at BHEL Site Office	PERFORMANCE	1		Cumulative number of days recording or logging was not done / all days of the month	Daily Log Book entry/Incident Registers/letter references
#3.01	Percentage of Manpower Deployed w.r.t. Plan for the month as per Form-14.	RESOURCES	7		As per Part-B2 of Form-14	Daily Log Book entry/Incident Registers/letter references
#3.02	Percentage of T&P Deployed w.r.t. Plan for the month as per Form-14.	RESOURCES	7		As per Part-B1 of Form-14	Daily Log Book entry/Incident Registers/letter references
#3.03	Cumulative number of major instances in the month hampering / affecting progress of work due to breakdown or non-availability of major T&P and MME for the work, under the scope of Contractor	RESOURCES	3		Cumulative number of instances	Daily Log Book entry/Incident Registers/letter references
#3.04	Cumulative number of major instances in the month hampering / affecting progress of work due to non-availability of Consumables/ use of improper consumables under the scope of contractor	RESOURCES	3		Cumulative number of instances	Daily Log Book entry/Incident Registers/letter references
#4.01	Number of non-compliances during the month for Statutory requirements like validity of Labour Licence, Insurance Policy, Labour Insurance, PF, BOCW Compliance etc. and any other applicable laws/ Regulation, Electrical Licence, T&P fitness certificate, Contractors' All Risk Policy etc. as applicable	SITE INFRASTRUCTURE & SERVICE	1		Total number of non-compliances	Daily Log Book entry/Incident Registers/letter references
#4.02	Cumulative number of days in a month poor illumination is reported at storage area, erection area, pre-assembly area and other designated areas by BHEL site.	SITE INFRASTRUCTURE & SERVICE	0.5		Total number of non-compliances/random checks	Daily Log Book entry/Incident Registers/letter references
#4.03	Cumulative number of days of non-availability of well-maintained toilets facilities for workers (separate for men and women) and non-availability of potable drinking water stations for workers in specified areas.	SITE INFRASTRUCTURE & SERVICE	1		Total number of non-compliances/random checks	Daily Log Book entry/Incident Registers/letter references

Name and Signature of BHEL Package In-charge

Name and Signature of Contractor

Project		Vendor			Package/Unit	
Sl. No.	Parameter for Measurement	Classification	Max Score	Score Obtained	Measurement Key/Scheduled date	Supporting Documents
#4.04	Total number of instances in the month, Housekeeping NOT attended to in spite of instructions by BHEL -i.e. removal / disposal of surplus earth / debris / scrap / unused / surplus cable drums / other electrical items / surplus steel items / packing materials, thrown out scrap like weld butts, cotton waste etc. from the working area to identified locations	SITE INFRASTRUCTURE & SERVICE	2		Total number of non-compliances/random checks	Daily Log Book entry/Incident Registers/letter references
#4.05	Total number of instances in a month, Site Office with reasonably good facilities including enough nos. of computers and printers etc. for use by office and supporting staff was not made available/maintained.	SITE INFRASTRUCTURE & SERVICE	0.5		No discrepancy during regular or surprise visits	Photograph and report of the Engineer
#5.01	Number of days delayed in making labour payments for the last month	SITE FINANCE	2		Number of days delayed / Scheduled date is 7th day of next month	Daily Log Book entry/Incident Registers/letter references
#5.02	Number of complaints from labour/ sub supplier/ sub-contractor for non-receipt of payments from contractor	SITE FINANCE	1.5		Total number of complaints or reporting	Daily Log Book entry/Incident Registers/letter references
#5.03	Number of times the site operations were hampered for want of funds at the disposal of site-in-charge.	SITE FINANCE	1.5		Total number of non-compliances	Daily Log Book entry/Incident Registers/letter references
#6.0	Performance against HSE Parameters (as per Annexure-AA)	HSE	10		Score as per Safety Performance Evaluation System, scaled down to 10	Safety Performance Evaluation System
Total			100			

Less Deduction in Score Due to Fatal Accidents attributable to the Contractor @ 20 points/ accident	
Less Deduction in Score Due to Major Accidents (Permanent Disability or bodily injury by which person injured is prevented to resume to work within 48 hours or more after accident,, Major Damage to Equipment etc.) attributable to the contractor @ 15 points/ accident	
Less Deduction in Score Due to Minor Accidents attributable to the contractor @ 2 points/ accident	
Less Deduction in Score Due to not Maintaining of Labour Colony (if applicable) as per BHEL HSE policy @3 points in a month on verification any day	
Final Score	

Name and Signature of BHEL Package In-charge

Name and Signature of Contractor

Project		Vendor			Package/Unit	
Sl. No.	Parameter for Measurement	Classification	Max Score	Score Obtained	Measurement Key/Scheduled date	Supporting Documents
	Performance Score Summary for the Month	Total Score	Score Obtained			
	QUALITY	10				
	PERFORMANCE	50				
	RESOURCES	20				
	SITE INFRASTRUCTURE & SERVICE	5				
	SITE FINANCE	5				
	HSE	10				
	OTHERS (deductions if any)	0		-		
	TOTAL	100				

Note:

- 1) It is only indicative and shall be as per the online format issued by BHEL time to time.
- 2) No request will be entertained after specified date of current month w.r.t. changes requested in the scores of immediate previous month.

Name and Signature of BHEL Package In-charge

Name and Signature of Contractor

Monthly Safety Performance Evaluation of Contractor

SL	Parameter for Measurement	M/O	Wt	Supporting Documents
1a	Induction training for new workers conducted through audio-visual medium & documented ?	M	1	Induction Training Records
1b	Tool box talk conducted regularly as per plan, and documented?	M	1	Toolbox Talk Records
1c	Contractor in charge and safety in charge attended safety meetings?	M	2	Minutes of Meeting
1d	Whether observations in safety meetings are complied before next meeting?	M	2	-do-
1e	Preparation and submission of Monthly HSE report within stipulated time	M	1	Report submission date
1f	Preparation and submission of Incident/near-miss report and RCA Report (as applicable) within stipulated time	M	1	Incident/ Near Miss Records
1g	Carrying out Inspections and submission of Inspection reports within stipulated time	M	1	Inspection Records
1h	Regular Job Specific Training ensured for High Risk Workers (through audio-visual medium) as per plan	M	1	Training & Attendance Records
2a	Whether the contractor is registered under BOCW	M	2	BOCW Registration Certificate
2b	Availability of Qualified safety officer (1 for every 500 labour)	M	2	Safety Officer qualification & experience records
2c	Availability of Qualified safety supervisor (1 for every 100 labour)	M	2	Safety Officer qualification & experience records
2d	All the workers are provided and using safety helmets and safety shoes/gum boots	M	2	PPE Issue Records, Inspection/ non-conformity records
2e	Housekeeping done on regular basis and scrap removal at site	M	1	Housekeeping records, Inspection/ non-conformity records
2f	Usage of Goggles/Face shields and Hand gloves for gas cutter and grinders		1	PPE Issue Records, Inspection/ non-conformity records
2g	Wall openings & floor openings are guarded?		1	Inspection/ non-conformity records
2h	Adequate illumination provided in all working area?		1	Inspection/ non-conformity records
2i	Safety posters, sign boards and emergency contact numbers in all prominent location are displayed?		1	Inspection/ non-conformity records
2j	Availability of automatic reverse horns, Main horn, hook latches for Vehicles, mobile cranes, Hydras		1	Inspection/ non-conformity records
2k	Ban of carrying mobile phones to work place is implemented for workers		1	Inspection/ non-conformity records
2l	Availability of Tags & Inspection Certificates for Cranes of all capacities		1	Master T&P List with internal & external test details
2l.2	Availability of Tags & Inspection Certificates for Winches of all capacities		1	Master T&P List with internal & external test details
2l.3	Availability of Tags & Inspection Certificates, colour coding for Chain pulley blocks		1	Master T&P List with internal & external test details
2l.4	Availability of Tags & Inspection Certificates for Vehicles - Trailers, Dozers, Dumpers, Excavators, Mixers etc.		1	Master T&P List with internal & external test details
2l.5	Availability of Tags & Inspection Certificates for Welding machines, grinders, Drilling machines, etc.		1	Master T&P List with internal & external test details

2l.6	Availability of Tags & Inspection Certificates, colour coding for Wire rope slings etc.		1	Master T&P List with internal & external test details
2l.7	Availability of Tags & Inspection Certificates for Batching plants		1	Master T&P List with internal & external test details
2m.1	Use of Lifting Permit as per requirement		1	Permit Records
2m.2	Use of Height Permit as per requirement		1	Permit Records
2m.3	Use of Hot Work Permit as per requirement		1	Permit Records
2m.4	Use of Excavation permit as per requirement		1	Permit Records
2m.5	Use of Confined space work permit as per requirement		1	Permit Records
2m.6	Use of Grating removal and safety net removal permit as per requirement		1	Permit Records
2m.7	Use of Lockout-Tag out permit as per requirement		1	Permit Records
2m.8	Use of Radiography permit as per requirement		1	Permit Records
2m.9	Use of Night/ Holiday Work Permit as per requirement		1	Permit Records
2m.10	Use of Any other Applicable Permit as per requirement		1	Permit Records
3a	Material safety data sheet(MSDS) available for all chemicals and displayed in usage and storage area?		1	Inspection/ non-conformity records
3b	Spillages of oil/concrete and other chemical is controlled and cleaned by proper method in case of spill?		1	Inspection/ non-conformity records
3c	Availability of adequate number of urinals in workplace and in elevations and maintained	M	1	
3d	Availability of rest rooms for workers at site	M	1	
3e	Availability of Drinking water facility at work spot		1	
3f	Hygienic Labour colony is provided for workers.		1	
4a	Is heavy/complex critical lifting permit obtained for heavy, complex materials before handling/erection activity?		1	Work Permit records
4b	Whether area below lifting activities barricaded		1	Inspection/ non-conformity records
4c	Availability of experienced rigging foreman		1	Experience details of rigging foreman
4d	Is agency is following proper storage and handling procedure as per manufacturer standard for all hazardous material?		1	Procedure for storage & handling
4e	Are oxygen and acetylene cylinders are transported to work place from storage area in trolleys		1	
5a	Whether all deep excavation has been protected by barrier		1	Inspection/ non-conformity records
5b	Sloping/benching & shoring provided for excavation as per requirement?		1	-do-
5c	Proper access and egress provided for excavations?		1	-do-
5d	Blasting is done in controlled manner?		2	-do-
6a	Whether Electrical booth is equipped with CO ₂ fire extinguishers and fire buckets filled with sand?		2	Inspection/ non-conformity records
6b	Availability of Illumination lamp in electric booth?		1	-do-
6c	whether Caution Boards have been displayed?		1	-do-
6d	Usage of Metal Plug top for all hand power tools ?		1	-do-
6e	Usage of Insulated welding cables.		1	-do-
6f	Electrical Booth/Distribution Board to be covered by proper Canopy.		1	-do-
6g	Availability of functional & individual 30mA ELCB / RCCB and MCB for protection and conducting periodical check-up?		1	-do-
6h	Double earthing for panel boards and all machinery & proper earth pit with regular inspection available?		1	-do-
6i	Whether Electrician is qualified and experienced		1	Qualification & Experience records of electrician
6j	Availability and usage of Rubber hand gloves by electrician?		1	Inspection/ non-conformity records

7a	Whether Scaffolding pipes made with steel or aluminium, are being used and checked periodically by experienced/ certified scaffolder?		2	Inspection/ non-conformity records
7b	8mm Stainless Steel wire rope with plastic cladding is provided for life line (Vertical / Horizontal) during height work?		2	-do-
7c	Availability of emergency lighting in case of power failure		1	-do-
7d	Whether all the openings are covered with Safety Nets made of fire proof Nylon?		1	-do-
7e	Whether MS pipe rails around staircases & platforms in usage are provided with top, middle rails and toe guard ?		1	-do-
7f	Whether Ladder with vertical life line /Fall arrestor is available to climb?		1	-do-
7g	Whether all workers deployed for working at height have been issued height pass after undergoing vertigo test?		1	Height Pass records
7h	Whether all workers deployed for height work / climbing ladder are provided and using Double lanyard safety belt?		1	PPE Issue records, inspection/ non-conformity reports
7i	Is all hand tools/Small material used by height workers is tied firmly to prevent fall?		1	-do-
8a	Flash back arrestors for all gas cutting sets is available on Torch side and cylinder side		1	Inspection/ non-conformity records
8b	Oxygen/Acetylene/LPG cylinders not in use have caps in place and stored separately?		1	-do-
8c	Availability of Face screen, Hand gloves, and Apron, for welders		1	-do-
8d	Protection from falling hot molten metal during metal cutting / welding at height by providing GI sheet below the cutting area especially in fire prone areas		1	-do-
9a	Pre-employment medical check-up done for all workers and submitted?		1	Medical check records
9b	Availability of first aid centre, with MBBS doctor(Own or Sharing basis)	M	2	Attendance records
9c	Availability of Ambulance facility 24 hours (Own or sharing basis)	M	2	-do-
9d	Is First aid trained personnel's are available and their names are displayed at site?	M	1	-do-
9e	Availability of Emergency vehicle at site		1	
9f	Periodical medical check-up is conducted for all the workers and submitted?		1	Medical check records
9g	Availability of sufficient number of first aid box as per standard list and maintaining record		1	Inspection records
10a	Availability of Fire extinguishers, buckets at all vulnerable points		2	Fire extinguisher records
10b	Periodic fire mock drill conducted?		1	Fire, Mock drill records
10c	Are all flammable materials are stored separately?		1	
10d	Periodic grass cutting is done in material storage area?		1	
10e	Availability of 24V DC lighting in confined space work area		1	
10f	Availability of exhaust fan in confined space work area		1	

Note:

- M: Mandatory; O: Optional. Points other than mandatory can be excluded with appropriate justification (scope etc.) by BHEL. Score obtained in selected parameters divided by maximum possible score of selected parameters shall be multiplied by 10 for use in as per point Sl. no. # 6.0 as detailed at page 4 of Form F-15.
- There shall be deduction of marks from overall score for Fatal/ Major/ Minor Accidents and for not maintaining labour colony, as detailed at page 4 of Form F-15.

PROFORMA OF BANK GUARANTEE (in lieu of SECURITY DEPOSIT)

(On non-Judicial paper of appropriate value)

(Para 4.7.6 of Works Accounts Manual)

Bank Guarantee No.....

Date.....

To

(Employer's Name and Address)

.....

In consideration of Bharat Heavy Electricals Limited (hereinafter referred to as the 'Employer' which expression shall unless repugnant to the context or meaning thereof, include its successors and permitted assigns) incorporated under the Companies Act, 1956 and having its registered office at *BHEL House, Siri Fort, Asiad, New Delhi – 110049* through its unit at *Bharat Heavy Electricals Limited, Power Sector Southern Region, Tek Towers, No.11, Old Mahabalipuram Road, Okkiyam Thoraipakkam, Chennai - 600097* having agreed to exempt _____¹ (Name of the Vendor / Contractor / Supplier) with its registered office at _____² (hereinafter called the said "Contractor" which term includes supplier), from demand under the terms and conditions of the Contract arising vide Letter of Intent (LOI) reference No. _____ dated _____³ valued at Rs. _____⁴ (Rupees _____ only)⁴ (hereinafter called the said Contract), of Security Deposit for the due fulfilment by the said Contractor of the terms and conditions contained in the said Contract, on production of a Bank Guarantee for Rs. _____⁵ (Rupees _____ only),

We, the(Name & address of the Bank)
..... having our Head Office at
.....(hereinafter referred to as the Bank), at the request of
_____ [Contractor(s)], being the Guarantor under this Guarantee, do hereby irrevocably and unconditionally undertake to forthwith and immediately pay to the Employer, an amount not exceeding Rs. _____ without any demur, immediately on demand from the Employer and without any reservation, protest, and recourse and without the Employer needing to prove or demonstrate reasons for its such demand

Any such demand made on the bank, shall be conclusive as regards the amount due and payable by the Bank under this guarantee. However, our liability under this guarantee shall be restricted to an amount not exceeding Rs. _____⁵.

We undertake to pay to the Employer any money so demanded notwithstanding any dispute or disputes raised by the Contractor(s) in any suit or proceeding pending before any Court or Tribunal or Arbitrator or any other authority, our liability under this present being absolute and unequivocal.

The payment so made by us under this guarantee shall be a valid discharge of our liability for payment hereunder and the Contractor(s) shall have no claim against us for making such payment.

We, further agree that the guarantee herein contained shall remain in full force and effect during the period that would be taken for the performance of the said Contract and that it shall continue to be enforceable till all the dues of the Employer under or by virtue of the said Contract have been fully paid and its claims satisfied & the Employer certifies that the terms and conditions of the said Contract have been fully and properly carried out by the said contractor(s) or acceptance of the final bill or discharge of this guarantee by the Employer, whichever is earlier. This guarantee shall initially remain in force upto and including _____⁶ and shall be extended from time to time for such period as may

be desired by the Employer. Unless a demand or claim under this guarantee is made on us in writing on or before the _____⁷, we shall be discharged from all the liability under this guarantee thereafter.

We, _____(indicate the name of the Bank) further agree with the Employer that the Employer shall have the fullest liberty without our consent and without affecting in any manner our obligations hereunder to vary any of the terms and conditions of the said Contract or to extend time of performance by the said contractor(s) from time to time or to postpone for any time or from time to time any of the powers exercisable by the Employer against the said contractor(s) and to forbear or enforce any of the terms and conditions relating to the said Contract and we shall not be relieved from our liability by any reason of any such variation or extension being granted to the said contractor(s) or for any forbearance, act or omission on the part of the Employer or any indulgence by the Employer to the said contractor(s) or by any such matter or thing whatsoever which under the law relating to sureties would but for this provision have effect of so relieving us.

The Bank also agrees that the Employer at its option shall be entitled to enforce this Guarantee against the Bank as a principal debtor, in the first instance without proceeding against the Contractor and notwithstanding any security or other guarantee that the Employer may have in relation to the Contractor's liabilities.

This Guarantee shall not be determined or affected by liquidation or winding up, dissolution or change of constitution or insolvency of the Contractor but shall in all respects and for all purposes be binding and operative until payment of all money payable to the Employer in terms thereof. This guarantee will not be discharged due to the change in the constitution of the Bank or the Contractor(s).

We, ... BANK lastly undertake not to revoke this guarantee during its currency except with the previous consent of the Employer in writing.

Notwithstanding anything to the contrary contained hereinabove:

- a) The liability of the Bank under this Guarantee shall not exceed.....⁵
- b) This Guarantee shall be valid up to ⁶
- c) Unless the Bank is served a written claim or demand on or before _____⁷ all rights under this guarantee shall be forfeited and the Bank shall be relieved and discharged from all liabilities under this guarantee irrespective of whether or not the original bank guarantee is returned to the Bank.

We, _____ Bank, have power to issue this Guarantee under law and the undersigned as a duly authorized person has full powers to sign this Guarantee on behalf of the Bank.

Date _____ Day of _____
for _____ (indicate the name of the Bank)

(Signature of Authorised signatory)

¹ NAME OF VENDOR /CONTRACTOR / SUPPLIER

² REGISTERED OFFICE ADDRESS OF THE VENDOR /CONTRACTOR / SUPPLIER.

³ LETTER OF INTENT(LOI) REFERENCE NO. WITH DATE

⁴ CONTRACT VALUE (AS MENTIONED IN LOI)

⁵ BG AMOUNT IN FIGURES AND WORDS

⁶ VALIDITY DATE

⁷ DATE OF EXPIRY OF CLAIM PERIOD (CLAIM PERIOD SHALL BE MINIMUM OF 3 MONTHS AFTER VALIDITY DATE)

Note:

1. The BG should be on Non-Judicial Stamp paper/e-stamp paper of appropriate value as per Stamp Act prevailing in the State(s) where the BG is submitted or is to be acted upon or the rate prevailing in the State where the BG was executed, whichever is higher. The Stamp Paper/e-stamp paper shall be purchased in the name of Vendor/Contractor/Supplier /Bank issuing the guarantee.
2. In Case of Bank Guarantees submitted by Foreign Vendors-
 - a. From Nationalized/Public Sector / Private Sector/ Foreign Banks (BG issued by Branches in India) can be accepted subject to the condition that the Bank Guarantee should be enforceable in the town/city or at nearest branch where the Unit is located i.e. Demand can be presented at the Branch located in the town/city or at nearest branch where the Unit is located.
 - b. From Foreign Banks (wherein Foreign Vendors intend to provide BG from local branch of the Vendor Country's Bank)
 - b.1 In such cases, in the Tender Enquiry/ Contract itself, it may be clearly specified that Bank Guarantee issued by any of the Consortium Banks only will be accepted by BHEL. As such, Foreign Vendor needs to make necessary arrangements for issuance of Counter- Guarantee by Foreign Bank in favour of the Indian Bank's (BHEL's Consortium Bank) branch in India. It is advisable that all charges for issuance of Bank Guarantee/ counter- Guarantee should be borne by the Foreign Vendor. The tender stipulation should clearly specify these requirements.
 - b.2 In case, Foreign Vendors intend to provide BG from Overseas Branch of our Consortium Bank (e.g. if a BG is to be issued by SBI Frankfurt), the same is acceptable. However, the procedure at sl.no. b.1 will required to be followed.
 - b.3 The BG issued may preferably be subject to Uniform Rules for Demand Guarantees (URDG) 758 (as amended from time to time).

PROCEDURE FOR CONDUCT OF CONCILIATION PROCEEDINGS

1. The proceedings of Conciliation shall broadly be governed by Part-III of the Arbitration and Conciliation Act 1996 or any statutory modification thereof and as provided herein:
2. The party desirous of resorting to Conciliation shall send an invitation/notice in writing to the other party to conciliate specifying all points of Disputes with details of the amount claimed. The party concerned shall not raise any new issue thereafter. Parties shall also not claim any interest on claims/counter-claims from the date of notice invoking Conciliation till the conclusion of the Conciliation proceedings. If BHEL is to initiate Conciliation, then, the invitation to Conciliate shall be extended to the concerned Stakeholder in **Format 7** hereto. Where the stakeholder is to initiate the Conciliation, the notice for initiation of Conciliation shall be sent in **Format-8** hereto.
3. The party receiving the invitation/notice for Conciliation shall within 30 days of receipt of the notice of Conciliation intimate its consent for Conciliation along with its counter-claims, if any.
4. The Conciliation in a matter involving claim or counter-claim (whichever is higher) up to Rs 5 crores shall be carried out by sole Conciliator nominated by BHEL while in a matter involving claim or counter-claim (whichever is higher) of more than Rs 5 crores Conciliation shall be carried out by 3 Conciliators nominated by BHEL. The appointment of Conciliator(s) shall be completed and communicated by the concerned Department/Group of BHEL Unit/Division/Region/Business Group to the other party and the Conciliator(s) within 30 days from the date of acceptance of the invitation to conciliate by the concerned party in the **Format-9**. The details of the Claim, and counter-claim, if any, shall be intimated to the Conciliator(s) simultaneously in **Format-5**.
5. The Parties shall be represented by only their duly authorized in-house executives/officers and neither Party shall be represented by a Lawyer.
6. The first meeting of the IEC shall be convened by the IEC by sending appropriate communication/notice to both the parties as soon as possible but not later than 30 days from the date of his/their appointment. The hearings in the Conciliation proceeding shall ordinarily be concluded within two (2) months and, in exceptional cases where parties have expressed willingness to settle the matter or there exists possibility of settlement in the matter, the proceedings may be extended by the IEC by a maximum of further 2 months with the consent of the Parties subject to cogent reasons being recorded in writing.

- 7.** The IEC shall thereafter formulate recommendations for settlement of the Disputes supported by reasons at the earliest but in any case within 15 days from the date of conclusion of the last hearing. The recommendations so formulated along with the reasons shall be furnished by the IEC to both the Parties at the earliest but in any case within 1 month from the date of conclusion of the last hearing.
- 8.** Response/modifications/suggestions of the Parties on the recommendations of the IEC are to be submitted to the IEC within time limit stipulated by the IEC but not more than 15 days from the date of receipt of the recommendations from the IEC.
- 9.** In the event, upon consideration, further review of the recommendations is considered necessary, whether by BHEL or by the other Party, then, the matter can be remitted back to the IEC with request to reconsider the same in light of the issues projected by either/both the Parties and to submit its recommendations thereon within the following 15 days from the date of remitting of the case by either of the Parties.
- 10.** Upon the recommendations by the Parties, with or without modifications, as considered necessary, the IEC shall be called upon to draw up the Draft Settlement Agreement in terms of the recommendations.
- 11.** When a consensus can be arrived at between the parties only in regard to any one or some of the issues referred for Conciliation the draft Settlement Agreement shall be accordingly formulated in regard to the said Issue(s), and the said Settlement Agreement, if signed, by the parties, shall be valid only for the said issues. As regards the balance issues not settled, the parties may seek to resolve them further as per terms and conditions provided in the contract.
- 12.** In case no settlement can be reached between the parties, the IEC shall by a written declaration, pronounce that the Conciliation between the parties has failed and is accordingly terminated.
- 13.** Unless the Conciliation proceedings are terminated in terms of para 22 (b), (c) & (d) herein below, the IEC shall forward his/its recommendations as to possible terms of settlement within one (1) month from the date of last hearing. The date of first hearing of Conciliation shall be the starting date for calculating the period of 2 months.
- 14.** In case of 3 members IEC, 2 members of IEC present will constitute a valid quorum for IEC and meeting can take place to proceed in the matter after

seeking consent from the member who is not available. If necessary, videoconferencing may be arranged for facilitating participation of the members. However, the IEC recommendations will be signed by all members. Where there is more than one (1) Conciliator, as a general rule they shall act jointly. In the event of differences between the Members of IEC, the decision/recommendations of the majority of the Members of IEC shall prevail and be construed as the recommendation of the IEC.

- 15.** The Draft Settlement Agreement prepared by the IEC in terms of the consensus arrived at during the Conciliation proceedings between the Parties shall be given by the IEC to both the parties for putting up for approval of their respective Competent Authority.
- 16.** Before submitting the draft settlement agreement to BHEL's Competent Authority viz. the Board Level Committee on Alternative Dispute Resolution (BLCADR) for approval, concurrence of the other party's Competent Authority to the draft settlement agreement shall be obtained by the other party and informed to BHEL within 15 days of receipt of the final draft settlement agreement by it. Upon approval by the Competent Authority, the Settlement Agreement would thereafter be signed by the authorized representatives of both the Parties and authenticated by the members of the IEC.
- 17.** In case the Draft Settlement Agreement is rejected by the Competent Authority of BHEL or the other Party, the Conciliation proceedings would stand terminated.
- 18.** A Settlement Agreement shall contain a statement to the effect that each of the person(s) signing thereto (i) is fully authorized by the respective Party(ies) he/she represents, (ii) has fully understood the contents of the same and (iii) is signing on the same out of complete freewill and consent, without any pressure, undue influence.
- 19.** The Settlement Agreement shall thereafter have the same legal status and effect as an arbitration award on agreed terms on the substance of the dispute rendered by an arbitral tribunal passed under section 30 of the Arbitration and Conciliation Act, 1996.
- 20.** Acceptance of the Draft Settlement Agreement/recommendations of the Conciliator and/or signing of the Settlement Agreement by BHEL shall however, be subject to withdrawal/closure of any arbitral and/or judicial proceedings initiated by the concerned Party in regard to such settled issues.
- 21.** Unless otherwise provided for in the agreement, contract or the Memorandum of Understanding, as the case may be, in the event of likelihood of prolonged

absence of the Conciliator or any member of IEC, for any reason/incapacity, the Competent Authority/Head of Unit/Division/Region/Business Group of BHEL may substitute the Conciliator or such member at any stage of the proceedings. Upon appointment of the substitute Conciliator(s), such reconstituted IEC may, with the consent of the Parties, proceed with further Conciliation into the matter either de-novo or from the stage already reached by the previous IEC before the substitution.

22. The proceedings of Conciliation under this Scheme may be terminated as follows:

- a.** On the date of signing of the Settlement agreement by the Parties; or,
- b.** By a written declaration of the IEC, after consultation with the parties, to the effect that further efforts at conciliation are no longer justified, on the date of the declaration; or,
- c.** By a written declaration of the Parties addressed to the IEC to the effect that the Conciliation proceedings are terminated, on the date of the declaration; or,
- d.** By a written declaration of a Party to the other Party and the IEC, if appointed, to the effect that the Conciliation proceedings are terminated, on the date of the declaration; or,
- e.** On rejection of the Draft Settlement Agreement by the Competent Authority of BHEL or the other Party.

23. The Conciliator(s) shall be entitled to following fees and facilities:

Sl No	Particulars	Amount
1	Sitting fees	Each Member shall be paid a Lump Sum fee of Rs 75,000/- for the whole case payable in terms of paragraph No. 27 herein below.
2	Towards drafting of settlement agreement	In cases involving claim and/or counter-claim of up to Rs 5crores. Rs 50,000/- (Sole Conciliator) In cases involving claim and/or counter-claim of exceeding Rs 5 crores but less than Rs 10 crores. Rs 75,000 (per Conciliator)

Sl No	Particulars	Amount
		In cases involving claim and/or counter-claim of more than Rs 10 crores. Rs 1,00,000/- (per Conciliator) Note: The aforesaid fees for the drafting of the Settlement Agreement shall be paid on the, Signing of the Settlement Agreement after approval of the Competent Authority or Rejection of the proposed Settlement Agreement by the Competent Authority of BHEL.
3	Secretarial expenses	Rs 10,000/- (one time) for the whole case for Conciliation by a Sole Member IEC. Where Conciliation is by multi member Conciliators –Rs 30,000/- (one time)- to be paid to the IEC
4	Travel and transportation and stay at outstation Retired Senior Officials of other Public Sector Undertakings (pay scale wise equivalent to or more than E-8 level of BHEL)	As per entitlement of the equivalent officer (pay scale wise) in BHEL.
	Others	As per the extant entitlement of whole time Functional Directors in BHEL. Ordinarily, the IEC Member(s) would be entitled to travel by air Economy Class.
5	Venue for meeting	Unless otherwise agreed in the agreement, contract or the Memorandum of Understanding, as the case may be, the venue/seat of proceedings shall be the location of the concerned Unit / Division / Region /

Sl No	Particulars	Amount
		Business Group of BHEL. Without prejudice to the seat/venue of the Conciliation being at the location of concerned BHEL Unit / Division / Region / Business Group, the IEC after consulting the Parties may decide to hold the proceedings at any other place/venue to facilitate the proceedings. Unless, Parties agree to conduct Conciliation at BHEL premises, the venue is to be arranged by either Party alternately.

- 24.** The parties will bear their own costs including cost of presenting their cases/evidence/witness(es)/expert(s) on their behalf. The parties agree to rely upon documentary evidence in support of their claims and not to bring any oral evidence in IEC proceedings.
- 25.** If any witness(es) or expert(s) is/are, with the consent of the parties, called upon to appear at the instance of the IEC in connection with the matter, then, the costs towards such witness(es)/expert(s) shall be determined by the IEC with the consent of the Parties and the cost so determined shall be borne equally by the Parties.
- 26.** The other expenditures/costs in connection with the Conciliation proceedings as well as the IEC's fees and expenses shall be shared by the Parties equally.
- 27.** Out of the lump sum fees of Rs 75,000/- for Sitting Fees, 50% shall be payable after the first meeting of the IEC and the remaining 50% of the Sitting Fees shall be payable only after termination of the conciliation proceedings in terms of para 22 hereinabove.
- 28.** The travelling, transportation and stay at outstation shall be arranged by concerned Unit as per entitlements as per Serial No. 4 of the Table at para 23 above, and in case such arrangements are not made by the BHEL Unit, the same shall be reimbursed to the IEC on actuals limited to their entitlement as per Serial No. 4 of the Table at Para 23 above against supporting documents. The IEC Member(s) shall submit necessary invoice for claiming the fees/reimbursements.
- 29.** The Parties shall keep confidential all matters relating to the conciliation proceedings. Confidentiality shall extend also to the settlement agreement,

except where its disclosure is necessary for purposes of its implementation and enforcement or as required by or under a law or as per directions of a Court/Governmental authority/ regulatory body, as the case may be.

- 30.** The Parties shall not rely upon or introduce as evidence in any further arbitral or judicial proceedings, whether or not such proceedings relate to the Disputes that is the subject of the Conciliation proceedings:
- a.** Views expressed or suggestions made by the other party in respect of a possible settlement of the Disputes;
 - b.** admissions made by the other party in the course of the Conciliator proceedings;
 - c.** proposals made by the Conciliator;
 - d.** The fact that the other Party had indicated his willingness to accept a proposal for settlement made by the Conciliator.
- 31.** The Parties shall not present the Conciliator(s) as witness in any Alternative Dispute Resolution or Judicial proceedings in respect of a Disputes that is/was the subject of that particular Conciliation proceeding.
- 32.** None of the Conciliators shall act as an arbitrator or as a representative or counsel of a Party in any arbitral or judicial proceeding in respect of a Disputes that is/was the subject of that particular Conciliation proceeding.
- 33.** The Parties shall not initiate, during the Conciliation proceedings, any arbitral or judicial proceedings in respect of a Disputes that is the subject matter of the Conciliation proceedings except that a Party may initiate arbitral or judicial proceedings where, in his opinion, such proceedings are necessary for preserving his rights including for preventing expiry of period of limitation. Unless terminated as per the provisions of this Scheme, the Conciliation proceedings shall continue notwithstanding the commencement of the arbitral or judicial proceedings and the arbitral or judicial proceedings shall be primarily for the purpose of preserving rights including preventing expiry of period of limitation.
- 34.** The official language of Conciliation proceedings under this Scheme shall be English unless the Parties agree to some other language.

**STATEMENT OF CLAIMS/COUNTER CLAIMS TO BE SUBMITTED TO THE
IEC BY BOTH THE PARTIES**

1. Chronology of the Disputes
2. Brief of the Contract/MoU/Agreement/LOI/LOA
3. Brief history of the Disputes:
4. Issues:
5. Details of Claim(s)/Counter Claim(s):

Sl. No.	Description of claim(s)/Counter Claim	Amount (in INR)Or currency applicable in the contract	Relevant contract clause

6. Basis/Ground of claim(s)/counter claim(s) (along with relevant clause of contract)

Note– *The Statement of Claims/ Counter Claims may ideally be restricted to maximum limit of 20 pages. Relevant documents may be compiled and submitted along with the statement of Claims/ Counter Claims. The statement of Claims/ Counter Claims is to be submitted to all IEC members and to the other party by post as well as by email.*

FORMAT-7

FORMAT FOR NOTICE INVOKING CONCILIATION CLAUSE BY BHEL FOR REFERRING THE DISPUTES TO CONCILIATION THROUGH IEC

To,

M/s. (Stakeholder's name)

Subject: **NOTICE FOR INVOCATION OF THE CONCILIATION CLAUSE OF THE CONTRACT BY BHEL**

Ref: Contract No/MoU/Agreement/LOI/LOA& date _____.

Dear Sir/Madam,

As you are aware, with reference to above referred Contract/MoU/Agreement/LOI/LOA, certain disputes have arisen, which, in spite of several rounds of mutual discussions and various correspondences have remained unresolved. The brief particulars of our claims which arise out of the above- referred Contract/MoU/Agreement/LOI/LOA are reproduced hereunder:

Sl. No.	Claim description	Amount involved

As you are aware, there is a provision in the captioned Contract/MoU/Agreement/LOI/ LOA for referring disputes to conciliation.

In terms of Clause -----of Procedure i.e., Annexure ----- to the Contract/MoU /Agreement / LOI / LOA, we hereby seek your consent to refer the matter to Conciliation by Independent Experts Committee to be appointed by BHEL. You are invited to provide your consent in writing to proceed with conciliation into the above mentioned disputes within a period of 30 days from the date of this letter along with details of counter-claims, if any, which you might have with regard to the subject Contract/ MoU/ Agreement/ LOI/ LOA.

Please note that upon receipt of your consent in writing within 30 days of the date of receipt of this letter by you, BHEL shall appoint suitable person(s) from the BHEL Panel of Conciliators.

This letter is being issued without prejudice to our rights and contentions available under the contract and law.

Thanking you
Yours faithfully

Representative of BHEL

Note: The Format may be suitably modified, as required, based on facts and circumstances of the case.

FORMAT-8

**FORMAT FOR NOTICE INVOKING CONCILIATION CLAUSE BY A
STAKEHOLDER FOR REFERRING THE DISPUTES TO CONCILIATION
THROUGH IEC**

To,

BHEL (Head of the Unit/Division/Region/Business Group)

Subject: **NOTICE FOR INVOCATION OF THE CONCILIATION CLAUSE OF THE
CONTRACT BY A STAKEHOLDER**

Ref: Contract No/MoU/Agreement/LOI/LOA& date _____.

Dear Sir/Madam,

As you are aware, with reference to above referred Contract/MoU/Agreement/LOI/LOA, certain disputes have arisen, which, in spite of several rounds of mutual discussions and various correspondences have remained unresolved. The brief particulars of our claims which have arisen out of the above-referred Contract/MoU/Agreement/LOI/LOA are enumerated hereunder:

Sl. No.	Claim description	Amount involved

As you are aware, there is a provision in the captioned Contract/MoU/Agreement/LOI/ LOA for referring inter-se disputes of the Parties to conciliation.

We wish to refer the above-said disputes to Conciliation as per the said Clause of the captioned Contract/MoU/Agreement/LOI/ LOA. In terms of Clause -----of Procedure i.e., Annexure ----- to the Contract/MoU /Agreement / LOI / LOA, we hereby invite BHEL to provide its consent in writing to proceed with conciliation into the above mentioned disputes within a period of 30 days from the date of this letter along with details of counter-claims, if any, which it might have with regard to the subject Contract/ MoU/ Agreement/ LOI/ LOA and to appoint suitable person(s) as Conciliator(s) from the BHEL Panel of Conciliators.

This letter is being issued without prejudice to our rights and contentions available under the contract and law.

Thanking you

Yours faithfully

Representative of the Stakeholder

Note: The Format may be suitably modified, as required, based on facts and circumstances of the case.

FORMAT FOR INTIMATION TO THE STAKEHOLDER ABOUT APPOINTMENT OF CONCILIATOR/IEC

To,

M/s. (Stakeholder's name)

Subject: **INTIMATION BY BHEL TO THE STAKEHOLDER AND CONCILIATOR(S) ABOUT APPOINTMENT OF CONCILIATOR/IEC**

Ref: Contract No/MoU/Agreement/LOI/LOA& date _____.

Sir,

This is with reference to letter dated ----- regarding reference of the disputes arising in connection with the subject Contract No /MoU/Agreement/LOI/LOA to conciliation and appointment of Conciliator(s).

In pursuance of the said letter, the said disputes are assigned to conciliation and the following persons are nominated as Conciliator(s) for conciliating and assisting the Parties to amicably resolve the disputes in terms of the Arbitration & Conciliation Act, 1996 and the Procedure ---- to the subject Contract/MoU/Agreement/LOI/LOA, if possible.

Name and contact details of Conciliator(s)

a)

b)

c)

You are requested to submit the Statement of Claims or Counter-Claims (strike off whichever is inapplicable) before the Conciliator(s) in Format 5 (enclosed herewith) as per the time limit as prescribed by the Conciliator(s).

Yours faithfully,

Representative of BHEL

CC: To Conciliator(s)... for Kind Information please.

Encl: As above

Note: The Format may be suitably modified, as required, based on facts and circumstances of the case.

(On non-Judicial paper of appropriate value)
(Para 4.7.6 of Works Accounts Manual)

Bank Guarantee No.....
Date.....

To
(Employer's Name and Address)
.....

Dear Sirs,

In accordance with the terms and conditions of Invitation for Bids/Notice Inviting Tender No.....¹ (Tender Conditions), M/s. ² having its registered office at ³ (hereinafter referred to as the 'Tenderer'), is submitting its bid for the work of.....⁴ invited by Bharat Heavy Electricals Limited (hereinafter referred to as the 'Employer' which expression shall unless repugnant to the context or meaning thereof, include its successors and permitted assigns) incorporated under the Companies Act, 1956 and having its registered office at *BHEL House, Siri Fort, Asiad, New Delhi – 110049* through its unit at *Bharat Heavy Electricals Limited, Power Sector Southern Region, Tek Towers, No.11, Old Mahabalipuram Road, Okkiyam Thoraipakkam, Chennai – 600097*.

The Tender Conditions provide that the Tenderer shall pay a sum of Rs ⁵ as Earnest Money Deposit in the form therein mentioned. The form of payment of Earnest Money Deposit includes Bank Guarantee executed by a Scheduled Bank.

In lieu of the stipulations contained in the aforesaid Tender Conditions that an irrevocable and unconditional Bank Guarantee against Earnest Money Deposit for an amount of ⁶ is required to be submitted by the Tenderer as a condition precedent for participation in the said Tender and the Tenderer having approached us for giving the said Guarantee,

we, the(Name & address of the Bank)
..... having our Head Office at
.....(hereinafter referred to as the Bank) being the Guarantor under this Guarantee, hereby irrevocably and unconditionally undertake to forthwith and immediately pay to the Employer without any demur, merely on your first demand any sum or sums of Rs.....⁶ (in words Rupees.....) without any reservation, protest, and recourse and without the beneficiary needing to prove or demonstrate reasons for its such demand.

Any such demand made on the Bank shall be conclusive as regards the amount due and payable by the Bank under this guarantee. However, our liability under this guarantee shall be restricted to an amount not exceeding Rs. ⁶

We undertake to pay to the Employer any money so demanded notwithstanding any dispute or disputes raised by the Tenderer in any suit or proceeding pending before any Court or Tribunal, Arbitrator or any other authority, our liability under this present being absolute and unequivocal.

The payment so made by us under this Guarantee shall be a valid discharge of our liability for payment hereunder and the Tenderer shall have no claim against us for making such payment.

We Bank further agree that the Employer shall have the fullest liberty without our consent and without affecting in any manner our obligations hereunder to vary any of the terms and conditions of the said Tender or to extend the time of submission of from time to time or to postpone

for any time or from time to time any of the powers exercisable by the Employer against the said Tenderer and we shall not be relieved from our liability by reason of any such variation, or extension being granted to the said Tenderer or for any forbearance, act or omission on the part of the Employer or any indulgence by the Employer to the said Tenderer or by any such matter or thing whatsoever which under the law relating to sureties would but for this provision have effect of so relieving us.

The Bank also agrees that the Employer at its option shall be entitled to enforce this Guarantee against the Bank as a principal debtor, in the first instance without proceeding against the Tenderer and notwithstanding any security or other guarantee that the Employer may have in relation to the Tenderer's liabilities.

This Guarantee shall be irrevocable and shall remain in force upto and including.....⁷ and shall be extended from time to time for such period as may be desired by the Employer.

This Guarantee shall not be determined or affected by liquidation or winding up, dissolution or change of constitution or insolvency of the Tenderer but shall in all respects and for all purposes be binding and operative until payment of all money payable to the Employer in terms hereof. However, unless a demand or claim under this Guarantee is made on us in writing on or before the ⁸ we shall be discharged from all liabilities under this Guarantee.

We, ... Bank lastly undertake not to revoke this guarantee during its currency except with the previous consent of the Employer in writing.

Notwithstanding anything to the contrary contained hereinabove:

- a) The liability of the Bank under this Guarantee shall not exceed.....⁶
- b) This Guarantee shall be valid up to ⁷
- c) Unless the Bank is served a written claim or demand on or before ⁸ all rights under this guarantee shall be forfeited and the Bank shall be relieved and discharged from all liabilities under this guarantee irrespective of whether or not the original bank guarantee is returned to the Bank

We, ... Bank, have power to issue this Guarantee under law and the undersigned as a duly authorized person has full powers to sign this Guarantee on behalf of the Bank.

For and on behalf of
(Name of the Bank)

(Signature of Authorised signatory)

Date.....

Place of Issue.....

¹ Details of the Invitation to Bid/Notice Inviting Tender (Tender Ref. No. Eg. - BHEL PSSR SCT XXXX)

² Name of Tenderer

³ REGISTERED Office Address of the Tenderer

⁴ Details of the Work i.e Tender Description

⁵ EMD Amount as mentioned in Notice Inviting Tender

⁶ BG Amount in words and Figures (BG Amount shall be Minimum of EMD amount less Rs. 2 Lakhs)

⁷ Validity Date

⁸ Date of Expiry of Claim Period (Claim Period shall be minimum of 3 Months after the validity date of Bank Guarantee)

Note:

- 1. The BG should be on Non-Judicial Stamp paper/e-stamp paper of appropriate value as per Stamp Act prevailing in the State(s) where the BG is submitted or is to be acted upon or the rate prevailing in the State where the BG was executed, whichever is higher. The Stamp Paper/e-stamp paper shall be purchased in the name of Vendor/Contractor/Supplier /Bank issuing the guarantee.

2. In Case of Bank Guarantees submitted by Foreign Vendors-
 - a. From Nationalized/Public Sector / Private Sector/ Foreign Banks (BG issued by Branches in India) can be accepted subject to the condition that the Bank Guarantee should be enforceable in the town/city or at nearest branch where the Unit is located i.e. Demand can be presented at the Branch located in the town/city or at nearest branch where the Unit is located.
 - b. From Foreign Banks (wherein Foreign Vendors intend to provide BG from local branch of the Vendor Country's Bank)
 - b.1 In such cases, in the Tender Enquiry/ Contract itself, it may be clearly specified that Bank Guarantee issued by any of the Consortium Banks only will be accepted by BHEL. As such, Foreign Vendor needs to make necessary arrangements for issuance of Counter- Guarantee by Foreign Bank in favour of the Indian Bank's (BHEL's Consortium Bank) branch in India. It is advisable that all charges for issuance of Bank Guarantee/ counter- Guarantee should be borne by the Foreign Vendor. The tender stipulation should clearly specify these requirements.
 - b.2 In case, Foreign Vendors intend to provide BG from Overseas Branch of our Consortium Bank (e.g. if a BG is to be issued by SBI Frankfurt), the same is acceptable. However, the procedure at sl.no. b.1 will required to be followed.
 - b.3 The BG issued may preferably be subject to Uniform Rules for Demand Guarantees (URDG) 758 (as amended from time to time).

PROFORMA OF BANK GUARANTEE (in lieu of RETENTION AMOUNT)

(On non-Judicial paper of appropriate value)

Bank Guarantee No.....
Date.....

To
Bharat Heavy Electricals Limited,
Power Sector Southern Region,
Tek Towers, No.11, Old Mahabalipuram Road,
Okkiyam Thoraipakkam,
Chennai – 600097

In consideration of Bharat Heavy Electricals Limited (hereinafter referred to as the 'Employer' which expression shall unless repugnant to the context or meaning thereof, include its successors and permitted assigns) incorporated under the Companies Act, 1956 and having its registered office at BHEL House, Siri Fort, Asiad, New Delhi – 110049 through its Unit at Bharat Heavy Electricals Limited, Power Sector Southern Region, Tek Towers, No.11, Old Mahabalipuram Road, Okkiyam Thoraipakkam, Chennai – 600097 having agreed to exempt _____¹ (Name of the Vendor / Contractor / Supplier) with its registered office at _____² (hereinafter called the said "Contractor" which term includes Supplier), from demand under the terms and conditions of the Contract reference No. _____ dated _____³ valued at Rs _____⁴ (Rupees _____)⁴ (hereinafter called the said Contract), of Retention Amount for the due fulfilment by the said Contractor of the terms and conditions contained in the said Contract, on production of a Bank Guarantee for Rs _____⁵ (Rupees _____ only),

We _____ (indicate the name and address of the Bank) having its Head Office at _____ (address of the Head Office) (hereinafter referred to as the Bank), at the request of _____ [Contractor(s)], being the Guarantor under this Guarantee, do hereby irrevocably and unconditionally undertake to forthwith and immediately pay to the Employer, an amount not exceeding Rs _____ without any demur, immediately on demand from the Employer and without any reservation, protest, and recourse and without the Employer needing to prove or demonstrate reasons for its such demand.

Any such demand made on the bank, shall be conclusive as regards the amount due and payable by the Bank under this guarantee. However, our liability under this guarantee shall be restricted to an amount not exceeding Rs _____.

We undertake to pay to the Employer any money so demanded notwithstanding any dispute or disputes raised by the Contractor(s) in any suit or proceeding pending before any Court or Tribunal or Arbitrator or any other authority, our liability under this present being absolute and unequivocal.

The payment so made by us under this guarantee shall be a valid discharge of our liability for payment hereunder and the Contractor(s) shall have no claim against us for making such payment.

We, further agree that the guarantee herein contained shall remain in full force and effect during the period that would be taken for the performance of the said Contract and that it shall continue to be enforceable till all the dues of the Employer under or by virtue of the said Contract have been fully paid and its claims satisfied & the Employer certifies that the terms and conditions of the said

PROFORMA OF BANK GUARANTEE (in lieu of RETENTION AMOUNT)

Contract have been fully and properly carried out by the said contractor(s) or acceptance of the final bill or discharge of this guarantee by the Employer, whichever is earlier. This guarantee shall initially remain in force upto and including _____⁶ and shall be extended from time to time for such period as may be desired by the Employer. Unless a demand or claim under this guarantee is made on us in writing on or before the _____⁷, we shall be discharged from all the liability under this guarantee thereafter.

We, _____ (indicate the name of the Bank) further agree with the Employer that the Employer shall have the fullest liberty without our consent and without affecting in any manner our obligations hereunder to vary any of the terms and conditions of the said Contract or to extend time of performance by the said contractor(s) from time to time or to postpone for any time or from time to time any of the powers exercisable by the Employer against the said contractor(s) and to forbear or enforce any of the terms and conditions relating to the said Contract and we shall not be relieved from our liability by any reason of any such variation or extension being granted to the said contractor(s) or for any forbearance, act or omission on the part of the Employer or any indulgence by the Employer to the said contractor(s) or by any such matter or thing whatsoever which under the law relating to sureties would but for this provision have effect of so relieving us.

The Bank also agrees that the Employer at its option shall be entitled to enforce this Guarantee against the Bank as a principal debtor, in the first instance without proceeding against the Contractor and notwithstanding any security or other guarantee that the Employer may have in relation to the Contractor's liabilities.

This Guarantee shall not be determined or affected by liquidation or winding up, dissolution or change of constitution or insolvency of the Contractor but shall in all respects and for all purposes be binding and operative until payment of all money payable to the Employer in terms thereof. This guarantee will not be discharged due to the change in the constitution of the Bank or the Contractor(s).

We, _____ Bank lastly undertake not to revoke this guarantee during its currency except with the previous consent of the Employer in writing.

Notwithstanding anything to the contrary contained hereinabove:

- a) The liability of the Bank under this Guarantee shall not exceed _____⁵
- b) This Guarantee shall be valid up to _____⁶
- c) Unless the Bank is served a written claim or demand on or before _____⁷ all rights under this guarantee shall be forfeited and the Bank shall be relieved and discharged from all liabilities under this guarantee irrespective of whether or not the original bank guarantee is returned to the Bank.

We, _____ Bank, have power to issue this Guarantee under law and the undersigned as a duly authorized person has full powers to sign this Guarantee on behalf of the Bank.

Date _____ Day of _____

for _____ (indicate the name of the Bank)

(Signature of Authorized signatory)

PROFORMA OF BANK GUARANTEE (in lieu of RETENTION AMOUNT)

- ¹ NAME OF THE VENDOR /CONTRACTOR / SUPPLIER.
- ² ADDRESS OF THE VENDOR /CONTRACTOR / SUPPLIER.
- ³ DETAILS ABOUT THE NOTICE OF AWARD/CONTRACT REFERENCE
- ⁴ CONTRACT VALUE
- ⁵ BG AMOUNT IN FIGURES AND WORDS
- ⁶ VALIDITY DATE
- ⁷ DATE OF EXPIRY OF CLAIM PERIOD

Note:

1. Units are advised that expiry of claim period may be kept 3-6 months after validity date. It may be ensured that the same is in line with the agreement/ contract entered with the Vendor.

2. The BG should be on Non-Judicial Stamp paper/e-stamp paper of appropriate value as per Stamp Act prevailing in the State(s) where the BG is submitted or is to be acted upon or the rate prevailing in the State where the BG was executed, whichever is higher. The Stamp Paper/e-stamp paper shall be purchased in the name of Vendor/Contractor/Supplier /Bank issuing the guarantee.

3. In line with the GCC, SCC or contractual terms, Unit may carry out minor modifications in the Standard BG Formats. If required, such modifications may be carried out after taking up appropriately with the Unit/Region's Law Deptt.

4. In Case of Bank Guarantees submitted by Foreign Vendors-

a. From Nationalized/Public Sector / Private Sector/ Foreign Banks (BG issued by Branches in India) can be accepted subject to the condition that the Bank Guarantee should be enforceable in the town/city or at nearest branch where the Unit is located i.e. Demand can be presented at the Branch located in the town/city or at nearest branch where the Unit is located.

b. From Foreign Banks (wherein Foreign Vendors intend to provide BG from local branch of the Vendor Country's Bank)

b.1 In such cases, in the Tender Enquiry/ Contract itself, it may be clearly specified that Bank Guarantee issued by **any of the Consortium Banks only** will be accepted by BHEL. As such, Foreign Vendor needs to make necessary arrangements for issuance of Counter- Guarantee by Foreign Bank in favour of the Indian Bank's (BHEL's Consortium Bank) branch in India. It is advisable that all charges for issuance of Bank Guarantee/ counter- Guarantee should be borne by the Foreign Vendor. The tender stipulation should clearly specify these requirements.

b.2 In case, Foreign Vendors intend to provide BG from Overseas Branch of our Consortium Bank (e.g. if a BG is to be issued by SBI Frankfurt), the same is acceptable. However, the procedure at **sl.no. b.1** will required to be followed.

b.3 The BG issued may preferably be subject to Uniform Rules for Demand Guarantees (URDG) 758 (as amended from time to time). The BG Format provided to them should clearly specify the same.



BHEL-PSSR, SAS Secunderabad
CHECK LIST TO BE SUBMITTED WITH EACH RUNNING BILL (R&M WORKS)

Work Order Ref.		Name of the Agency	
Brief Description of Work :		RA Bill No. & date :	
Sl.No.	DESCRIPTION	Check list (Tick in the box)	Remarks
1) Documents to be submitted by the Contractor with each RA Bill			
1.1	GST number and billing address should be as per work order. BHEL GST and vendor GST should be present in invoice. HSN Code to be specified in the invoice.		
1.2	Bill/Execution period to be mentioned in Invoice		
1.3	Validity of Labour License and Validity of Bank guarantee/FD etc., submitted towards security deposit to be verified before forwarding invoice		
1.4	Supporting Doc-Wage Sheets (with bank confirmation copy)corresponding to bill execution peroid.		
1.5	Supporting Doc-PF corresponding to bill execution peroid.		
1.6	Supporting Doc-ESI/Insurance corresponding to bill execution peroid.		
1.7	Supporting Doc-HR Format		
1.8	Form-14s for the peroid corresponding to bill execution peroid.		
1.9	WAM-06 jointly prepared by contractor and BHEL Resident engineer.		
1.10	Measurement sheet duly signed by contractor with certification from Resident engineer and Site In-charge.		
1.11	Control Register duly signed by contractor. Soft copy in Microsoft excel format to be forwarded to SAS-Finance department.		
1.12	Protocols related to works as mentioned in invoice. Protocols for milestone activities in case billing is done towards milestone activities.		
1.13	Corresponding LR copies, packing list and DBR register for processing material handling bills.		
1.14	Copies of relavant Indicies while claiming PVC bills.		
1.15	GST Remittance proof		
1.16	Contractor signed in M-Book with "Measurement accepted" with stamp.		
1.17	If the contract period has expired during execution period, vendor to give request for work order extension so that delay note proposal can be initiated by Resident Engineer. As far as possible, M Book entry / Invoice, should be made only after extension of contract to avoid delay in further processing of the bills.		
2) Additional documents to be submitted by the Contractor (in addition to listed at sl. No. 1.1 to 1.17) with First RA Bill			
2.1	Proof of SD remittance (copies of BG, FD, EFT etc.,)		
2.2	Contract agreement copy		
2.3	Letter from contractor regarding option for performance bank guarantee		
2.4	Letter regarding date of start of works certified by resident engineer		
2.5	Power of attorney for contractor representative		
2.6	E Remittance letter		
3) Additional documents to be submitted by the Contractor (in addition to listed at sl. No. 1.1 to 1.17) with Final RA Bill			

3.1	Material reconciliation duly signed by contractor and BHEL resident engineer.		
3.2	WAM-07 jointly prepared by contractor and BHEL Resident engineer.		
3.3	No Dues certificate from customer.		
3.4	No further claim certificate from contractor and certification of no further claim in M-book		
3.5	Date of completion of works (MOM)/ Date of handing over of unit (customer protocol) for considering completion date.		
3.6	Idemnity bond as per the SCC & GCC.		
3.7	Request letter along with SD refund form (GCC) for refund of SD & Performance bank guarantee.		
Signature of contractor			

Sl.No.	DESCRIPTION	Check list (Tick in the box)	Remarks
4. Certifications to be done by BHEL Resident Engineer / Site Incharge			
4.1	To ensure Compliance of all the points listed at Sl. No. 1, 2 & 3 above		
4.2	Ensure Invoice is as per the WO payment terms. Part payments not allowed without approvals. Recoveries/amount to be withheld if any, with reasons to be specified in M-book and claim to be generated accordingly with supporting documents. In case of recommendations for recoveries/amount to be withheld, Vendor's acceptance should also be taken in M-Book to avoid dispute at later stage.		
4.3	If there is any delay in completion of works w.r.t work order completion peroid, request for work order extension should be taken from the vendor and delay note proposal should be initiated. It has been obsrved that delay note approval is taking approx. one month time as the same is to be scrutinised at various level before final approval by Competent authority. Therefore, Proactive action should be taken to initiate delay note around one month prior to contract expiration date.		
4.4	Execution period corresponding to invoice to be certified in M-book.		
4.5	RAB No. & WO Ref. to be certified in M-book.		
4.6	Certification regarding payment, deployment of T&P as per the work order in M-book duly signed by Resident Engineer & Site In-charge.		
4.7	Certification on original invoice.		
4.8	Claim generated and signed by Resident Engineer & Site In-charge.		
4.9	Entry to be made in Payables Management System (PMS) & acknoweldgmnent number generated in PMS to be mentioned in the claim generated.		
BHEL Resident Engineer/Site Incharge			