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ASSAM POWER GENERATION CORPORATION LIMITED

BIDDING DOCUMENTS

(NATIONAL COMPETITIVE BIDDING)

FOR

ELECTROMECHANICAL WORKS CONTRACT PACKAGE FOR KARBI LANGPI MIDDLE-II HYDRO POWER PROJECT (24 MW) (ASSAM, INDIA)

Bid No: KLM-II-HPP/PKG- 3

ELECTROMECHANICAL WORKS

VOLUME-III

Technical Specifications

May 2026

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1. SCHEDULE OF REQUIREMENT

The following is the scope of work of Contractor, which includes the Design, manufacture, procurement, supply, fabrication, shop assembly, painting, shop testing, transportation, insurance & delivery to project site, receipt & storage at site, erection, testing & commissioning including packing & forwarding for shipment and trial operation, as built drawings and instruction manuals of Goods as detailed in Technical Specifications or elsewhere. The equipment / systems / Services to be furnished shall consist of mainly, but not be limited to, the following. All accessories, fittings, indicating, signaling instruments, etc. are to be supplied and installed, though all of them may not be detailed explicitly in the description below. Contractor shall note that the price shall be quoted for the following scope of work in the format, provided in Price Schedule of Specification.

2. SCOPE OF SUPPLY AND SERVICES/WORKS

Sl. No.	Brief Description of "Goods"	Quantity
1.	**Turbine & its Accessories**	
a.	Horizontal Axis Francis turbine (428.6 RPM) and accessories comprising of Runner, adjustable guide Vanes, turbine Shaft, indicating and recording instruments, Control & Safety Devices, Lube Oil System, piping etc., complete with its associated Spiral Casing & other accessories, including embedded and foundation parts, Instruments, complete in all respects to develop rated output of 8.0 MW at rated net head and capable of delivering a continuous output of 110% of rated output at rated net head & discharge at Generator terminal	3 sets.
b.	Draft Tube, Draft Tube Cone, Elbow, Spiral Casing, Stay rings and other embedded and foundation parts with foundations bolts and embedded pipes, etc.	3 sets
c.	Guide apparatus complete with Side Cover, bottom ring with guide vane bearings, guide vanes, levers, links, operating mechanism, servomotors, bearings, bushes etc.,	3 sets

d.	Draft Tube, supports, anchor bars, embedded and exposed piping complete with fitting, flanges, valves, bolts, nuts etc.	3 sets

e.	Rotating assembly complete with shaft, runner, shafts seals, bearing assembly, complete with bearing elements aligning mechanism, end cover etc.,	3 sets
f.	Speed sensing gear, Mechanical over speed switch & feedback transducer assembly	3 sets
g.	Digital electronic governor and governing equipment complete in all respects for optimizing and controlling the turbines.	3 sets
h.	Common Pressure Oil system (OPU) complete with pumps, motors, valves, nitrogen-based oil pressure accumulators, piping, associated electrical system etc., for actuating guide vanes for Governor and Butterfly Valve.	3 sets
i.	Cooling water system complete with main and standby pumps sets, motors, valves, piping, necessary cabling, motors starters, alarms & safety devices etc.,	3 set
j.	Station drainage & de-watering system complete with main and stand by Vertical turbine / submersible pump sets, motors, valves, piping, necessary cabling, motor starters etc	1 set
k.	Compressed Air System	1 Set
l.	Mechanical Workshop Machine tools, hand tools, measuring devices, testing devices, and accessories etc.	1 Lot
m.	Bed plates, base frames, foundation bolts etc., for all equipment	3 sets
n.	Instrumentation, control and safety devices such as pressure gauges, flow indicators, guide vanes position indicators, limit switches, gates position indicator, for complete instrumentation, including transducers, recorders, annunciators, control and safety of the goods as per the list of indicating and recording devices.	3 sets
2.	**Generator and Excitation System**	

a.	Horizontal Axis synchronous generator of 3 phase 11 kV, 50 Hz, 0.85 p.f lag, 8.0 MW with 10% continuous inherent overload capacity, Class F insulation with temperature rise as stipulated in specification and designed to withstand runaway speed for 15 minutes (without water supply to bearing), coupled directly to the turbine complete in all respects and consisting of followings:	3 nos.
i)	Stator complete with frame, punching and windings	3 nos.
ii)	Rotor complete with shaft, spider rim, poles with winding, rotor fan for cooling and accessories and pedestal bearings.	3 nos.
iii)	Static Excitation system and Digital voltage regulation equipment (AVR panels)	3 sets
iv)	Control Panels & Annunciation Panel	
a.	LAVT panel (11 kV) Consisting of following:	
	i. Single Phase, Two Core, PT for metering, synchronising and protection	9 Nos.
	ii. Single Phase, Single Core, PT for AVR and Voltage Balance Relay Circuit	9 Nos.
	iii. 10 kV, 10 kA, Single Phase Lightning Arrester (LA) for Lightning Protection and capacitance for surge protection	9 Nos.
	iv. Current Transformer (CT) Single Phase, 600/5A, 3 core for protection	9 Nos.
	v. Current Transformer (CT) Single Phase, 50/1A, 3 core for protection	9 Nos
b.	Generator neutral grounding transformer cubicle with 600/5A and 5 core CT's	3 Sets
c.	Generating Unit & its auxiliaries control panel (UCB)	3 sets
d.	Generator Relay, metering Protection Panel	3 sets
3.	**Auxiliary Transformers**	
a.	Unit Auxiliary Transformer, Dry Type, 3 phase, 250 kVA, 11 kV/0.415 kV, 50 Hz with all acces	3 nos.

	sories.	
b.	Station service Transformer, ONAN type, 800kVA, 33/0.415 KV 50 Hz with all accessories	1 no
c.	Auxiliary Transformer for Barrage ONAN type, 250kVA, 33/0.415 KV 50 Hz with all accessories	1 no
d.	Auxiliary Transformer for Colony ONAN type, 500kVA, 33/0.415 KV 50 Hz with all accessories	1 no
4.	**Medium Voltage Switchgear**	
a	33KV Switchgear with incoming and outgoing breakers complete with bus bar chamber, supports, wiring terminals, blocks, fuses, labels, interlocks & metering as specified	1 no
5	**415V Low Voltage Switchgear**	
a	415 V Station Service Board with LT breaker, and outgoing MCCB's complete with bus bar chamber, supports, small wiring terminals, blocks, fuses, labels, interlocks & metering as specified	1 set
b	415 V Unit Auxiliary Board with LT breaker, and outgoing MCCB's complete with bus bar chamber, supports, small wiring terminals, blocks, fuses, labels, interlocks & metering as specified	3 sets
6.	**Control & Protection System**	
a	Protection System comprising of Numerical relays and metering for Generator Units, Generator Transformers, Switchyard and transmission lines etc	1 Lot
7	**Control and Monitoring System (SCADA)**	
a	Supervisory Control and Data Acquisition System (SCADA) with engineering operator work stations in control room, UPS for SCADA	1 Lot
	for complete power system control for 3 units	
8	**DC System**	

a	220 VDC, 400 AH, VRLA Battery along with battery charger and DC distribution boards and necessary DC to DC converter	1 Lot
9	**Power & Control cables and cable trays**	
	Control, Instrumentation and power cables of various rating and sizes and 11kV and 33kV power cables including 11 KV unearthed XLPE cable for connection between generator and other equipment and cable trays and accessories for complete works	1 Lot
10	**Illumination System**	
	Powerhouse / Switchyard, Barrage, Intake area and outdoor area illumination and Emergency Lighting (DC supply)	1 Lot
11	**Earthing System**	1 Lot
	Earthing system with MS rods, bolts, nuts, washer, earth electrodes etc. (for powerhouse, switchyard, Barrage, intake area etc.)	1 Lot
12	**Emergency Diesel Generator Sets**	
	250kVA DG set with AMF panel and all other accessories and Acoustic enclosure	1 set
13	Communication System	1 Lot
	Plant Communication System(VoIP) and Public Address System, CCTV & Surveillance System including UPS for Powerhouse, Barrage and Switchyard	1 Lot
14	33 KV Switchyard	
a	33 kV Switchyard equipment for Generating end switchyard (Complete with the supporting Structures & Accessories) consisting of following:	1 lot
b	33 kV, 1250 A, 25 KA triple pole, VCB, complete with operating mechanism, terminal connector and mounting structures & marshalling box.	6 nos.
c	33 kV, 1250 A, 25 KA triple pole, horizontal double break, hand operated isolators (with earthing switch) complete with operating mechanism, terminal connector and mounting structures & marshalling box.	6 nos.

d	33 kV, 1250 A, 25 KA triple pole, horizontal double break, hand operated isolators (without earthing switch) complete with operating mechanism, terminal connector and mounting structures & marshalling box.	1 no.
e	33 kV, 200/1 ratio, Single Phase, 50 Hz, 4 Core, current transformers complete with terminal connector, junction boxes & mounting Structure.	12 nos.
f	33 kV, 600/1 ratio, Single Phase, 50 Hz, 5 Core, current transformers complete with terminal connector, junction boxes & mounting Structure.	6 nos.
g	33kV single phase, three Core (33kV/Sqrt3)/(110V/Sqrt3)/(110V/ Sqrt3)/(110V) Electromagnetic voltage transformers (for Bus) suitable for star/ Star/ Delta connections complete with protection Fuses, terminal connectors, junction boxes, mounting structure etc.	6 nos.
h	33kV single phase, three core (33kV/ Sqrt3)/(110V/Sqrt3)/(110V/ Sqrt3)/(110V)Electromagnetic voltage transformers (for line) suitable for star/ Star/ delta connections complete with protection Fuses, terminal connectors, junction boxes, mounting structure etc	6 nos.
i	Single phase, 30 kV, 10 KA nominal discharge current non-linear metal oxide surge arresters complete with insulating base, surge counters, Structure) leakage currentindicators, terminals connector, mounting structure	18 nos.
j	33 kV post insulators complete in the terminal connector & mounting structure	1 lot
k	33 kV Porcelain Insulator Strings complete with fittings	1 lot
l	Conductors, Ground wire, tubular bus, clamps and connectors	1 lot
15	**33kV Overhead line from Powerhouse to Barrage (~ 3km)**	1 Lot
16	**Electrical Workshop**	
	Machine tools, hand tools, measuring devices, testing devices, and accessories etc.	1 Lot
17	**45/10T EOT Crane pendant operated with all controls**	1 lot
18	**Main Inlet Butterfly valve (2000 mm diameter)**	3 Nos.

19	**Fire Fighting System**	
	Firefighting system comprising fire stations with rack/reels, hoses, nozzles, fire alarm system with panels, pumps, valves, pipings, portable fire extinguishers, waterfilled/sand filled buckets etc. mandatory as per TAC complete for power house.	1 lot
20	Heating, Ventilation & Air-Conditioning (HVAC) System Spilt type Air conditioning equipment for Powerhouse control room, Office and Conference Room, Ventilation equipment for powerhouse	1 Lot
21	**Erection/Maintenance tools & tackles**	1 Lot

2.1. Miscellaneous Equipment / Items

S. No	Equipment/Items	Quantity
1	Mandatory spares for all items as per Technical Specifications	1 Lot
2	Mandatory Tools & Plants for all items as per of Technical Specifications	1 Lot
3	Field Instruments and Receiving Instruments;	As required
4	Complete Monitoring and Safety Instruments pertaining to the TG set;	3 sets
5	First fill of Oil for all equipment supplied, with 10% extra;	As required
6	Storage, Transportation to place of erection, Erection, Testing and Commissioning of all equipment;	As required
7	Field efficiency testing of Turbines-Generators and required testing equipments	1 lot
8	Training of Employer's Personnel	As required

9	As-built drawings & documents for various Systems / Equipment.	As required or specific
10	Part Manufacturing Drawings for major wearing parts / components;	As required
11	Instruction Manuals for Operation & Maintenance.	As required
12	Repair procedure for underwater parts i.e Spiral, Guide vanes, Runner etc.	As required
13	Commissioning Procedures and Reports	As required
14	Any Additional Spares, as recommended by Bidder required for 5-year trouble free operation over and above Mandatory Spares. List to be furnished along with price for consideration of the Employer.	As recommended. (Optional)

OTHER INFORMATIONS AND NOTES

1. The specifications and accompanying drawings are intended to describe and provide a finished piece of work. It is to be understood and agreed by Contractor, that the work desired shall be complete in detail, even though every item involved is not particularly mentioned. Contractor shall be required to provide all materials, equipment, labour, etc. necessary for the entire completion of the work described and shall not avail himself of any manifesting unintentional error, omission or inconsistency that may exist. Contractor shall carry out and complete the work in every respect to the satisfaction of Employer. The work shall meet the requirements laid down by Employer / Engineer, latest local regulations of state, safety codes, fire and general insurance regulations and all other standards accepted practices.

2. This specification calls for execution of the Work in the most expeditious manner so as to ensure successful and timely commercial operation of the equipment installed. It is essential that Contractor has adequate experience for supply / erection / commissioning of similar equipment under his direct responsibility and supervision. It must have in its possession, adequate quantity of precision tools and erection / installation aids and must have on its direct roll, adequately qualified and experienced supervisory staff and craftsmen.
3. Contractor shall supply the equipment from reputed and experienced manufacturers. Preferred makes of major equipment shall be as per approved Vendors list. In case of any deviation, bidder to submit list of preferred vendors for Owners approval.
4. The Bidder shall furnish main offer as per above details, for the purpose of evaluation. However, the Bidder can make an alternative, if desired, for consideration of owner along with all the required information.
5. Cost of additional Spares recommended by Bidder over and above Mandatory Spares will not be used for Price Comparison of Bid but will be used for guidance of the Employer. Employer reserves his right to accept / reject in part or total the offer for spares.

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1. SCOPE

The Tenderer shall quote for the scope specified in the Contract including the "Technical Specifications" and shall include in the scope all the equipment and services required for the project in full and complete shape even though some of the equipment and services are not specifically mentioned (or) detailed here or elsewhere so that the units and auxiliaries are functionally complete in all respects. The Contractor shall perform all such work and/or supply all such items and materials not specifically mentioned in the Contract but that can be reasonably inferred from the Contract, as being required for attaining completion of the project, as if such work and/or items and materials were expressly mentioned in the Contract.

Bids are invited for Design, manufacture, procurement, supply, fabrication, shop assembly, painting, shop testing, transportation, insurance & delivery to project site, receipt & storage at site, erection, testing & commissioning including packing & forwarding for shipment and trial operation, Unloading/storage/transportation at site, of Electro-Mechanical Equipment for 3 x 8 MW Karbi Langpi Middle II Hydro Power Project.

The Goods and Services shall meet the stipulations of the "Technical Specifications "and other requirements of the Contract.

The final destination for "Goods" to reach is: 24 MW Karbi Langpi Middle II Hydro Power Project Site, West Karbi Anglong

1.1. SALIENT

Salient features of Karbi Langpi Middle-II HPP are presented in the following table below:

1	**Head Works**	
1.1	**Barrage Complex (General)**	
1.1.1	**Location**	**River Borpani West Karbi Anglong district of Assam.**
1.1.2	**Type of Barrage**	**Conventional Barrage**
1.1.3	**Top of Barrage (Pier)**	**EL 392.00 m**
1.1.4	**Full reservoir level**	**EL 385.50 m**
1.1.5	**Maximum Water level**	**EL 390.44 m**
1.1.6	**Minimum draw down level**	**EL 385.50 m**
1.1.7	**Flood (1 in 500 year)**	**4670 Cumec**
1.1.8	**Flood (1 in 100 year)**	**3160 Cumec**
1.1.9	**Crest Level**	**EL 375.00**
1.1.10	**No of Gates**	**4 No's**
1.1.11	**Gate Type**	**Radial Gate**
1.1.12	**Size**	**10.0 m (W) x 10.50 m (H)**
1.1.13	**Hoisting arrangement**	**Hydraulic Hoist**
1.1.14	**No of Stop log gates**	**1 Set of 4 Bays**

1.2	River Diversion Scheme	
1.2.1	River Diversion Flood	360 Cumec (25 Years Return Period Non-Monsoon Flood)
1.2.2	Diversion Channel	5 m wide,
1.2.3	Height of Upstream side Coffer dam	8.50 m
1.2.4	Height of Downstream side Coffer dam	8.62 m
1.2.5	U/S coffer dam top El	383.65 m
1.2.6	D/S coffer dam top El	383.00 m
1.3	Power Intake	
1.3.1	Location	Right bank
1.3.2	Design discharge at Trash Rack	47.60 cumec (Design discharge) 52.36 Cumec (10% overload)
1.3.3	Design discharge for main Plant	52.36 Cumec (10% overload)
1.3.4	No of trash rack bays	3 No's
1.3.5	Trash rack sill level	EL 380.0 m
1.3.6	Trash rack opening size	4.2m (W) x 12.0m (H)
1.3.7	Type	Fixed
1.3.8	Trash rack inclination	12o
1.3.9	TRCM	No
1.3.10	No. of gates	2 no. (1- Service & 1- Emergency.)
1.3.11	Gate size	6.2 m (W) x 4.0 m (H)
1.3.12	Crest Elevation	EL 377.00 m
1.3.13	Type of Intake Gate	Vertical slide
2	Water Conductor System-Main plant	
2.1	Feeder Tunnel/Duct	
2.1.1	No. of Feeder Tunnels	One
2.1.2	Feeder Tunnel	Transition+5.2m D-Shaped
2.1.3	Concrete lined	Yes
2.2	Head Race tunnel	
2.2.1	No.	One
2.2.2	Design discharge (Rated)	47.6 Cumec
2.2.3	Shape & Size of HRT	D-Shaped, 5.2 m Día
2.2.4	Length	3065.0 m
2.3	Adit to HRT	
2.3.1	No.	Two
2.3.2	Size & Shape	Adit- 1: 4.5 m, Adit- 2: 4.5 m D-Shaped
2.3.3	Length of Adit	80.0 m,96.85 m
2.3.4	Adit gate - Hinge Type	No (concrete plugged)
3	Surge Shaft	
3.1	Type	Elevated, Restricted Orifice Type
3.2	Diameter	15.00 m (Finished)
3.3	Minimum Down surge level	EL 373.00 m
3.4	Maximum Up-surge level	EL 395.50 m
3.5	Reinforced concrete lining	Yes

3.6	Dia of Orifice (including gate grooves)	2.8 m
4	Pressure shaft Embedded in Concrete	
4.1	Pressure Shaft	
4.1.1	No.	One
4.1.2	Size & Shape	3.70 m, circular
4.1.3	Length (up to trifurcation)	43.8 m
4.1.4	Steel lined	Yes
4.2	Unit Pressure shaft (after trifurcation)	
4.2.1	No.'s	Three
4.2.2	Diameter	2.2 m
4.2.3	Total length (Longest unit pressure shaft)	80.44 m
4.2.4	Concrete encasement	Yes
4.3	Inlet Pipe (reducer)	
4.3.1	No.'s	Three
4.3.2	Diameter	2.2 m
4.3.3	Concrete encasement	Yes
5	Power House Complex	
5.1	Main Power House	
5.1.1	Type & Location	Surface & Right Bank
5.1.2	Type of turbine	Horizontal Francis
5.1.3	Installed Capacity	3 x 8 MW = 24 MW
5.1.4	Centre line of Turbine	EL 315.55 m
5.1.5	Normal TWL	EL 320.4 m
5.1.6	Min TWL (For one Unit)	EL 319.8 m
5.1.7	Top of Tail Race Channel Outlet Weir	EL 319.5 m
5.1.8	Minimum Size (Machine Hall including service bay)	52.0m (L) x 17.0 m (W)
5.1.9	Rated Gross Head	65.1 m
5.1.10	Head Loss through Water Conductor System	8.0 m
5.1.11	Rated Net Head	57.1 m
5.1.12	Rated Discharge Per Unit	15.87 Cumec
5.1.13	Service Bay Level	EL 327.00m
5.1.14	HFL at Powerhouse	EL 325.50 m
6	Tailrace	
6.1	Tailrace for Main Powerhouse	
6.1.1	Width of Tailrace	33.2m
6.1.2	Tailrace Ducts	Three separate ducts merging into one common duct
7	Switchyard	
7.1	Voltage Level	33.0 kV
7.2	Size	33.0m x 40.1 m
7.3	Scheme	Outdoor
7.4	Finished Ground Level	EL 335.00m

1.2. TRANSPORT LIMITATIONS

The equipment shall be manufactured and supplied so as to suite transport limitations including Trailor weight and packing material for heaviest package. The bidders are advised to visit the site to have detailed information about roads, railways & bridges along with to have a detailed route survey plan from manufactures point to the project site.

1.3. INTERCHANGEABILITY

All similar component parts of similar equipment supplied shall be interchangeable with one another.

1.4. DEVIATIONS FROM SPECIFICATIONS

1. Should the Tenderer wish to depart from these specifications, he shall submit a complete and itemized list of such departures together with full particulars of the reasons for the departures in a separate schedule with reference to section and paragraph numbers of these tender specifications along with this Bid.

2. Unless this is done the Goods offered shall be deemed to comply in every respect with this Tender document. The statement of departures shall be made as a separate Schedule to the Tender.

1.5. APPROVAL OF DRAWINGS

1. Successful Tenderer shall start submitting all relevant drawings for fabrication/ installation along with design calculations of components (four copies each for hard along with soft copy) of equipments within four (4) weeks from the issuance of NTP, for approval. The approval of the drawings shall be accorded within two (2) weeks to be checked of receipt of the drawings. After approval of the drawing by the Employer/Engineer, each drawing becomes a Contract drawing. The contractor shall thereupon furnish Employer/Engineer with four (4) prints and one reproducible/soft copy of the drawings, which shall include the appropriate revision number after incorporating all corrections. The Contractor shall not depart from contract drawings except by the written permission of the Employer/Engineer.

2. Manufacture of the Goods to commence only after receipt of drawing approval. Any manufacture performed prior to the approval of drawings will be at the Contractor's risk.

3. When revised drawings are submitted for approval, the changes from the previous submitted drawings shall be clearly identified on the drawings, with every revision made during the lifetime of the Contract shown by number, date and subject in a revision block and its notation

shall be given in the drawing margin. The drawings shall be clear and legible in all respects.

4. The drawings shall be clear, facilitating easy identification of all parts with part number for ordering of spares by the Employer without referring to Contractor.
5. Approval of the drawings will not relieve the Contractor of his responsibility for the correctness of the design and construction of the plant, guarantees and warrantees on the performance of the Goods as per the terms and conditions of the specifications.

6. All drawings must be prepared on AutoCAD2002 or above and supplied in soft copy also along with six hard copies for each drawing.

1.6. TRAINING OF EMPLOYER PERSONNEL

The contractor shall give training to the Employer personnel in full, extend complete practical training for operation and maintenance, repair of equipment at its works as well as site also.

1.7. LOCATION AND PROJECT ACCESSIBLITY

The proposed Karbi Langpi Middle -II HPP is located near the village Morinto, in Karbi Anglong district of Assam. The project will be located upstream of existing Lower Langpi HEP (100MW) and is one of the four identified upstream projects. The village Morinto can be approached by motorable road from Amsoi which is connected by NH-37. The project road will be required to approach barrage and powerhouse sites from village Morinto. The powerhouse site will be located on the opposite bank of the exiting road. To approach barrage site about 3.6 km of access road will be required from village Morinto. The same road will be extended from downstream of barrage site to approach powerhouse site. A bridge and a road of about 3.4km along the right bank of river will be required to approach the powerhouse site. Presently, barrage and powerhouse sites are approachable with the help of footpaths.

The village Morinto is about 22km from the nearest town called Langeri. Most of this stretch of road is blacktopped with the exception of about 5km of katchha road. Langeri town is connected by NH-37 with Guwahati and is at a distance of about 117km. Guwahati is well connected by air, rail and road networks with other parts of the country. The project site is about 139kms from Guwahati. The nearest broad-gauge rail head is Jagiroad and is about 94kms from the powerhouse site.

1.8. TOPOGRAPHY AND PHYSIOGRAPHY OF THE BASIN

Umkhem/Borpani River is a left bank tributary of River Kopili. It originates near the village Laitker in the District East Khasi Hills of the State of Meghalaya with the name of Umkhen and finally meets River Kopli in Assam after flowing for a total distance of about 139 kilometres. Total catchment area of Borpani River up to its confluence with kopli is 2326 km^2 and up to the proposed barrage site is 1090. 0km^2.The entire catchment is rain fed and lies below permanent snowline, considered at El 4500m. The highest elevation in the catchment is 1891m and most part of the catchment area is under mild to moderate slope, leaving aside

small patches near the ridge area towards the southwest which has extremely steep slopes of 50% or larger. The major portion of the basin is under forest cover. The elevation in the project area varies from 600 to 300m.

1.9. GEOLOGY

The project area falls in the Archean basement terrain of Mikir hill. The Archean group of rocks mainly consists of prophyritic granite, granites, granite gneiss with its variants like biotite gneiss, biotite-hornblende gneiss and quartzose gneiss. There are few rock exposures in the project area which are present near the river while the slopes are mostly covered with scree/ slopewash material covered with dense vegetation cover.

Based on available geological data including the surface geological mapping and geotechnical investigations completed for the project structures, the site may be considered suitable for construction of project components. No adverse geological features have been observed and noted during the geological mapping and investigations. The project area may be categorized to the extent of having satisfactory geological conditions.

Similar to Lower Kopili HEP (120 MW), the Karbi Langpi HPP area lies in the Seismic zone 'V' of India as incorporated in the Indian Standard Criteria for Earthquake Resistant Design of Structures (IS: 1893 Part 1-2002). According to "Seismotectonic Atlas of India and its Environ (SEISET-14)" the Dhansiri-Kopili Fault trending NW-SE passes along the Kopili river for a distance of approximately 40 km from theproject area.

1.10. CLIMATIC CONDITION

The project catchment experiences moderate summers & winters and are in sub-tropical agro climatic zone. The region experiences four seasons viz., the winter (starting from late November and continuing up to March), the Pre- Monsoon (April and May), South-West Monsoon (end of May to September) and Post Monsoon (October to beginning of November). Temperature in the region varies generally from a maximum of 23°C to 32°C in summer to a minimum of 6°C to 12°C in winter. Summer in Karbi Anglong is hot, humid and sultry. During winter the area experiences fog and mist. The average relative humidity varies between 73% and 84%.

The average annual rainfall in the catchment is 2484.8mm. June to October has been considered as monsoon period and November to May has been considered as non- monsoon period.

1.11. EXISTING INFRASTRUCTURE FACILITIES

NH37 is a stable road well maintained by NHAI. This road follows flat land up Amsoi with vegetation and habitation on both sides of the road. After Amsoi the 41 kms long motorable road is leading the way to APGCL guest house at Langeri. The road enters hilly terrain after crossing Langeri. There is a stretch of

22 kms from Langeri to Morionto. It is assumed and expected that this stretch of road shall be improved by various operational schemes by various State/Central Govt. agencies e.g. National Rural Employment Guarantee Scheme (NREGS) or Pradhan Mantri Gram Sadak Yogna (PMGSY) etc. There is a Govt. dispensary with basic facilities of health care, primary Govt. school & banks are available at nearest town Langeri, which is about 22 kms from Morinto village. There is an existing petrol pumping station near Baithalangso, which is about 25 km from the Morinto village.

1.12. SURVEY & INVESTIGATION

The following topographical surveys were carried out for project layout, geological mapping & planning of infrastructure and construction facilities etc.

i) Survey of India Topo sheet (Scale 1:50,000)

Survey of India topo sheet no. 83-C/5 which covers all the components of the project area while other topo-sheets 83-C/1, 83-C/2, 83-C/3, 83-C/6 and 83-C/9 were used for the catchment area.

ii) Topographical Maps 1:2,000 of the entire Project Area with a contour interval of 2.0m.

iii) L-Section of Borpani river covering 500 m downstream of powerhouse area to 500mupstream of the weir axis.

iv) River cross section at Barrage axis was prepared on 1:1000 at 25m interval for 100mupstream of the weir axis.

v) River cross section at Barrage axis was prepared on 1:1000 at 25m interval for 50mdownstream of the weir axis.

vi) River cross section at powerhouse axis was prepared on 1:1000m for 50m upstreamof the powerhouse location.

vii) River cross section at powerhouse axis was prepared on 1:1000m for 50m downstream of the powerhouse location.

A total of 12 drill holes have been drilled for the different project components to assess the geotechnical competence.

1.13. CIVIL ENGINEERING STRUCTURES

The following are the main civil engineering structures of the project (Refer

Tender drawings for sizes and dimensions):

- The River Diversion Scheme comprises a Single Stage Diversion Channel designed for managing non-monsoon floods, specifically handling a 360 Cumec flow with a 25-year return period, and involves the use of Rockfill Dams as coffer dams, featuring specific dimensions for effective water control.The Barrage Complex, situated on the River Borpani in the West Karbi Anglong district of Assam, is a Conventional Barrage with a crest level at EL 375.00 m, designed to handle a flood of 4740 Cumec; it features 6 Radial Gates (7.0 m W x 10.50 m H)

  operated by a Hydraulic Hoist, and employs a Sloping Stilling Basin for energy dissipation.The Power Intake is situated on the right bank and incorporates a Trash Rack with 3 bays featuring specific dimensions and design features; it also includes a Vertical Slide-type Intake Gate with 2 gates.The Water Conductor System for the main plant features a 3065.0m long, D-shaped Head Race Tunnel with a 5.2m diameter, starting downstream of the Intake and terminating at the Surge Shaft, with proposed shotcrete lining; access to the Head Race Tunnel is facilitated through two adits.An open-to-air Surge Shaft with a diameter of 15.00m and a height of 30m (Approx.), designed as a Restricted Orifice Type, is proposed upstream of the powerhouse to manage surge waves and water hammer pressure, featuring a reinforced concrete lining.The Pressure Shaft system consists of one main pressure shaft with specific dimensions and features, trifurcating into three-unit pressure shafts, each with a diameter of 3.7m. An adit is proposed for access to the Surge Shaft, facilitating transportation and erection of steel liner/bifurcation manifolds in the systemThe Main Power House, located on the right bank and of surface type, features Horizontal Francis turbines with a combined installed capacity of 24 MW, operating at a rated gross head of 65.1 m and a net head of 57.1 m, with a rated discharge of 15.87 Cumec per unit, and specified dimensions and elevation levels.The Tailrace for the Main Powerhouse comprises a tailrace with a width of 33.5m, featuring three separate ducts that converge into a single common duct, necessary for maintaining the required tail water levelsSwitch yard.

  To support the construction and operation of the project components, access roads have been proposed for the Switchyard, which operates at a voltage level of 33.0 kV, with dimensions of 33.0m x 40.1m, following an outdoor scheme, and located at a finished ground level of EL 335.00m.

1.14. INFRASTRUCTURE & CONSTRUCTION FACILITIES

The main infrastructure works envisaged are as follows:

i) About 2708m of Project Road (PR-1) from bifurcation from PWD road to Powerhouse at right bank

ii) About 379m of Project Road (PR-2) from junction point on PR-1 to surge shaft at right bank

iii) About 2971m of Project Road (PR-3) from Morianto village to Barrage axis at left bank

iv) One temporary bailey bridge (span of 35m to 45m) at 100m d/s of Barrage site to provide access from left bank to right bank and also to access the Adit-1

Portal.

v) About 400m of Temporary Project Road (TR-1) from Powerhouse to Adit-2 at right bank

vi) About 488m of Temporary Road (TR-2) from Bailey Bridge to Barrage at right bank

vii) About 177m of Temporary Road (TR-3) from Bailey Bridge Adit-1 at left bank

viii) Temporary roads to quarry site locations, Crusher plant, Concrete batching plants, Muck Disposal Area, Explosive Magazine site

ix) All temporary buildings for site offices for the contractors including their labour etc. Arrangements etc. have been planned on left bank. Limited muck disposal has also been planned on theright bank.

x) Construction power may be drawn from nearest substation by laying 3 kms of 11kV transmission line. The dependability of construction power shall always be the key concern and hence adequate back-up arrangement estimated as 1.5MW shall have to be made for providing construction power to carry out uninterrupted construction activities.

xi) The boulders and pebbles transported by the river shall be used as a construction material at Barrage and powerhouse sites, in situ rock at Barrage site can also be advantageously used as construction material after due processing.

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1. GENERAL TECHNICAL REQUIREMENTS

1.1. GENERAL

This part covers the general technical conditions and requirements supplement to all the Technical Specifications and requirements brought out in the accompanying Technical Specifications. Contractor's proposal shall be based on the use of equipment and materials complying fully with the requirements specified herein. Alternative proposal offering similar equipment based on the manufacturer's standard practice will also be considered if such proposals fully meet the required specific design, standard and performance requirements.

Note: This section in General Technical Requirements is general in nature and is applicable to all the equipment whether covered in this contract package or other packages, and thus some specific clauses may not be relevant and thus apply as applicable.

1.2. STANDARDS

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 and/or other standards and the specifications, the later shall govern. Such codes and/or standards referred to shall mean the latest additions, amendments/changes adopted and published by the relevant agencies. In case of any further conflict in this matter, the same shall be referred to Engineer, whose decision, if given in writing, shall be implemented.

Other internationally acceptable standards which ensure equal or higher performance than those specified herein shall also be accepted provided that the Contractor submits for approval the detailed standards which he proposes to use.

All works shall conform to rules in force under Electricity Act/Rules and other legislation applicable at the place of works.

If requested by the Engineer, the Contractor shall supply at his own expense three copies in English and one in the original language of any standards, which are applicable to the Contract.

1.2.1. Standards for General Application

Standard publications issued by the following organizations of standardization are considered being approved standards for the works:

Abbrevation	Organization
AISI	American Iron and Steel Institute
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society
IEC	International Electro technical Commission
IEEE	Institute of Electrical and Electronic Engineers
IIW	International Institute of Welding
IS	Indian Standards
ISO	International Standards Organization
ASME	Boiler and Pressure Vessel Code
NFPA	National Fire Protection Association

"Not withstanding reference made to various standards all equipment and works as per provisions and requirements of relevant and latest International Standards or approved equivalent shall be acceptable".

1.2.2. Material Standards

- ASTM American Society for Testing Materials
- AISI American Iron and Steel Institute

The materials to be used in the project shall be new and of first-class quality, suitable for the purpose, free from defects and imperfections, and the classifications and grades in conformance with the latest issue of the respective ASTM, AISI, DIN, BS or other approved standards. Material to other standards may be used if approval by the Engineer has been obtained. Material specifications, including grade or class data, shall be shown on the appropriate detail drawings submitted for review and approval.

If using stock material not specifically prepared for the works under this Contract, the Contractor shall submit evidence that the material complies with the approved standards and that the material is adequate for the intended use.

The Contractor shall indicate in his proposal, the materials and applicable standards for all major parts of the supply. The material specification shall be indicated in the Contractor's detailed drawings.

The materials shall be carefully selected for the intended purpose and due consideration of the site conditions and the tropical weather environment. Higher-grade material shall be used where ordinary material is insufficient.

The use of materials (wood, gyproc, etc.) to be attacked by termites or other insects will not be acceptable.

“Not withstanding reference made to various-standards all equipment and works as per provisions and requirements of relevant and latest International Standards or approved equivalent shall be acceptable".

1.2.3. Electrical Standards

The following basic standards for electrical works or any other approved standard shall be applied:

Abbrevation	**Organization**
IS	Indian Standards
IEC (For specific standards see the Particular Technical Specifications)	International Electro Technical Commission
IEEE	Institute of Electrical and Electronic Engineers
ANSI	American National Standards Institute

1.3. UNITS OF MEASUREMENTS

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

For the purpose of design/calculations if imperial units are used, the equivalent Metric/SI units should be given in brackets.

1.4. WORKS IDENTIFICATION SYSTEM

An approved, uniform Works identification system (tags with colour codes) shall be applied for all mechanical, electrical and Instrumentation and Control (I &C) Works to be agreed upon during detailed design.

1.5. MANUFACTURE AND DELIVERY SCHEDULE

Contractor shall submit to the Engineer its procurement, manufacture and delivery schedules for all equipment and materials within sixty (60) days from the date of the Letter of Award. Such schedules shall be in line with the detailed network for all phases of the work of Contractor and shall be reviewed by Engineer. Contractor shall submit the updated schedules once per month thereafter, to Engineer.

The "Programme" to be submitted shall include the following information

- Design work
- Shop work
- Testing and inspection of works
- Transport to the Site and Delivery
- Storage at site
- Preparations at the Site
- Interdependence with work of other Contractors
- Erection, Pre-Commissioning and Wet commissioning
- Acceptance testing
- Handing over
- Removal of erection equipment and clearing of the Site
- Start and finish dates
- Handover of As-Built drawings, Operation and Maintenance Manuals.

1.6. LIMIT OF CONTRACT

Equipment furnished shall be complete with all mountings, fittings, fixtures and standard accessories normally provided with such equipment and/or needed for erection, completion and safe operation of the equipment as required by applicable Codes though they may not have been specifically detailed in the respective specifications (unless included in the list of exclusions). All similar standard components/parts of similar standard equipment provided shall be interchangeable with one another.

1.7. ENGINEERING DATA

Contractor shall submit the Design Memorandum for all major equipment/system (viz., Metering & Protection, electrical and mechanical auxiliary systems, etc.,) to Employer for review/approval before procurement of equipment. Design Memorandum shall cover design methodology, general description of equipment/specification, data sheets, design calculations, performance curves, technical literature/catalogue, etc., of all major equipment/system. Further, datasheet for all equipment, instrumentation, etc., associated with above system shall also be reviewed / approved by Employer.

All Engineering data and information required by Employer shall be provided by Contractor. The review of these data by Engineer will cover only the general conformity of the data to the specifications and documents, interfaces with the equipment provided under specifications, external connections and dimensions which might affect plant layout. The review by Engineer may not indicate a thorough review of all dimensions, quantities and details of the equipment, materials, any devices or items indicated or the accuracy of the information submitted. This review by Engineer shall not relieve the Contractor of any of his responsibilities and liabilities for mistakes and deviations from the requirements, specified under these specifications and documents.

All engineering data submitted by Contractor after final process including review and/or approval by Engineer shall form part of the Contract documents and the entire Contract covered under these specifications shall be performed in strict conformity, unless otherwise expressly requested by Engineer in writing.

1.7.1. Finite Element Methods (FEM) (As Applicable)

At least the following components shall be calculated using finite element methods (FEM), making sure that the modelling is fully representative of the real geometry, with quadratic elements or better, up to full convergence of stress concentrations:

- Spiral distributor/Casing,
- Runner and runner components, including resonant frequencies of the buckets/blades, as applicable,
- Generator rotor spider and appurtenant equipment:
  - At rest, after rim shrinking,
  - At maximum load,
  - At maximum runaway speed,
- Brackets and bearing supports for critical speed analysis.

Contractor shall provide evidence that the first critical OIL SERVOMOTORSthe unit shaft line is above 125% of the maximum runaway speed, using conservative evaluations of the stiffness of the bearings and bearing supports.

1.8. DRAWINGS

The geographical location and general arrangement of the plant are shown in the drawings in Volume V. The drawings are merely illustrative and can be modified where possible to suit the design of the equipment to be supplied or at the convenience of Employer and/or Engineer with Contractor's agreement to improve the productivity of the plant and/or operation and maintenance facilities, subject to approval by the Employer as detailed below.

As soon as possible but not later than 45 days after the award of Contract, Contractor shall provide layout, general arrangement and detailed drawings sufficiently complete (including the overall dimensions and relative locations) to permit the final design and construction of the civil works to accommodate the equipment and its embedded parts. All other drawings shall be prepared by Contractor at suitable dates so that the delivery schedule required by Employer can be adhered to. Contractor shall submit a complete list of all drawings along with issuance schedule for Engineer's review/approval.

All drawings submitted by Contractor shall be in sufficient detail to indicate the type, size, material, arrangement, weight of each component, foundation bolts, foundation details, the sub-assembly drawing number, the static and dynamic forces, break-down for packing and shipment, the external connections, fixing arrangements required, the dimensions required for installation and interconnections with other equipment and materials, clearances and spaces required between various portions of equipment and any other information specifically requested in the drawing schedules.

Each drawing submitted by Contractor shall be clearly marked with the name of Employer, the unit designation, the specification title, Contract number, name of project and a drawing number. The sample drawing title block shall be provided for Engineer's review and approval. If standard catalogue pages are submitted, the applicable items shall be indicated there. All titles, notes, markings and writings on the drawing shall be in English.

Before starting the shop fabrication of any part of the equipment, Contractor shall prepare and submit for Engineer's review the drawings which will describe the equipment in detail. The drawings will be reviewed by Engineer and shall be modified by Contractor if any modifications and/or corrections are required by Engineer. Contractor shall incorporate such modifications and/or corrections and submit the final drawings for approval. A total time of not more than 15 days will be required by Engineer for review of each drawing and 7 days for each subsequent revision. These periods are exclusive of the mailing time.

Four (4) copies of the drawings shall be sent for Engineer's review. One print of such drawings will be returned to Contractor by Engineer marked "Reviewed with Notations". When revised drawings are submitted for approval, the changes from the previous submitted drawings shall be clearly identified, with every revision shown by number, date and subject in a revision block. Contractor shall thereupon furnish Employer with six (6) prints and one (1) reproducible original of the drawings which shall include the appropriate revision number after incorporating all corrections. Electronic versions (AUTOCAD / TIF) of each version shall be sent electronically at the same time as the prints.

Further work by Contractor shall be in strict accordance with these reviewed drawings and no deviation shall be permitted without the written review of Engineer.

All manufacturing and fabrication works in connection with the equipment prior to the approval of the drawings shall be at Contractor's risk. Contractor may make any changes in the design which are necessary to make the equipment conform to the provisions and intent of Contract and such changes will again be subject to review by Engineer. Review of Contractor's drawings or works by Engineer shall not relieve the Contractor of any of its responsibilities and liabilities under the Contract for correctness of design and construction of the Plant, guarantees and warrantees on the performance of the Goods.

Drawings shall include all installations and detailed piping drawings. All piping of 65 mm and larger size shall be routed in detail and smaller pipes shall be shown schematically or by isometric drawings.

The drawings shall be clear, facilitating easy identification of all parts with part number for ordering of spares by the Employer.

Drawings are to include: layouts, cutaway views, elevations, detailed one line diagrams, three line electrical schematics, control schematics, wirings, interconnections, cable lists, material lists, cable schedules, I/O lists, control architecture schematic, logic schematics, loop schematics, general arrangement drawings etc.

1.8.1. As -Built Drawings

The contractor has to furnish six (6) sets and one (1) electronic Version (Autocad) of all the final "As-Built" Drawings.

1.9. MANUALS, TESTS AND PROCEDURES

Contractor shall submit to Engineer various instruction manuals for all the equipment covered under the Contract as detailed below. The instruction manuals as listed below shall contain full details and drawings of all the equipment furnished the erection procedures, testing procedures, and operation and maintenance procedures of the equipment.

1.9.1. Installation Procedures

The 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/Owner to plan and supervise the Works at site, if required.

1.9.2. Pre-Commissioning Procedures and Tests

Pre-commissioning procedures and tests 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.

1.9.3. Commissioning Procedures

The commissioning procedures shall sequentially and in sufficient detail describe activities and tests for all systems covered under the Contract.

1.9.4. Wet Commissioning Tests and Commissioning Reports

Commissioning acceptance tests shall be carried out, on all generating units, and other equipment to verify the rating characteristics of generating units and other equipment's in accordance with relevant standards.

The complete site commissioning (Including Pre-Commissioning) acceptance test reports shall be prepared by the Contractor and submitted to Employer for approval.

1.9.5. Test Trial Run or Energization

The test trial run or Energization on Turbine generating units and other equipment shall be carried out as per relevant provisions of IEC standards.

1.9.6. Operation and Maintenance Manuals

These instruction manuals shall be issued in two volumes, one containing all operating information required including drawings and the other containing maintenance instructions. Twelve (12) hard copies and one (1) electronic copy of each volume of instruction manuals shall be furnished along with one copy of the reproducible original drawings/sketch forming part of manuals.

If after the commissioning and initial operation of the plant, the instruction manuals require any major modifications/additions/changes, the same shall be incorporated and the updated final instruction manuals in the form of one (1) set of electronic files as CD and twelve (12) copies shall be submitted by the Contractor to Employer. In case of minor modifications/additions/changes affecting only some sections, the required amendments shall be furnished by Contractor in twelve (12) copies. All manuals shall also be provided in electronic version (Microsoft Word doc. format).

1.10. SCHEDULE-CUM-PROGRESS REPORTS DURING DESIGN AND MANUFACTURING

During design and manufacturing the Contractor shall monthly submit the progress reports in a format acceptable to 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 include any notable problems, which were encountered.
- The total overall percentages of design and manufacturing works completed, with reference to the Master Control Network programme. 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 all activities of scheduled and actual progress during the reporting period including actual starting dates versus scheduled starting dates and actual completion dates versus scheduled completion dates for each activity. Appropriate remarks shall explain any differences, and also methods/actions prepared to be taken for making up the deficiencies in actual design and manufacturing process.
- A list of activities scheduled to be started within the next period of two (2) weeks, with expected starting and completion dates. If the expected starting and/or completion dates are different from those shown on the Master Control Network, an explanation shall be given.

In case of having Sub-Contracted any item of work (with the prior approval of the Employer), Contractor shall submit the monthly progress report from its Sub-Contractors for their portion of work, with its review/comments/action marked therein.

1.11. SCHEDULE-CUM-PROGRESS REPORTS DURING INSTALLATION AT SITE

During erection the Contractor shall, submit monthly progress reports in a format acceptable to 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 include any notable problems, which were encountered.
- The total overall percentage of erection works completed, with reference to the Master Control Method programme. Appropriate comments shall explain any differences.
- The percentages of each main work activity completed during the reported month with reference versus the scheduled programme. Appropriate comments shall explain any differences.
- A list of all activities of scheduled and actual progress during the reporting period including actual starting dates versus scheduled starting dates and actual completion dates versus scheduled completion dates for each activity. Appropriate remarks shall explain any differences. In case of delays, steps shall be taken up to make up the delay.
- 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 Master Control Network, an explanation shall be-given.
- A list of local manpower (by trade classification) employed during the reporting period.
- A list of expatriate personnel (by position) employed during the reporting period.

- A list of the Contractor's Equipment, vehicles, tools and materials presently located at the Site. Also, a list of equipment and materials, which arrived at Port of entry and is in the process of being cleared through customs.
- Progress photographs of significant events. The Engineer may direct the inclusion of specific photographs if deemed necessary.
- Main items of temporary facilities constructed during the reporting period.
- 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 about labour relations and an explanation of an actual or potential problems
- A listing of each accident at the site involving the hospitalization and/or death of any person
- A listing of the amount & date of any payments received during the reporting period & the amount of any monthly invoice, which has been submitted but not yet paid.
- A list of claims (if any) submitted during the reporting period including the claimed cost & extension of time.
- A statement concerning potential problems and recommendations on how they could be resolved.

1.12. FIRST FILL OF OIL

The first fill of oil which will be required to put the equipment covered under the scope of Contract into successful trial operation, will be furnished by the Contractor at its charge. 10% extra oil shall be provided.

Before or during filling, the oil shall be treated to remove impurities. The oil shall not contain more than 50 PPM of water and shall conform to NAS 6.

1.13. DESIGN IMPROVEMENTS

Engineer or Contractor may propose changes in the specifications of the equipment or quality thereof and if the parties agree upon any such changes the specification shall be modified accordingly.

If any agreed changes are such that it affects the price and schedule of completion, the parties shall agree in writing as to the extent of any change in the price and/or schedule of completion before Contractor proceeds with the change. Following such agreement, the provisions thereof shall be deemed to have been amended accordingly. There will not be any change in scheduled completion of plant due to change in specification or quality agreed between the Engineer and Contractor.

It is, however, understood that no extra payment will accrue to Contractor on this account if the change asked for is for an equipment found to be inadequate in operation or not operating properly.

1.14. QUALITY ASSURANCE (QA) PROGRAM / QUALITY CONTROL (QC)

To ensure that the equipment and services under the scope of this Contract whether manufactured or performed within Contractor's works or at its Sub-Contractor's premises or at Employer's site or at any other place of work are in accordance with the specifications, Contractor shall adopt a suitable quality assurance program to control such activities at all points. Such program shall be outlined by Contractor and shall be finally accepted by Engineer after review and/or discussions. An outline description of the QA program to be used by Contractor shall be included in its Bid. A QA program of Contractor shall generally cover, but not limited the following:

1. Its organization structure for the management and implementation of the proposed QA program,
2. Documentation control system,
3. The procedure for purchasing of materials, parts, components and selecting of Sub-Contractor's Services including vendor analysis, source inspection, incoming raw material inspection/verification of materials purchased, MTR (Material Traceability Report or mill test), etc.
4. System for shop manufacturing and site erection controls including process controls, fabrication and assembly controls,
5. The procedure for shop welding and test,
6. The procedure for site welding and test,
7. Control of non-conforming items and system for objective actions,
8. Inspection and test procedures both for manufacture and field activities,
9. Control of calibration for testing and measuring equipment,
10. System for indication and appraisal of inspection status,
11. System for quality audits,
12. System for handling storage and delivery; and
13. System for maintenance of records

Contractor shall prepare, submit, discuss with Employer and based on the review and/or discussions, finalize within Thirty (30) days from the Letter of Intent, the detailed quality assurance plan in the proforma prescribed by Employer, for all components of the equipment manufactured by Contractor/its Sub-Contractors. For the components/equipment produced by Contractor/its Sub-Contractors for the purpose of this Contract, its purchase specifications and inquiries shall call for such quality plans along with their proposals. The quality plan of Contractor shall be discussed and finalized in the aforesaid manner and shall form part of its purchase order on its sub-vendor. Employer also reserves the right to carry out quality audit and quality surveillance of the system and procedures. However, such audit or quality surveillance by Employer shall not relieve Contractor of any of its responsibilities under the terms of Contract.

Within sixty (60) days from the date of the Letter of Award, 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.

1.15. INSPECTION, TESTING AND INSPECTION CERTIFICATE

Clause 8, Section IV of Special Conditions of Contract shall apply.

1.16. PROTECTIVE GUARDS

Suitable guards shall be provided for protection of personnel on all exposed rotating and/or moving machine parts. All such guards with necessary spares and accessories shall be designed for easy installation and removal for maintenance purposes.

1.17. NOISE LEVEL

Maximum noise level resulting from any of the operating conditions shall not exceed 90 dBA at any place 1 m away from any of the operating equipment.

1.18. RECTIFICATION OF DEFECTS

During the warranty period, apart from issues covered by liquidated damages, any non-conform equipment or part of the equipment shall be corrected in agreement with this Technical Specification. Employer, at his discretion, will hold back any payment due to Contractor until the defect is repaired or replaced by Contractor so as to enable the equipment to be made to conform within a reasonable, mutually acceptable timeframe. Otherwise, the Employer, will have the same repaired or replaced by a third party and back charge the costs incurred thereby, to the Contractor.

If the field tests prove that the performance of the equipment offered by Contractor does not meet the guaranteed requirements, Contractor will be offered an opportunity to rectify the defects within two (2) months from commissioning to bring the equipment to a condition to satisfy the guaranteed requirements, but no extension of delivery period will be granted. No further chance will be given. Based on the test results, Employer may either accept the equipment under penalty condition or reject it.

1.19. EQUIPMENT BASE

A cast iron or welded steel base plate shall be provided for all pumps and compressors which are to be installed on a concrete base unless otherwise agreed to by Engineer. Each base plate shall support the unit and its drive assembly, shall be of a neat design with pad for anchoring the units, shall have a raised lip all around and shall have threaded drain connections.

1.20. RATING PLATES, NAME PLATES AND LABELS

Each main and auxiliary item of the equipment is to have permanently attached to it in a conspicuous position a stainless steel rating plate upon which is to be engraved the manufacturer's name, equipment, type or serial number together with details of the loading conditions under which the item of equipment in question has been designed to operate, year of manufacture, and such diagram plates as may be required by Engineer.

Each item of equipment is to be provided with a name plate or label designating the service of the particular equipment. The inscriptions are to be approved by Engineer or shall be as detailed in the appropriate sections of the Technical Specifications.

Silicon & Halogen-free polyester labels shall be provided for all apparatus such as relays, switches, fuses etc. contained in control cabinets, marshalling kiosks or marshalling boxes.

Descriptive labels for mounting indoors or inside cubicles & kiosks shall be of silicon & halogen free polyamide material with V2 inflammability class as per UL 94 that will ensure permanence of numbering as marked with the use of solvent free ink through Bluemark with UV technology.

Such name plates or labels are to be of white non-hygroscopic material with engraved black lettering or alternatively, in the case of indoor circuit breaker, starter, etc., of transparent plastic material with suitably coloured lettering engraved on the back.

Items such as valves, which are subject to handling, are to be provided with an engraved Chromium plated name plate or label with engraving filled with enamel.

1.21. MATERIALS AND WORKMANSHIP

1.21.1. Materials

All materials shall comply with the latest International Standards, or equivalent standards, unless otherwise specified. The detailed specifications of the equipment indicate the materials for various components. Contractor, however, shall offer the same or better than that considering its experience in the relevant field and workmanship throughout shall be the best of their respective kinds. The design of all equipment shall be such that installation, replacements and general maintenance may be undertaken with the minimum of time and expense.

All parts shall have at least the weight as per the dimensions given in the drawings and shall be built in accordance with approved drawings only. All fitted joints shall be machined and castings shall be spot faced for nuts.

No patching, plugging or other such means of overcoming defects, discrepancies or errors shall be done without the written permission of Engineer.

The ultimate strength, limit of elasticity, ductility, hardness, etc., shall be determined from test pieces obtained as described in the specification for the material in question. Where no definite specification is given, test pieces shall be obtained as required by Engineer. Contractor shall provide all test pieces, blanks, etc. cut and machined to the sizes, shapes and dimensions as directed by Employer.

1.21.2. Design Stresses and Factor of Safety

The design, dimensions and materials of all parts of the equipment in the plant shall be such that they will not suffer damage under the most adverse service conditions. All mechanisms shall be so constructed as to avoid sticking due to rust or corrosion.

Contractor shall be responsible for an adequate design. The Von Mises and principal stresses in the materials used shall be proposed by Contractor and approved by Engineer. The equipment and each part of it shall be strong enough and sufficiently well connected to resist total operating stresses including any stresses resulting from an earthquake with ground acceleration of 0.39 g in horizontal direction and 0.26g in vertical direction.

All plants shall be designed to:

- Minimize the risk of fire and any consequent damage,
- Prevent accidental contact with live parts; and
- Be capable of continuous operation as required with minimum attention and maintenance under tropical climatic conditions.

The unit stresses under any normal operating condition shall not exceed one third of the yield strength or one fifth of the ultimate strength of material, whichever is lesser, unless otherwise specified.

The TG unit stresses under accidental conditions, such as runaway speed, short-circuit of armature or field windings, or seismic accidents shall not exceed two thirds of the yield strength of the material.

1.21.3. Castings

All castings shall be true to pattern, of good workmanship finish and of uniform quality and condition, free from injurious blow holes, porosity, hard spots, shrinkage defects, cracks or other defects as determined by visual inspection and shall be satisfactorily cleaned for their intended purpose. The surfaces of castings which do not undergo machining, particularly those in contact with water, shall be dressed smooth with all joints blended into adjacent surfaces and shall be free from foundry irregularities, such as projections, ridges, hollows, honeycombing, peck marks or chip marks so that they will not require surface smoothening operations prior to painting.

All defects shall be fully explored and castings shall not be repaired, plugged or welded without permission from Engineer. Such permission will be given only when the defects are small and do not adversely affect the strength, use or machinability of the castings.

No major welding shall be carried out after the casting is finally annealed. Excessive segregation of impurities or alloys during the casting might result in the rejection of the element. Large fillets compatible with the design shall be incorporated whenever a change in section occurs. The casting mould and casting practice shall be designed to minimize the occurrence of hot tears or shrinkage cavities. Casting moulds shall be designated to allow free Contraction upon cooling to minimize the occurrence of high stresses caused by the mould or chills.

Test coupons from which test specimens are prepared shall be attached to all castings weighing 250 kg or more. The number, size and location of the test coupons shall meet with Engineer’s approval.

Casting repair welds shall be carried out in accordance with the applicable Standards. No repair welds to carbon steel castings in excess of 20 mm in thickness will be permitted without stress relieving unless approved by Engineer. Contractor shall submit the complete repair procedure (welding & heat treatment process, etc.) including the Welder’s certificates to Employer for approval.

Repair welding on steel castings, if approved, other than repair welding of minor defects, shall be done by the metallic arc process followed by thermal stress relieving. No major welding shall be done after final heat treatment. Repair welding on iron castings will not be permitted.

Employer reserves the right to inspect the castings at different stages of the manufacturing process.

1.21.4. Forgings (As applicable)

The ingots from which the forgings are made shall be cast in metal moulds. The workmanship shall be first class in every respect and the forgings shall be free from all defects affecting their strength and durability, including seams, pipes, flaws, cracks, scales, fins, porosity, hard spots, excessive non-metallic inclusions and segregation.

Test coupons shall be provided in accordance with ASTM Specifications.

All forgings shall be given the uniform heat treatment as required to produce materials conforming to the requirements of the specifications and shall be normalized and tempered.

The largest fillets compatible with the design shall be incorporated wherever a change in section occurs.

Tool marks or tearing of the metal by the finishing tool will not be acceptable on the surface of fillets. Such marks, if they occur, shall be removed by grinding or polishing. All finished surfaces of forgings shall be smooth and free from tool marks.

The shaft of MIV (Main Inlet Valve), Turbine and Generator shall be made from Forging.

The forging shall be clearly stamped with the heat number in such a location as to be readily observed when the forging is assembled in a complete unit.

The Employer reserves the right to check / inspect the forging at any stages of the manufacturing process.

1.21.5. Plate Steel

Plate steel, plates, shapes, bars, etc. for welded construction or pressure withstanding parts shall be in accordance with ASTM Specifications.

All fabricated parts, except those in which stresses are not important, shall be designed, manufactured, tested and inspected in accordance with the ASME Boiler and Pressure Vessel Code “Section VIII, Requirements for Unfired Pressure Vessels fabricated by Welding”.

All specified mill tests shall be performed and transmitted to the engine for each plate to be used in the manufacture of the work.

1.21.6. Fastenings

Unless otherwise specified, all screws, bolts, studs and nuts shall be designed/selected according to ISO standards. Stainless steel nuts and screws shall be used where corrosive conditions exist to ensure that the equipment can be readily dismantled after long periods of service.

1.21.7. Floor Plates

Steel floor plates, wherever used, shall be a checker plate with a minimum plate thickness, excluding raised pattern, of not less than 8mm. All edges of plates shall be planned and joints shall be smoothened where practicable, so as to maintain continuity of the pattern.

1.21.8. Stainless Steel

Stainless steel plate, bars, etc. shall be in accordance with ASTM standards. The grade, Standard Number and chemical composition are subject to Employer's approval.

1.21.9. Babbitt Metal

Where not specified, Babbitt metal for bearings shall be ASTM B23 type 2 or of a suitable grade type for the particular bearing and approved by Employer.

1.21.10. Bronze

Bronze for bushings shall be soft lubricated, Deva or approved equivalent.

1.21.11. Piping and Tubing

All piping shall comply with the latest IS 1239 for 150 mm and less pipes and IS 3589 for larger pipes. Equivalent ASTM standards can also be used. Pipes over 25 mm in diameter shall be flanged (ISO or SAE). Line fittings shall be of the compression type.

All piping systems shall be pre-fabricated in so far as practicable, leaving only joint connections as may be necessary for installation or possible subsequent dismantling for repair. All piping tubing shall be thoroughly cleaned and properly capped or plugged before shipment. All necessary fittings, fasteners and supports, etc., required in connection with the field assembly of the lubrication system shall be designed, supplied, shipped, installed and tested by Contractor.

Contractor shall perform the shop and field pressure tests for all pipelines with a pressure of 50% above their maximum allowable working pressure and a suitable time indicated by Engineer, and shall supply all labour, materials, air, water power, pumps, plugs, gauges, and other equipment necessary to make the complete test.

1.21.12. Galvanizing

Parts to be galvanized shall be properly prepared and galvanized by the hot galvanizing process. All cutting, drilling and welding shall be carried out prior to galvanizing. After galvanizing, the parts shall not be subjected to any action detrimental to the coating.

1.21.13. Welding- General

Wherever welding is specified or permitted, the electric arc welding process, using approved filler material, shall be used. All welding shall conform to the accepted welding rules of the Indian Welding Society. All shop welding shall be done according to the welding rules applicable in the country of origin but subjected to the Employer's approval.

Plates to be joined by welding shall be accurately cut to the correct size suitable for the type of weld to be used.

The dimensions and shape of the edges to be joined by welding shall be such as to allow through fusion and complete penetration, and the edges of plates shall be properly formed to accommodate the various welding conditions. The surfaces of the plates for a distance of 50 mm back from the welding edge shall be thoroughly cleaned of all paint, rust, grease and scale to bright metal.

When welding carbon steel plates, in which one or both plates exceed 25 mm in thickness, the continuous areas of plates surrounding the welding operation shall be preheated to not less than 70 degree centigrade and kept at a substantially uniform temperature throughout the process. The temperature shall be measured by Tempilsticks or other approved means. Low hydrogen electrodes shall be used. Penning of multiple pass welds to control distortion or to minimize residual stresses may be carried out with light blows from a power hammer using an elongated round nose tool. Penning shall be done after the welding has cooled to a temperature warm to the hand. Care shall be exercised to prevent scaling, flaking or rupturing of the weld and base metal from overpeening. Neither the first nor the last pass of a multiple pass weld shall be peened.

Minimum weld sizes between members shall not be less than those specified by Indian Welding Society.

Contractor shall supply all material and shall do the welding required for the above tests including all machining and testing of specimens.

After the welding process has been approved by Engineer, Contractor shall record it on a special drawing (welding map) which shall become one of the drawings of Contract.

1.21.14. Electrodes

Welding electrodes shall conform to ANSI/AWS A5 Standards. Low hydrogen Electrodes grades 9016G shall be used for welding of penstock, pipes, structures etc.

1.21.15. Bracing

Temporary bracing and attachments shall be removed, exercising care that the base metal to which they are attached is not adversely affected. Projecting welds remaining after this operation shall be chipped and ground flush and the area touched-up with paint if necessary. Tears in the base metal shall be welded up and ground flush.

If temporary bracing or attachments are welded to plates under 25 mm thick, the preheat requirement may be waived; however, upon removing these attachments, the base Tears in the base metal shall be welded up and metal shall be ground flush and inspected for cracks.

1.21.16. Material Inspection and Testing – General

In addition to and notwithstanding any requirements covered in previous clauses, Contractor shall perform adequate inspection and quality control and conform to the inspection procedure outlined below.

Wherever possible, all material entering into the work shall be subject to inspection by Engineer and all purchase orders for materials and supplies shall carry a notation to this effect. Copies of all purchase orders and subcontracts shall be submitted to Engineer at the time of placing the order.

Waiving inspection by Engineer shall not relieve Contractor from the responsibility of supplying material and workmanship acceptable to Engineer. Contractor shall be responsible for proving the quality of material and workmanship, either by records of inspection or by immediate inspection.

Contractor shall perform any non-destructive testing and inspection required by Engineer on any material or workmanship in which defects are suspected. Witness tests and inspection of material will be made at the places of manufacture by Engineer. Engineer shall at all times have access to all places of manufacture where equipment or materials are being made or prepared for use under this Contract and shall have full access to facilities, including office space and communication facilities, for unrestricted inspection of such materials and equipment. Whereas such witnessing and inspection will be conducted so as to interfere as little as possible with the operation of the manufacturer, Contractor shall conform to the requests made by Engineer concerning the method of test or correction of defective workmanship.

Unless otherwise specified, any rejection based on witness tests or general inspection will be reported to the manufacturer within fifteen (15) days. Materials which show injurious defects subsequent to its acceptance at the manufacturer's works, will be rejected and the manufacturer will be notified. Test pieces which represent rejected material shall be preserved for a period of time to be mutually agreed upon between Engineer and Contractor for reference, if any, at a later stage. The Contractor shall make/ arrange the component / material due to such rejection by Engineer well in time. This will not be any extension given due to such rejections.

Magnetic particle inspection shall be conducted in accordance with ASTM Specifications E-109 and E-125, Degree 2. Radiography on welds for pressure-containing parts, including the standard of acceptability, shall be performed according to paragraph UW-51 of the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1. Radiography testing of welds on structural steel including the standards of acceptability, shall be performed in accordance with ASTM specifications. All radiographic examination of the shop welds shall be done by Contractor and all radiographic examination of the field welds will be carried out by Employer. All field labour and access to equipment required for field radiographic examination shall be provided by Contractor.

Ultrasonic testing shall be in accordance with ASME Boiler and Pressure Vessel Code and ASTM specifications.

All unacceptable defects in welds shall be chipped out to sound metal and such areas shall be checked by magnetic particle inspection, radiography or ultrasonic testing by Contractor, as directed by Engineer, to ensure that the defects has been completely removed before repair welding.

1.21.17. Casting Inspection

Radiographic examination and standards of acceptability of steel shall be in accordance with ASTM Specification.

Ultrasonic testing and standards of acceptability for steel castings shall be in accordance with ASTM specification. Any discontinuities whose reflections do not exceed a height equal to 20% of the normal back reflection or do not reduce the height of the back reflection by more than 30% during movement of the transducer 50 mm in any direction, shall be considered acceptable. Indications exceeding these limits shall be repaired. Steel castings shall not be finally annealed before inspection without the permission of Engineer. The castings will also be inspected after repairs, heat treatment and during machining.

A complete report of the entire heat treatment & welding procedure shall be furnished to Engineer, prior to execution of the works.

1.21.18. Test Coupon Inspection

For castings weighing 250 kg, or less, one tension and one bend test shall be required; for castings weighing more than 250 kg, two tension and two bend tests shall be required. The bend tests shall be made on specimens 25 mm by 15 mm in cross section with corner radii not exceeding 2 mm. They shall withstand being bent cold around a pin 25 mm in diameter and through an angle of 90 degrees without cracking on the outside of the bent portion.

1.21.19. Forging Inspection

All forgings in excess of 150 mm diameter shall be subjected to internal examination for the detection of flaws and to heat treatment for the relief of residual stresses.

Particulars of the heat treatment proposed for all important forgings and in each case the name of the proposed manufacturer, shall be submitted to Engineer for approval. All such forgings shall be examined at the place of manufacture by the latest non-destructive methods for the detection of defects. Further, Employer shall inspect/check the forging at different stage of manufacturing process.

1.21.20. Coating

1.21.20.1. GENERAL

Unless otherwise specified, and insofar as possible, all of the Contractor's supply shall be shop painted according to the following specifications. Only touch-ups shall be done on site. The paint manufacturer's recommendations shall be followed for film thickness, drying time, application method moisture, temperature and other parameters. These recommendations shall be transmitted to Engineer for approval, before the start of the application of coating.

After painting, surfaces shall be protected from cold, moisture, dirt or new paint until they are completely dry.

For every planned field weld, an area 50 mm on either side of the weld shall not be painted. After the weld, the surface to be painted shall be considered a touch-up.

Unless otherwise specified, surface preparation shall be SSPC-SP6/Sa 2 "Commercial blast cleaning". Every surface preparation shall be inspected before painting and an inspection report shall be given to the Employer. SSPC Standards are published by the Society for Protective Coatings.

All surfaces destined to be embedded in concrete shall not be surface-prepared or painted.

There are no particular paint requirements for mass-produced standard components such as instruments, panels, cubicles, etc. However, exposed plain steel surfaces of these parts shall be supplied painted by the manufacturer, at the very least.

The protective coating shall be guaranteed with respect to materials and workmanship. This guarantee covers, among other things, the separation between the base and the coating.

Care shall be taken to protect workers against fumes and irritants, with the use of proper ventilation, masks, protective clothing, as specified in the respective Material Safety Data Sheet (MSDS) instructions. The personnel assigned to the preparation of surfaces and application of paint shall be qualified for and experienced in this type of work and be directed by an experienced supervisor.

Approximately 5% extra paint shall be provided to the Employer in sealed containers once the work is completed, for additional touch-ups at later times.

1.21.20.2. REQUIREMENTS FOR SPECIFIC COMPONENTS

- Piping
- Carbon steel piping, including any interface with stainless steel, shall be painted with two coats of alkyd paint.
- Steel surfaces designed for permanent contact with water
- Unless otherwise specified, two coats of polyamine epoxy paint shall be applied within four hours of SSPC SP10/ Sa 2 1/2 near white blast cleaning.
- Machined surfaces designed for contact (i.e. flanges or seal surfaces)

- No surface preparation and no paint shall be applied. However, surfaces shall be cleaned according to SSPC-SP1 “Solvent cleaning” and protected for shipping using an appropriate surface protector such as Cosmoline or Rustveto.
- Other steel surfaces, except for embedded surfaces

One coat of zinc rich primer and one coat of alkyd paint.

1.21.20.3. TOUCH-UP PAINT

Contractor shall touch-up all surfaces that have been burned, dented, welded, deeply scratched or have been damaged in any other way during site installation.

The surface preparation for the touch-ups shall be done according to SSPC-SP3 “Power Tool Cleaning”. All touch-ups shall be done with the original paint system and thicknesses shall be as specified by the paint manufacturer.

The paint shall be inspected after any touch-ups and touched-up again if necessary.

1.21.20.4. COLOURS

Unless otherwise specified, colours of the finishing coat shall be as below:

Turbine	Sky Blue
Generator	Sky Blue
Control panels	Grey (as per manufacturer’s standard)
Oil components	Brown
Water piping	Sea Green
Fire protection	Fire Red
Compressed air	Sky Blue
EOT Crane	Golden Yellow

1.22. SPARE PARTS AND TOOLS

1.22.1. Spare Parts

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. Before issue of the Completion Certificate, the spare parts shall be checked at the Site by the Contractor in presence of the Engineer/Employer.

Acceptance of any spare parts will not take place before the Contractor has submitted the complete final detailed list of all spare parts and tools.

All spare parts shall be protected against corrosion and shall be marked with identification labels in the English Language. The identification shall be in accordance with the agreed Works Identification System.

All spare parts, tools and materials shall be delivered in marked boxes of sufficient sturdy construction to withstand long term storage. Material that is subjected to long term storage shall be stored in a dry, ventilated room with low humidity.

Spare parts such as rubber disc seal, packing and seals of all kinds, o ring etc. shall be stored in a cool room with relative humidity less than 65% and not exposed to light.

1.22.2. Specified Spare Parts

The required specified spare parts are listed separately in the Particular Technical Specifications. The price for each listed special spare part shall be quoted individually in the Price List; the total price shall be included in the Contract Price.

1.22.3. Recommended Spare Parts

The Contractor shall give a list of additional spare parts recommended for five (5) years operation. The list of these spare parts shall be finalized during detailed engineering.

Employer reserves the right to place order for these spares at the same rate within eighteen (18) months from the date of finalisation of the Contract.

1.22.4. Tools and Appliances

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 Contract Price.

The tools, wrenches, etc. shall be unused. Customary tools for erection shall be of the forged and polished chrome-vanadium type. Use of special tools and devices for erection shall be allowed but shall be approved by the Engineer in each case. Special tools and devices shall be provided with means for ready identification.

All lifting devices and wire ropes slings to be used at site shall be tested at works at 150% capacity and test certificate shall be supplied to the Engineer.

Suitable hardwood or steel boards arranged for wall mounting as well as tool carts and/or toolboxes shall be included in the delivery. An itemized list and description of all provided tools, auxiliary devices, storage equipment, etc. shall be included in the Tender. Acceptance of any tool or device shall not take place before the Contractor has submitted the complete final detailed List of Tools and Appliances.

All ropes, slings etc. shall be brand new and handed over in their original packaging. The Employer shall be entitled to take over from the Contractor the entire erection tools, appliances, instruments at mutually agreed conditions.

1.23. MECHANICAL WORKS AND STEEL STRUCTURES

1.23.1. General

All mechanical Works and steel structures of any mechanical or electrical installation shall comply with this General Technical Specification and the requirements of the Particular Technical Specifications.

The Works result shall be an approved, reliable design providing the highest possible degree of uniformity and interchangeability.

The design and arrangement of the Works and installations shall facilitate the erection, test, operation and maintenance of all components of the project.

All Works shall be pre-assembled in the manufacturer's premises to an utmost extent.

Revolving parts shall be truly balanced both statically and dynamically so that when running at normal speed and at any load up to the maximum, there will be no vibration due to lack of such balance.

1.23.2. Bolts, Screws, Nuts, Etc.

All bolts, studs, screws, nuts, and washers shall conform to the ISO metric system except where other standards are considered for specific applications and as approved by the Engineer. The extent to which other standards are proposed shall be indicated by the Contractor. Bolts and nuts shall be hexagonal or socket headed. Sizes smaller than 4 mm shall be used only for instrument and relay internal connections.

Where mild steel bolts and nuts are used, they shall be of the precision cold forged washer faced type if commercially available in the size required. Alternatively, approved hot forged bolts and nuts, machined so that the undersides of bolt head and nut are faced and parallel to one another when assembled, may be used. In the latter case, a suitable fillet shall be machined between the bolt head and shank. All parts, other than structural steel work, bolted together, shall be spot faced on the back to ensure that nuts and bolt heads bed down satisfactorily. Bolts machined from bar stock shall not be used without approval of the Engineer. All bolting material shall be adequately treated against corrosion before dispatch from the workshop. Mild steel nuts and bolts shall be zinc or cadmium plated. Stainless steel bolts, nuts washers and screws shall be used in water or when exposed to high humidity, for holding renewable parts and parts made of stainless steel.

All bolts or studs which will be subject to high stress and/or temperature shall be of approved high tensile material with nuts of approved material. All bolts and studs larger than 60 mm in diameter, which are not accessible for tightening, and untightening by commercially available pneumatic impact wrenches shall have an extension for pre-tensioning by hydraulic tools.

Washers shall be provided under bolt heads and nuts unless otherwise approved by the Engineer. All ferrous nuts and bolts on Works items where dismantling may be required during the life of the Works shall have their threads coated with an approved anti-seize compound. When in position, all bolts or studs shall project through the corresponding nuts by at least one thread, but this projection shall not exceed three threads, unless more length is required for adjustment. All nuts and set screws shall be securely fastened, to prevent loosening due to vibrations, using spring washers, lock nuts, split pins, self-locking inserts or 'Loctite' as appropriate for the purpose and material used.

The Contractor shall supply the net quantities plus 5 percent of all permanent bolts, screws and other similar items and materials required for installation at the Site. Any such rivets, bolts, screws, etc., which are surplus after the installation of the Works has been completed shall become spare parts and shall be wrapped, marked and handed over to the Employer.

1.23.3. Seals

The material for large gate seals shall be of first quality non-ageing rubber material, which shall be unaffected by wetting and drying or substantial temperature changes. The degree of hardness according to Shore shall be 65 +/- 5 for sealings. In case the Contractor intends to supply synthetic rubber material, with or without fluoro-carbon cladding, he shall furnish the name of the manufacturer and technical data of the material for the Engineer's approval.

1.23.3.1. RUBBER SEALS

Seals shall be designed and mounted in such a manner that they are adjustable, watertight and shall be readily removed and replaced.

Seals shall be moulded. Extruded seals will not be permitted. Where seals are installed curved, they shall be clamped in a jig, which shall form them to the proper radius before the holes are laid out and drilled, and the ends trimmed. Holes in related parts of the seal assemblies shall be carefully drilled, using a template, to assure proper matching when the seal units are assembled. Arrangements shall be made to provide effective continuity of sealing at the corners.

All adjusting screws and bolts for securing the seals and seal assembly in place shall be of stainless steel.

Seals shall be made of synthetic rubber suitable for the temperature ranges of equipment and conditions at the Site and shall be of a material that has proven successful in similar applications, furthermore, joints shall be watertight. The seal materials shall have the following physical properties.

Property	**Limits**
Tensile strength	21.0 MPa minimum
Ultimate elongation	450% minimum
Durometer hardness (Shore, Type A)	60 - 70
Specific gravity	1.1 to 1.3
Water absorption (70°C for 48 hours)	5% by weight (max.)
Compression set	30% maximum
Tensile strength after oxygen bomb ageing (48 hours at 70°C)	80% (min.) of tensile strength before ageing

1.23.4. Drives and Gears

All moving parts of machinery including shafts, couplings, collars, projecting key heads, gear wheels, rope/belt-drives shall be completely guarded to provide full protection. All setscrews on revolving shafts shall be countersunk or suitably protected. The guards shall be of approved design and shall be fitted, where necessary, with inspection doors/openings. All guards shall be arranged so that they can be removed without disturbing the parts of the gears and works, which they protect.

Gears shall be designed so that all stresses are within allowable limits when the maximum loads are being handled. All gears shall be designed and calculated in accordance with DIN, or equivalent international standards, or widely approved methods and to the individual experience of the manufacturer. On request of the Engineer, the manufacturer shall submit the calculation of the gears.

Where worm gears are used as a direct drive, they shall have the same load and time rating as the motors driving them. The gears shall work in oil and the temperature rise of the oil bath shall not exceed 40-50 degrees C under normal working conditions at Site. The materials of the mating faces of worm wheel and worm shall be of a bronze/steel alloy.

Where practicable, gear wheels shall be forced fit on the shaft and in addition, shall be keyed adequately to prevent any relative motion between the wheel and shaft. Where gears and couplings are secured in position by means of keys, they shall be easily accessible for tightening or removal. All keyways shall be machine cut. Couplings and collars shall be the shrouded or protected-type, free from projections of any kind.

All bearings shall be mounted in dust-proof housings. Base of hearing supports shall be machined and shall rest on machined surfaces.

1.23.5. Lubrication, Lubricants, Fuel

Efficient means of lubrication, suitable for use under Site conditions, shall be provided for all moving parts.

The contamination of the air, water and soil by lubricants and fuel shall by all means be avoided by applying of an appropriate design and layout of the Works in conformity with the latest recognized standards for modern engineering practice.

The number of different lubricants, transformer oils, oils for pressure systems, etc., used in the items of Works throughout the Works shall be limited to a minimum in order to facilitate keeping stocks and maintenance.

The Employer reserves the right to request the use of certain types of lubricants, oils, etc. The Contractor shall not be entitled to claim extra payment for this request. All different types of oils, lubricants, etc., shall be subject to the written approval of the Engineer.

Unless otherwise stated in the Particular Technical Specifications, the first oil or grease filling for bearings, pressure oil systems, transformers, etc., including the necessary quantity for flushing and for the first oil change shall be included in the Tender Price.

1.24. PIPING, FITTINGS, VALVES, GATES AND HEAT EXCHANGERS

1.24.1. General

Unless otherwise stated, all piping shall be designed for a "nominal pressure" PN 10. All piping shall be tested with 1.5 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.

Welding as well as application of corrosion protection coats shall be done in the manufacturer's shop as far as possible.

Metric flanges shall be used throughout. Welded flanges shall be weld-neck or slip-on flanges. The raised face shall be machined.

Joints between stainless and normal steel flanges shall be of the insulated type.

If the piping crosses over joints of civil structures of different settlement, the piping shall be provided with flexible joints to allow for vertical, horizontal, and angular deviations.

Piping installation shall be sloped to prevent trapping of air bubbles. Where required suitable venting system shall be provided.

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.

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

1.24.2. Valves, Gates

Small valves and gates shall conform to relevant IS, "Conditions and Terms for Delivery of Valves."

Generally, valves shall be leak-proof in either flow direction (except for non-return valves) when the nominal pressure is applied.

All valves with design pressures of PN 10 and higher, and diameters larger than DN 100 shall be workshop-tested to relevant IS for tightness and soundness of materials.

The change of disc type seals of butterfly valves shall be possible without dismantling of disc and body.

Valves shall close clockwise and be provided with position indicators. The drive units of motor-driven valves shall also be provided with hand wheels for manual operation. The hand wheel shall be operable under all conditions and shall be independent of the motor drive. Further, it shall not be rigidly coupled to the motor drive and shall not compulsorily turn when the motor is energized.

To facilitate operation, large valves and gates shall be provided with bypass lines for pressure balancing, if required.

All valves shall be readily accessible for both operation and maintenance, and where necessary for ease of operation the spindles shall be extended and an approved form of pedestal hand-wheel provided at convenient operating floor level.

Shut-off valves shall be suitable for opening and closing against full unbalanced pressure, including closure against free discharge. If necessary, bypasses are to be provided to meet these requirements.

Valves spindles and pins shall be of stainless steel, spindle nuts and bushes of bronze, the body at least of improved C.I. (e.g. Mechanite).

All pressure reduction valves; safety valves and similar components shall be workshop-tested and provided with a work certificate as per applicable standard.

1.24.3. Pipes and Fittings

All interconnecting piping in the scope of Contractor shall conform to the following specifications.

1. Oil Piping
   - Seamless piping conforming to ASTM A-106 Gr. B, or equivalent.
   - Fittings: ASTM A-105, or equivalent.
   - Valves: Forged carbon steel to ANSI B 16.11 600 # Socket Weld ends.

   Threaded connections will not be acceptable in oil piping.

2. Water Piping
   All fittings shall be seamless. NO electric resistance welded (ERW) fitting shall be acceptable. Unless otherwise specified in this specification water piping will be electric resistance welded piping to ASTM A53/B, or equivalent.
   - Fittings: ASTM A 105, or equivalent
   - Valves: Up to 50 mm – Bronze
   - Above 50 mm - Cast Steel with SS Trim
   - (Cast iron valves will not be accepted)

   Piping for brake jet, (wherever applicable) shall be stainless steel with stainless steel valve and fittings, hydrostatically tested at 15 MPa.

3. Connections
   Threaded connections will not be acceptable in oil piping. Flanged couplings shall be provided for assembly and dismantling.

1.24.4. Pipe Support and Hangers

All pipe work and accessories shall be installed, mounted and supported in a safe and neat manner.

All brackets, supports, frames, hangers, etc. for carrying and supporting the pipes, including their fasteners shall be included in the supply of materials and installed by the Contractor at the Site. Pipes and fittings shall be supported at or near flanges wherever possible.

Supports and hangers shall be designed and arranged so that any pipe can be withdrawn without disturbing the others.

All heavy valves and other mountings shall be supported independently of the pipes to which they connect, to the satisfaction of the Engineer.

The Contractor shall supply drawings showing the location of each major anchor and support and the weight to be carried by that support.

1.24.5. Heat Exchangers

Unless otherwise stated, all the heat exchangers shall be designed for a “nominal pressure” PN 16. All piping shall be tested with 1.5 times the design/ nominal pressure.

Specification of the material of the heat exchanger shall be:

- Cooling tube Cupro-nickel having chemical Composition of 90:10
- Thickness of cooling tube, 1 mm or more
- Frame/body Mild/cast steel

1.25. MECHANICAL INSTRUMENTS

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.

1.26. PRESSURE OIL SYSTEMS

Pressure tanks shall be designed, fabricated, installed and tested in accordance with approved standards. The appropriate inspection certificates shall be furnished. If the pressure is held by compressed air, then the requirements outlined in "Compressed Air System" of these General Technical Specifications shall also be applicable.

Oil sump tanks shall be provided with:

- Suitable access openings
- Fine mesh strainer combined with a magnetic filter through which all oil returning from the servomotors shall pass. The strainer shall be readily removable for cleaning.
- Dehumidifying air filter
- Flush-mounted oil-level indicator
- Filling connection with a suitable strainer
- Drain connection with hand operated shut-off valve.

Sump tanks shall be installed so that the bottom of the tank and the drain connection are at least 40 cm above the floor. The bottom of the tank shall be inclined in the direction of the drainage. The pumps shall be removable without the necessity of emptying the tank.

Servomotors shall be provided with suitable connections for pressure gauges on the pressure and suction sides of the piston. Servomotor piston rods shall be of stainless steel provided with a hard chromium layer of approximately 0.04 mm thickness. A suitable protection for the piston rod seal shall be provided.

1.27. COMPRESSED AIR SYSTEM

The provisions for safety of the entire compressed air system shall conform to internationally accepted standards. The standards proposed by the Contractor will in any case be subject to approval of the Engineer.

1.27.1. Vessels

Vessels shall be of the cylindrical, vertical type and shall be mounted on a structural steel base. The inner surfaces of the vessels shall be protected with an appropriate paint coating or the vessels shall be hot dip galvanized.

Each vessel shall be equipped with the following devices:

- 2 inlet sockets with valves
- 2 outlet sockets with valves
- 2 pressure safety valves
- 2 dial pressure gauges, one of the gauges with 4 electrical contacts
- 1 manhole or inspection hole
- 1 drain valve.

In case the pressure vessel is used for pressurized oil or water systems, the vessel shall further be equipped with:

- 1 transparent level gauge with shut-off valves at both ends
- Level indicators with electrical contacts in a number as required or specified.

1.27.2. Compressors

Compressors shall be provided with:

- Automatic lubrication
- Air-intake filter and silencer
- Thermometer for measuring temperature of the compressed air
- Automatic shut-down if the discharge air temperature exceeds a predetermined, adjustable value
- Discharging valves
- Water drain valves
- Water/oil separator
- Pressure safety valve
- Compressed air cooler
- Non-return valve
- Inlet pressure valve
- Outlet pressure valve
- Automatic moisture trap

The water / oil separator shall be equipped with an automatic

solenoid-operated drain valve to achieve automatic draining during standstill. The compressor stages shall be equipped with discharge valves, which shall close after a time delay to avoid the compressor to start against full pressure.

The compressors shall be delivered as package units on common frames with the appropriately sized AC squirrel cage motor and the respective motor starter panels, ready for operation.

Each vessel shall pass a pressure test at 1.5 times maximum working pressure for 8 hours in the manufacturer's workshop before coating is applied.

If requested by the Engineer, each compressor shall pass a performance test in the manufacturer's workshop to a standard mutually agreed upon, without extra cost. The readily assembled compressors, controls, and switchgear shall be subjected to functional tests.

Each vessel shall be furnished with a test certificate of an independent, reputable underwriter’s society.

1.28. PUMPS

1.28.1. Non-Submersible Pumps and Motors

Non-submersible pumps and motors shall be mounted on common frames.

Materials of the pumps shall be:

- Impeller stainless steel (CF8M)
- Shaft stainless steel (SS-410/316)
- Sleeves stainless steel
- Wear rings bronze
- Keys stainless steel

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

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

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.

Each pump shall be fitted with:

- Check valve at the discharge side
- Air and drain valve
- Pressure gauge.

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

1.28.2. Submersible Pumps & Motors

For submersible pumps, pump and motor shall be contained in the same casing and designed as a package unit.

The pumps shall be provided with standard accessories such as upper & lower mechanical seals, safety features/instruments, Pedestal Coupling for automatic coupling to discharge connection, Guide Rail piping, chain of SS/GI, etc.

The impeller shall be of stainless steel and the material for the other parts as specified for the non-submersible pumps above. For dirty water pumps, the water passages of corrosive material shall be rubber-lined.

The motors of submersible pumps shall not be filled with oil or other detrimental media.

Dirty water submersible sump pumps with the motors mounted on top of the pump shall have necessary controls to prevent dry running to avoid damage to seals, bearings, or motors.

For all other items, the requirements described for non-submersible pumps shall apply.

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

Prior to the test, the manufacturer shall provide certified motor performance curves.

1.29. LIFTING EQUIPMENT (AS APPLICABLE)

1.29.1. General Design Particulars

Nameplates stating the nominal capacity in tons shall be attached to both sides of the lifting equipment structure and to both sides of the tackle. The printing shall be clearly legible from the floor.

Hoists, ropes, drums, sheaves and related Works shall be calculated to relevant IS or equivalent standards.

Flexible couplings shall be installed to relieve the bearings and shafts from any stresses due to misalignment and to facilitate the removal of motors, wheels and gears. The motor couplings also shall be of the flexible type.

All couplings drive wheels and gears shall be press fit and keyed to the shaft.

All wheels shall have a hardened tread with a minimum Brinell hardness number of 300 and shall be made of carbon steel or low-alloy steel forgings. They shall have double flanges, shall be machined to a uniform diameter concentric with the hub bore.

All bearings shall preferably be anti-friction bearings designed to permit easy shaft disassembly and easy replacement. The minimum average lifetime under design load conditions shall be 5000 hours.

All sleeve bearings except those for the hooks and rope sheaves shall be lubricated by a central lubrication system. An independent system for the trolley and one or two independent systems for the bridge will be acceptable. These central lubrication systems shall satisfy the following requirements:

- The lubricant quantity for each bearing shall be variable
- Lubricant filters shall be installed in every lubricating pipe
- The lubrication piping shall be arranged to be easily accessible for maintenance

Gears shall preferably be designed as bevel gears. For all high-speed gears and pinions, oil bath lubrication shall be provided. Low-speed gears may be lubricated with soft grease. Suitable oil and grease drip pans shall be installed and be readily accessible for draining and cleaning.

Bridge and trolley drives shall be equipped with a spring-set, electrically (solenoid or electro-hydraulic) released shoe or disc brake, with capacities of at least 1.5 times the full operating torque of the drive.

The brake shall be applied when the motor control switch or the main switch is in the "off" position and/or in case of power failure in any phase. The braking action shall be gradual and the brake shall become fully effective after a certain time lag.

1.30. STEEL STRUCTURES

Generally, design and stress calculation shall conform to prevailing IEC /IS:

- Steel Structures, Construction
- Welded Steel Structures, Calculation and Design
- Stress Calculation of Steel Structures
- Steel Structures, Calculation and Construction

For standards applicable to steel structures of lifting equipment, refer to "Lifting Equipment".

The permissible design stresses for materials, bolts, rivets, etc. are given in relevant IS standards.

Adequate clearance of at least 2 m shall be provided at overhead steel structures to allow unobstructed passage.

Stairs and ladders shall have an inclination of approximately 30 degrees and 75 degrees respectively. Stairs shall be complete with handrails, min. 90 cm high, and kickboards of 8 cm height.

- Vertical ladders shall be installed alternating left hand/right hand side to horizontal platforms placed approx. every 10 m of vertical height. Vertical ladders of more than 2.5 m height shall be guarded.

Unless otherwise specified or stipulated in the applicable standards, platforms and stairs shall be provided with anti-slip checker plates.

1.31. ELECTRICAL EQUIPMENT COMPONENTS AND ACCESSORIES

1.31.1. General

Contractor shall coordinate the interfaces of all equipment of its supply. All works shall conform to the State rules in force under the “Electricity Act” and other legislations applicable during the project.

1.31.2. Power Supplies

Equipment and devices requiring electric power shall conform with the following parameters:

- AC 415 V 50 Hz 3 phase, 4 wire for power circuits,
- 240 V, 50 Hz, single phase for lighting and control circuits,
- DC 220 V for control and relay protection circuits,
- Design ambient temperature – 50 degree C

Contractor shall clearly indicate voltage, current and power requirements for each item of equipment.

Unless otherwise specified in this specification or any appropriate standard or specification all electrical equipment shall be suitable for reliable operation at voltages over the following ranges.

- AC voltage 85 to 110% of nominal,
- DC voltage 85 to 120% of nominal.

The station service AC supply is subject to rapid frequency rises in the event of load rejection. Contractor shall advise which auxiliaries and/or which of the controls cannot withstand such exposure and at what frequency these circuits must be disconnected automatically. Contractor shall realize the necessary load flow studies to determine voltage variation under all operating conditions including in such current of motors. The voltage shall remain within the range indicated above. Contractor shall take the necessary measures to assure proper voltage availability when supply is derived from units.

1.31.3. Electric Motors

All motors shall comply with the IS 325 and NEMA MG-1 standards for Motors and Generators.

Contractor shall be fully responsible for determining the motor duty cycle, rating, performance tests and mechanical arrangements which are entirely relevant and suitable for compliance with the above standards for the application at the station and in the environmental and site conditions specified.

The preferred type of AC motors is squirrel cage. They shall be totally enclosed and fan cooled, except for single phase motor under 1 kW where Contractor's standard types are acceptable, subject to approval. AC Motors above 0.5 kW shall be suitable for 3 phase operation.

The stator insulation system shall be Class F or a higher class, but in each case temperature rise shall be limited to Class B on full continuous rated load.

All AC motors shall be capable of direct on-line starting and of continuous operation at rated output under abnormal frequency conditions and shall also be capable of operation for a period of not less than 5 minutes, with a voltage 25% below nominal voltage, at nominal frequency, without injurious overheating. The starting current at full voltage shall not exceed 6 times the full load current. Each of the motors shall be tested at the manufacturer's shops to conform compliance with this requirement.

Ball or roller bearings 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. Vertical shaft motors shall have approved thrust bearings.

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 shall be identified. All terminal boxes shall have approved cable adaptor plates, sealing chambers or conduit entries.

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.

Where practicable, the motor end cover from the driving end shall have a removable plug to allow the speed to be checked by means of a portable tachometer.

All motors having a mass of 60 kg or more shall be fitted with lifting lugs.

Motors, when installed outdoors, shall be weatherproof and protected by a sun canopy.

1.31.4. Starters and Contractors

Motor starters shall be equipped with short circuit protection and local disconnecting devices. All starters shall be of similar brands.

Starters and contactors shall comply with latest IS Standards, IEC standard 60947 series and be suitable for direct on-line starting, uninterrupted electrical duty, and capable of 30 operations per hour. They shall be installed in ventilated enclosures for indoor installation and weatherproof enclosure for outdoor installation, unless otherwise approved by Engineer. The enclosures shall be complete with locks, cable sealing boxes, conduit entries, cable gland plates, Busbars, internal wiring, terminal boards, etc., as required by the duty of the starter, or contactor.

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.

Thermal type overloads and phase failure relays shall be supplied with starters for motors of 7.5 kW or above. For motors of less than 7.5 kW, suitably rated three phase thermal overloads will be acceptable. Ammeters with selector switch to read current in one phase shall be provided for motors above 7.5 kW.

Starters and contactors shall be weatherproof and protected from corrosion when located outdoors.

1.31.5. Metering Instruments

All instruments and meters shall be suitable for operation under the climatic conditions prevailing at site. The instrument cases shall be dust and vermin proof, watertight, vacuum proof and specially constructed to adequately protect the instruments against damages or deterioration due to varying ambient temperatures and humidity. The dials, pointers, etc. shall be designed to facilitate accurate reading by minimizing the error of parallax and glare from instrument window and by providing clear, bold dial markings. The size of dial and length of the scales of indicating instruments shall be large enough to suit the requirements and shall be subject to approval of Employer in each case. The scale plates of panel mounted indicating instruments shall have a permanent white matte finish with black graduations. The pointers shall be black, except that the maximum or minimum pointer or the pointer indicating contact setting (in contact working instruments) shall be distinguished from the main pointer by distinct colour and/or shape.

Instruments mounted on panels shall be of matching pattern, shape and finish so as to present a pleasing appearance consistent with functional requirement. The finish of the instrument case shall be subject to the approval of Employer. All instruments shall be designed to accurate measurement of the quantity under all conditions of operations and errors due to change in the ambient temperature, over the entire range of temperature obtainable at site shall be kept to the minimum. The instruments shall be provided with all the auxiliary appliances and any special tools required for maintenance.

The metric unit system shall be used for marking instrument dials. The range shall generally be such that the normal operation values are indicated in the middle third of scale.

All electrical instrument coils shall be designed for continuous operation on at least 110% of full rated current and for potential of the instruments. The instrument coil rating shall be coordinated with those of the associated instrument transformer.

The VA burden of the instrument coils shall be as low as possible consistent with the best modern design.

Electrical indicating instruments shall comply generally with the requirements of the International Standards/Indian Standards and shall be of accuracy specified in relevant sections.

All the analogue signals used for control and monitoring functions shall be made available for trending on the SCADA display screen. A minimum of six trending curves shall be displayed on each trending curves page. These trending curves are not intended for high speed disturbance fault recording.

Integrating watt-hour meters shall comply generally with the requirements of the International Standards/Indian Standards and shall be of the first grade for the purpose of accuracy classification.

Contact making instruments shall have contacts suitable for 250 V AC or 220 V DC currents.

All instruments shall have a high accuracy as possible consistent with the best modern design. The combination of instruments shall be mechanically sound and shall ensure permanence in accuracy. The limits of error for different instruments shall be stated in the Bid and their accuracy classification, where otherwise not specified shall be subject to the approval of Employer. All instruments shall be tested in accordance with the requirements of standard where specified. In case no specific standards are mentioned, Contractor shall submit the standards in accordance with which the instruments are proposed to be manufactured and tested and these shall be subject to the approval of Employer in every case.

The instruments shall be capable of withstanding the following tests, effect of shock, effect of vibration, effect of humidity and dielectric tests of 2000 Vrms to ground one minute in accordance with the Standards. A set of testing devices for calibrating pressure, temperature and flow meters required both for the turbine and generator shall be supplied by the turbine manufacturer. A set of testing devices for calibrating the electrical devices if required for the electrical equipment shall be supplied by the Contractor.

Where indicated, power meters shall be provided. Power meters shall measure voltage, current, power, kVA, power factor, kWh, etc. Power meters shall be provided with a 3 line LCD display, 4 analogue (4 20 mA) outputs and ETHERNET communication. Accuracy shall be 0.2% or better.

1.31.6. Moulded Case Circuit Breakers

All moulded case circuit breakers shall have thermal time delay and instantaneous trips with “On-Trip-Off”, indicating/operating mechanism with magnetic shunt trip release. Circuit breakers used in combination type motor starters and Contactors shall have the operating mechanism interlocked with the cover so that the cover cannot be opened unless the circuit breaker is open. The breakers shall comply with IEC standard 60947 series the applicable sections of ANSI C37.

1.31.7. 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. All contacts shall have a minimum rating of 10A over a range of 6 to 600 V AC. DC control relays shall have a minimum rating of 10 A at 220 V DC.

The interposing relays required input supply and switching capacity shall be of maximum 6.2 mm width for SPDT and 14 mm for DPDT to accommodate large numbers in the available space. It shall be mountable on 35mm DIN rail and the base element shall be able to accommodate electromechanical as well as Solid State (optocoupler) relays. The relays shall be pluggable and modular. It shall have integrated protection and signalling circuit i.e, built-in LED indicators in all and freewheeling diode wherever required. Option must be there for accessories for shorting of coil and / or contact terminals of multiple relays so as to reduce external jumper requirements.

The relays must be as per standard / regulation IEC 60947 series, IEC 60664A, 60255 series, DIN VDE 0110 and DIN VDE 0435 (in relevant parts).

Relays shall be with safe isolation in accordance with DIN EN 50178/ DIN VDE 160 and shall be made of inflammability class V0 in accordance with UL 94. It shall comply the contamination class 3 and surge voltage category III.

1.31.8. Pilot Devices

Pilot devices such as selector switches, push-button stations, thermostats, etc. shall be of heavy duty type, and when mounted outdoors, they shall be installed in weatherproof enclosures specially designed for the environment.

All electrical contacts for control, alarm and shutdown shall have a capacity of not less than 5 A at 125 V AC.

Pilot devices shall comply with IEC standard 60947 series.

1.31.9. Terminal Blocks

All terminal blocks shall be mounted in an accessible position with the spacing between adjacent blocks not less than 100 mm and the space between the bottom blocks and the cable gland plate being a minimum of 200 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.

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.

The terminal blocks shall be provided with shorting links and paralleling links where applicable, and mounted identification numbers and/or letters.

The terminal blocks shall conform to the applicable NEMA standard. The smallest size to be used shall be designated for 2.5 mm square wire and no more than two conductors shall be connected under one terminal clamp.

Terminal identification shall be provided corresponding to wire number of connected leads.

415 V AC circuit terminals shall be segregated from other terminals and shall be equipped with non-inflammable, transparent covers, to prevent contact with live parts. Warning labels with red lettering shall be mounted thereon in a conspicuous position.

Not less than fifteen (15)% of spare terminals shall be provided at each cubicle or panel.

i) For Control & Instrumentation Application

The control and instruments lead from switchboards or from other equipment shall be brought to terminal boxes or control cabinets in conduits. All interphase and external connections to equipment or to control cubicles shall be made through spring cage terminal blocks. The spring cage front entry terminal block as per IEC 60947-7-1 shall be made up of unbreakable polyamide 6.6 of V0 class according to UL94. The current carrying conductor shall be copper alloy and springs shall be made of non-corrosive metal. For the isolation of the input and output, knife disconnect terminal with hinged isolation link having a silver plated knife to facilitate higher conductivity shall be used. There shall be test sockets to facilitate testing and with front clear marking system. It shall have possibility of double shorting space to create alternate looping. It shall be able to wire with same size of lug and wire in the terminals. The terminal shall be ATEX approved and shall withstand 5g of vibration.

ii) For Power Application

The terminal block for the wire size above 6 sq mm. shall be as per IEC

60947-7-1. These shall be of mould piece made up of unbreakable polyamide 6.6 grade, touch proof. All metals parts including screws shall be non-ferrous in nature. The terminal block shall have screw locking design to prevent loosening of conductor/ screws and withstand vibration level of 5g.

iii) For CT/ PT Application

The terminal block for the current transformer and voltage transformer secondary leads shall be provided with sliding disconnect switch. All the testing & measuring operations like calibration of ammeter, relay testing, transformer short circuit shall be possible without removing the connection. All the metal parts for current transformer and voltage transformer terminal block shall be non-ferrous with fire retardant, unbreakable polyamide 6.6 of V0 class housing. All the accessories as well shall be of the similar material features.

iv) For Ring type connection Application:

The single bolt type terminal block shall be a mould piece made up of unbreakable polyamide 6.6 grade. All metals parts including bolt shall be

non-ferrous in nature. The bolt connection terminal block for cable lugs in accordance with DIN 46234 and DIN 46237. The bolt terminal block shall be marked with Zack marker on a large surface on both side of the terminal block.

The conducting part in contact with the cable is tinned or silver plated copper alloy and the rest of all metal parts shall be nickel plated copper alloy. However, springs shall be high grade steel.

The terminal blocks shall be extensible design and shall comply with applicable series of IEC standard 60947.

1.31.10. Small Wiring

Each conductor shall be individually identified at both ends through a system providing ready and permanent identification, utilizing slip-on thermoplastic sleeves approved by the Engineer.

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.

The markers must withstand a tropical environment and high humidity and only fungus proof materials will be accepted. Ferrules of adhesive type are not acceptable.

All trip circuits shall employ markers having a red background.

Sensitive control circuits (such as transducer, SCADA etc.) shall be effectively shielded against extraneous signals and interference. Analog, multi-pair cables shall contain individually shielded pairs and an overall shield. The shields shall be aluminum-mylar with bare copper drain wire. The shield shall be tied to the analog signal ground at only one end on the loop supply source side.

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.

Splices or tee connections between terminal points are not acceptable. Wire runs shall be neatly trunked inside the panels or in wiring troughs. Whenever possible, unused areas of the panels shall be kept free of wiring to facilitate the installation of future equipment.

Multi-conductor cables shall be connected to the terminal blocks in such a manner as to minimize crossovers. Approved claw washers or crimp type wire end connectors shall be used to terminate all small wiring. Insulating bushings shall be installed where necessary to avoid chaffing of wiring.

Coloured ferrules shall be used to specifically identify CT, PT & power circuit wires and their phase colour. The ferrules shall be colour coded as follows:

Designation	**Colour**
R Phase	Red
Y Phase	Yellow
B Phase	Blue
AC Neutral	Black
DC	Grey
Ground Connections	Yellow/Green strip

1.31.11. Power and Control Cables

Each set of current and voltage transformer secondary circuits shall be cabled separately. Voltage and current circuits shall likewise be run in separate cables.

Contractor shall supply and install at each end of the cables permanent and non erasable cable markers. The type and materials of the cable marker shall be subject to the approval of Engineer.

All cables entering or leaving terminal boxes shall be provided with separate terminations so that any cable out of a number of such cables can be removed or replaced without disturbing the remainder.

1.31.12. Cable Trays

Cables shall be installed in a Contractor supplied cable tray network, subject to approval of Engineer. Cable trays shall be made of galvanized steel and be of the vented type, 600 mm wide and 115 mm high and shall be able to support 67 kg per meter minimum. Cable tray support shall be spaced at no more than 1.5 meters.

1.31.13. Conduits

Cables that are not installed in cable trays shall be protected by continuous rigid conduit.

All conduits shall be in accordance with the following requirements.

Conduit Size	**Support Horizontal Run**	**Support Straps Vertical Run**
25 mm	1.75 m	2.0 m
25 to 30 mm	2.0 m	2.5 m
Over 30 mm	3.0 m	3.0 m

Conduit shall be galvanized rigid steel or rigid PVC and shall conform to NEMA RN - 1 Standard. Minimum conduit size shall be 20 mm.

Exposed conduit shall be of galvanized rigid steel and shall run parallel to the structural lines. Suitable conduit fittings and covers shall be used. The conduit shall be fastened using malleable iron pipe straps at spacings not greater than those given above.

All bends in conduit shall be made cold and the radius of bends shall not be less than 9 times the conduit diameter. No bend shall be permitted to flatten the conduit.

Wherever conduit crosses a structural expansion/contraction joint, approved expansion fittings and couplings with bonding jumpers shall be provided.

All conduct runs shall terminate at each end in a box or cabinet using approved connectors.

1.31.14. Cubicles and Control Panels

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.

Cubicles shall be fitted with close fitting, gasketed hinged lift-off-doors capable of being opened through 180 degree. The doors shall be provided with integral lock and master key.

Rack mount cubicle shall be provided with lift-off doors of shatterproof glass.

Cubicles and panels shall be vermin-proof. Removable gland plates shall be supplied and located to provide adequate working clearance for the termination of cables. Under no circumstances the floor/roof plate be used as a gland plate. The cable and wiring shall enter from bottom or top as approved or directed by Engineer.

The cubicles and panels shall be adequately ventilated, if required by vents or vermin-proof louvers and shall be so placed as not to detract from the appearance. All ventilating openings shall be provided with corrosion resistant metal screens or a suitable filter to prevent entrance of insects or vermin. Space heating elements with thermostatic control shall be included in each panel. Water drains shall be provided in areas where condensation may occur.

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.

Each cubicle, panel and junction box shall come complete with two copper ground busses, 40 mm width, 5 mm thick, extending throughout the required length in the corresponding cubicle. One of the bars shall be mechanically bounded to the metal structure of the cubicle while the other shall be isolated from the metallic parts of the cubicle. The first bar will be used for electrical grounding of the cubicle while the other will be used as the analogue ground.

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, busses 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.

All instruments, control knobs 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.

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 Contractor.

Blocking and test facilities accessible from the front of the panels shall be provided to permit safe protective relay testing and instrument calibration with primary equipment remaining in service. The facilities shall permit measurement of instrument transformer secondary conditions.

All control panels and cubicles shall be supplied with door-switched interior lights, 15A utility socket outlets and jacks with provision for connection to station telephone system.

The arrangement of control and protection devices on the panels and the exterior finish of the panels shall be subject to the approval of Engineer. The interior of all cubicles and panels shall have a matte white finish unless otherwise specified.

1. Interconnection
   Contractor shall supply, install, and connect all interconnecting cables between the various items of equipment supplied under Contract, except where otherwise specified bearing in mind that another Contractor will do the same work for the remaining equipment not covered by the present Contract. He shall collaborate with that Contractor.
   Unless otherwise specified, all cables for external connections will be supplied and installed complete with cable glands by Contractor. Contractor shall terminate these cable conductors on the terminals of equipment supplied under this Contract. Contractor shall co-operate where necessary with the Suppliers of related equipment in order to ensure the correct functioning of related equipment and instrumentation.

2. Interconnection Diagrams and Cable Schedules
   The Contractor shall prepare and submit the interconnection diagrams for each panel as well as the cable schedules for the equipment.

3. Grounding
   Contractor shall provide grounding terminals on all the equipment supplied under Contract and shall connect the grounding conductors to these terminals as approved or directed by Engineer.
   Unless specified otherwise, grounding mat and risers from the station earthing system up to different floors will be provided by Employer.

4. Alarm Contacts
   All alarm contacts shall be of galvanically isolated, dry types, and provide inputs for the following devices:
   - Unit control system inputs,
   - Supervisory control and sequence of event fault recorder system.

   All alarm contacts shall be of changeover (Form "C") type. Where required, relays shall be provided as contact multipliers.

5. Tropicalization
   In choosing materials and their finishes, due regard shall be given to the humid tropical conditions under which the plant is to work. Some relaxation of the provisions may be permitted where the plant is hermetically sealed, but it is preferred that tropical grade materials should be used wherever possible.
6. Marshalling Junction Boxes
   Marshalling junction boxes shall be provided as necessary to assure orderly connection of interconnection cables. Marshalling junction boxes shall be provided with the necessary barrier to discriminate power source. Protection A and protection B must not, under any circumstances, be present in the same marshalling box.

1.31.15. Miscellaneous Items

1. Iron and Steel

Iron and steel shall generally be painted or galvanized as appropriate. Indoor parts may alternatively have chromium or copper nickel plating or other approved protective finish. Small iron and steel parts (other than stainless 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 reasons be antirust 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 selected that the potential difference between them in the electro-chemical 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 coating of approved varnish compound. In areas subject to condensation and for high humidity, stainless steel shall be used for supports.

2. 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 due to tolerance limitations, shall be of corrosion-resisting steel. All wood screws shall be of dull nickel plated brass or of other approved finish. Instruments screws (except those forming part of a magnetic circuit) shall be of brass or bronze. Springs shall be of non-rusting material, i.e.: phosphor bronze or nickel silver, as far as possible. In areas where condensation may be present, stainless steel shall be used for all hardware.

3. 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. Sleeving and fabrics treated with linseed oil or linseed oil varnishes shall not be used.

4. Wood
   The use of wood in equipment shall be avoided as far as possible. When used, wood work 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. All wood work 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. All joints in wood work shall be dovetailed or tongued and pinned as far as possible. Metal fittings where used shall be of non-ferrous material. Furthermore, all wood components shall be impregnated with an approved fire retardant.

5. Adhesives

Adhesives are to be specially selected to ensure the use of types which 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.

6. Rubber
   Synthetic compounds not subject to deterioration due to the climatic conditions shall be used for gaskets, sealing rings, diaphragms, etc. Neoprene will be preferred for water, nitrite will be used for oil and fluorocarbon (Viton) when ozone temperature or any contaminant could affect the resistance of other compounds.

7. Plant
   The whole plant shall be designed to prevent ingress of vermin, dust and dirt. Where wiring, piping or ductwork passes through openings, these shall be constructed to prevent ingress of vermin. Wiring and piping enclosures and ductwork shall also be vermin proof.

8. Anti-Condensation Heaters
   Anti-condensation heaters shall be fitted in all motors, cubicles or panels containing control and/or relay equipment, whether or not they are ultimately to be in an air conditioned zone. They shall be installed in all junction boxes and mechanism outdoor boxes. The heaters shall be suitable for 250 V, 50 Hz operation with sufficient capacity to raise the internal ambient temperature to 50 degree centigrade. 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.

9. Panels and Location of the Heaters
   The construction of the panels and the location of the heaters shall be such that an effective circulation of air is ensured. All equipment shall be provided with suitable drainage for condensates and shall be designed to be free from pockets where moisture can collect.

1.32. ORIGIN OF MATERIAL AND EQUIPMENT

Contractor shall favour approved equal Manufacturers for all material and equipment that are used in the project unless there are serious quality and availability issues. If any of these issues arise, Contractor shall submit the problem to the Employer who shall make final judgment.

Contractor shall purchase the products listed in all relevant sections of the present specification, or elsewhere in the tender document.

Contractor shall provide all technical data, specification and details of the products, to the Engineer.

1.33. TRANSPORT AND INSTALLATION

1.33.1. General

Shipping, loading, transportation & insurance, unloading, storage, erection and test running shall be performed by the Contractor.

From the time of manufacturing until commissioning, all parts of the plant shall be protected and insured at the Contractor's expense against damage of any kind. Furthermore, parts which are damaged during transport, storage, erection or trial operation, shall be replaced at the Contractor's expense.

The Contractor shall provide the Engineer with complete packing lists of each performed shipment.

1.33.2. Packing

The Contractor shall prepare all plant equipment, devices and materials for shipment, protect them from damage in transit, & shall be responsible for make good all damages due to improper preparations, loading or shipment.

After the workshop assembly & prior to dismantling for shipment to the site, all items shall be carefully marked to facilitate site erection. Wherever applicable, these markings shall be punched or painted so they are clearly visible.

Dismantling shall be done in convenient sections, so that the weights & sizes are suitable for transport to site and for handling on the site under the special conditions of the project.

All individual pieces shall be marked with the correct designation shown on the Contractor's detailed drawings and other documents (packing lists, spare part lists, in Operating and Maintenance Instructions, etc.).

Marking shall be done preferably by punching the marks into the metal before painting, galvanizing, etc., and shall be clearly legible after painting, galvanizing etc. In labelling, the Contractor shall endeavour to use as few designations as possible and each part of identical size and detail shall have the same designation, regardless of its final position in the plant.

All parts shall be suitably protected against corrosion, water, sand, heat, atmospheric conditions, shocks, impact, vibrations, etc.

All electrical parts shall be carefully protected from damage by sand, moisture, heat or humid atmospheric conditions by packing them in high-pressure polyethylene foil. Where parts maybe affected by vibration, they shall be carefully protected and packed to ensure that no damage will occur while they are being transported and handled.

The material used for shipment of material frame at manufacturer's works withstanding the above shall be preferably environment friendly. Biodegradable packing shall be used to the extent possible.

The Engineer reserves the right to inspect & approve the packing before the items are dispatched but the Contractor shall be entirely responsible for ensuring that the packing is suitable for transit & such inspection will not exonerate the Contractor from any loss or damage due to faulty packing.

All packing costs shall be included in the scope of Work.

1.33.3. Marking

The Contractor shall mark all containers with the implementing document number pertinent to the shipment. Each shipping container shall also be clearly marked on at least two sides as follows:

- Consignee: (to be furnished at a later date)
  - Contract No. :
  - Country of Origin :
  - Port of entry :
  - Item number (if applicable) :
  - Package number, in sequence :
  - and quantity per package :
  - Description of Works :
  - Net and gross weight, volume :

1.33.4. Transport and Storage

The Contractor shall inform himself fully as to all relevant transport facilities and requirements, loading gauges and other limitations and shall ensure that the equipment as prepared for transport shall conform to such limitations. The Contractor shall also be responsible for obtaining from highway authorities any permit that may be required for the transport of loads exceeding the normal gauges.

For transport limitations, refer to Transport Limitations under Section A-1.

The Contractor shall provide means for all unloading and reloading for all consignments of plant; both during transport to Site and on the Site. Consignments shall be unloaded immediately on arrival at Site. The Contractor is required to take the necessary steps in order to provide the carriage, special supporting structures for heavy loads, etc.

All parts of the plant shall be brought, as far as possible, to their final place of erection. The Contractor shall construct his own storage facilities at site.

The warehouses shall be weatherproof, with good ventilation and solid floors. The floors of the warehouses and storage areas shall be designed to carry the loads imposed on them by the stored parts. All the parts shell be stored at least 300 mm above the ground level to avoid damages due to water logging.

The following parts shall be stored inside enclosed warehouses:

Bolts, pins, packing, tools, insulation materials, electrical parts with electrical devices attached, electric motors and excitation equipment, instruments, welding material and equipment, all small parts and all parts of the plant which have already been painted.

If large parts are stored in the open air, they shall be provided with weather resistant and fire-resistant covers. Electrical parts, which are not packed in heavy-duty polyethylene foil and those so packed, but whose packing has been damaged shall be kept in suitable places from the moment of storage to the moment of installation.

All insulation materials which will be taken from the warehouse for installation and which are stored temporarily in the station shall be protected from weather or humidity.

All the equipment shall be stored as per standard storage and preservation instructions of the Suppliers.

1.33.5. Preparation and Installation

Prior to commencement of installation, the Contractor shall closely inspect the site and all the foundations and other structures on which parts of the plant supplied under this Contract will be installed. He shall check that the foundations conform to the installation drawings by coordinating with the civil Contractor at the time of casting of foundation anchor bolt pockets.

The result of this check shall be reported to the Engineer in due time to allow any errors to be corrected before the commencement of erection. All parts of the plant shall be cleaned carefully of all contamination such as dust, sand, rust, mill scale and other dirt prior to installation.

1.33.6. Reference Points (layout, Measurements and Datum)

The Contractor shall employ a competent surveyor for setting-out of all datum lines including the constant checking and maintenance of the setting-out until the completion of his works.

The Contractor shall provide all necessary pegs, profiled templates and centre lines and shall establish all such permanent markings and recovery marks as may be required by the Engineer for checking the Contractor's setting-out. The Contractor shall be responsible for rectifying, at his own cost, all work rejected by the Engineer due to errors in setting-out.

All bench marks, notch marks, pegs and signals on the surface, alignment pins and the like put in by the Engineer for the purpose of checking the Contractor’s work of as permanent survey marks will be under the care of the Contractor during the period of the Contract. He shall, at his own expense, take all proper and reasonable care and precautions to preserve and maintain them in their true position where such marks are within or adjacent to his work area. In the event of their being disturbed or obliterated by any cause whatsoever, they may, if so determined by the Employer be replaced by the Engineer at the Contractor's expense.

The Contractor shall be responsible for the true and proper staking-out of the works and levels of reference given by the Engineer in writing, for the correctness of the positions, levels, dimensions and alignment of all parts of the works and for the provision of all necessary instruments, appliances and labour in connection with this.

The checking of any staking-out or of any line or level by the Engineer or the Engineer's Representative shall not in any way relieve the Contractor of his responsibility for its correctness.

1.33.7. General Notes on Installation Work, Embedded Parts

All transportation and handling of the plant from the place of storage to the place of installation shall be carried out by the Contractor. He shall provide all hoisting equipment, staging and scaffolding, winches and wire ropes, slings, tackles and all other appliances and temporary materials. The erection staging and scaffolding shall be provided with coverings and barriers and shall guarantee safe working conditions.

The Contractor shall comply with all applicable and approved safety regulations while carrying out the works on Site and with all reasonable requirements of the Engineer. This stipulation shall in no way release the Contractor from any obligation concerning his liability for accidents and damages. He shall be responsible for adequate protection of persons, plant and materials against injuries and damages resulting from his operations.

The plant or parts to be installed shall not be overstressed during the process of installation.

The Contractor shall be responsible to ensure that the installation of the plant and the equipment is properly executed to the correct lines and levels and in accordance with the manufacturer's instructions and the Contract requirements.

The alignment of the plant shall be done exactly; the tolerances indicated by the Manufacturers or in the drawings shall be respected at all times.

Setting of parts to be aligned shall be performed by means of fine measuring instruments. All erection clearances and settings shall be recorded. Copies of these records shall be given to the Engineer. After alignment, the parts shall be held firmly in position by means of set pins, fitted bolts, etc.

The Contractor shall supervise the installation of the anchor bolts and other embedded parts being embedded in the foundation concrete and shall satisfy himself that all parts to be embedded in concrete shall be set accurately & securely held in position and shall be supported rigidly to prevent displacement during the placing of concrete. Adjusting screws and bolts shall be drawn tight and secured adequately. Steel wedges shall be secured by welding. Wooden wedges shall not be used.

The Contractor shall verify carefully the position of all parts to be embedded before concrete is poured. All important measurements and dimensions shall be recorded. Copies of these records shall be given to the Engineer for checking and approval before items are built-in to the Works.

After concreting, the control measurements shall be verified again, indicated in the above-mentioned records and submitted to the Engineer.

Grouting of voids will not be undertaken sooner than seven (7) days of the concreting the embedded parts.

The Contractor shall provide all necessary anchors and braces to ensure the alignment and stability of the parts to be installed. All temporary scaffolding, anchors and bracings shall take care of all dead load, wind load, seismic and erection stresses, e.g., during concreting, and shall remain in place until they can be removed without endangering the stability of the plant.

Welding, torch-cutting and drilling work on the plant to be erected shall only be carried out with the approval of the Engineer, and only for modification if any.

If for installation purposes, auxiliary structures have been attached to the plant, they shall be removed after completion of work and the surface restored to proper condition by grinding and repainting.

Special care shall be taken not to damage surfaces of galvanized or specially treated plant during erection. Care shall be taken to prevent or remove any rust streaks or foreign matters deposited on galvanized or otherwise finished surfaces during storage or transport or after installation.

Glass parts or other parts, which can easily be damaged, shall be provided with suitable protective sheaths or coverings during installation.

Machined or bare metal surfaces, which are to receive no coat of paint, shall be protected during transportation, storage and erection by a suitable anti-corrosion film.

All power tools preferably to be operated pneumatically. They are to be handed over at the end of the installation work in good condition in accordance with the Engineer's instructions.

After erection, the works shall be finally painted, in accordance with the painting specification, and any damaged paintwork shall be restored.

The Contractor shall keep the site in clean condition during erection and commissioning time. On instruction of the Engineer, he shall remove waste from the place of installation to the defined deposit site at his own cost.

1.34. MECHANICAL EQUIPMENT MAKES VENDOR LIST (AS APPLICABLE)

The following makes for components are to be used. Any other make offered shall not be acceptable unless approved by the Employer. Sub-Vendors of Major Equipment too will be subject to Employer's approval if they deviate from the list below.

S. No.	Items	Brands
1	MIV/PPV	GE/Alstom, Fouress, TB Hydro, Andritz, Jyoti, BHEL, VAAS, Tyco, KBL and voith, or approved equivalent
2	Governor	AIMS, Heinzmann, Siemens, GE/Alstom, BHEL, ABB, or approved equivalent

3	OPU	Bosch Rexroth, Hydac, Yuken, Leonardo, Parkar, or approved equivalent
4	Pumps – Centrifugal	KSB, KBL, Flowmore, WPIL, Jyoti, Mody, Grundfos, or approved equivalent
5	Pumps - Submersible Sump	KSB, KBL, Mody, Kishore, Flowmore, or approved equivalent
6	Pumps - Vertical Turbine	KSB, KBL, WPIL, Flowmore, or approved equivalent
7	Cyclone Separators	Filteration Engineers (Timex), Lakos, Hydac, or approved equivalent
8	Motorised Automatic Water Strainers	Bollfilters, Hydac, Filteration Engineers, Sperflo Filters, EATON, or approved equivalent
9.	Heat Exchangers	GEA Ecoflex, Alfa Laval, or approved equivalent
10	Compressor	Atlas Copco, ELGI, Chicago Pneumatics, Ingersroll Rand, or approved equivalent
11	Oil Purifying Unit	Alfa Laval, Vacuum Plant & Instruments, Ferrocare, or approved equivalent
12	Valves	KBL, L&T, BDK, Keystone, Fouress, Leader, AV Valves, or approved equivalent
13	Gear / Screw Pump	Tushaco, Hydac, Parker, or approved equivalent
14	Pressure Transmitter	Rosemount, Endress + Hauser, Honeywell, Yukogawa, ABB, Siemens, or approved equivalent
15	Level Transmitter	Rosemount, Endress + Hauser, Yukogawa, ABB, Siemens, or approved equivalent
16	Pressure Gauge	WIKA, or approved equivalent
17	Over Velocity Device	Accusonic, Rittmeyer, Hydrovision, Endress + Hauser, or approved equivalent
18	Limit Switches	Speed-N-System, SKC, or approved equivalent

1.35 ELECTRICAL BOP EQUIPMENTS VENDOR LIST (AS APPLICABLE)

Sl. No.	Items	Brands
1	Bus Duct	Delta Unibus, GE, C&S, BHEL, or approved equivalent
2	Station Service Transformer	Alstom, ABB, CGL, RPG, Schneider, or approved equivalent
3	Dry Type Transformer	Alstom, BHEL, CGL, ABB, Schneider, RPG, or approved equivalent
4	MV Switchgear	ABB, Larson & Tourbo, Schneider, Siemens, CGL, GE, or approved equivalent
5	415V Switchgear	ABB, Schneider, GE, L & T, Siemens, C&S, L&T, NEC, Jakson, Jasper, BCH, or approved equivalent
6	DC System	Amara Raja, Exide, STATCON, HBL, Union Batteries, or approved equivalent
7	UPS System	Statcon, Emerson, Autometers, Hi Rel, Eaton, or approved equivalent
8	Illumination	Bajaj, Philips, GE, CGL, Havells, Wipro, or approved equivalent
9	Switchyard Equipment and GIS	Alstom, ABB, Siemens, CGL, GE, BHEL, or approved equivalent
10	Protection Relays	ABB, Siemens, GE, Alstom, or approved equivalent
11	PLCC System	ABB, Siemens, or approved equivalent
12	Cable	KEI, RPG, Finolex, CCI, Polycab, Universal Cables, Havells, or approved equivalent
13	Silent D.G. Sets	Jackson, Sudhir, Caterpillar, Sterling Generators, or approved equivalent
14	EPABX System	Alcatel, BPL, ITI, Tata, Siemens, HCL, MB Control, or approved equivalent
15	Power Meters	Schneider, Secure, Satec, or approved equivalent
16	OFC and Accessories	MB Control, SystiMax, Molex, or approved equivalent

17	Control Panel & Cubicle shell	Rital, Hoftman, Valrack, or approved equivalent
18	Vibration monitoring system	VibroSystM or GE Bentley Nevada, or approved equivalent

19	PD Measuring System	GE Energy or GE Omicron
20	Relay Testing Kit	Omicron
21	Generator	ANDRITZ, BHEL, VOITH,GE

NOTES:

1. Make of any other component/device not indicated above shall be subject to approval by the Employer.

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1. TURBINE

1.1. General

The Karbi Langpi Middle II Hydro Power Project, located in Karbi Anglong district of Assam, is a run of river scheme, utilizing the available total discharge of 47.6 Cumec. The scope of the contract includes supplies for Turbines and all auxiliaries and accessories as well as complete mounting ready to operate. Bids are invited for 3 Nos. Horizontal Francis Machines capable of generating a minimum of 8MW at Generator terminals at rated net head condition along with 10% continuous overload.

The Bidder must inspect and check all relevant details of the site and is expected to introduce all necessary steps in time. All equipment is to be delivered directly on site. All workshop-manufactured equipment should be coated and be treated as per coating requirements. Equipment shall be equipped with transport lugs for ease of mounting and handling. All lugs shall be retained to allow for future removal/installation of Turbines and auxiliaries.

The Bidder is expected to co-operate fully with other parties & civil contractors, involved in commissioning and other works on site. He shall supply all information for civil structure design and all details for structural design of the power station as per prudent practice and relevant IS codes. Any dissent shall not entitle for any additional claim.

The relevant codes must be respected as well as ranked as given below:

- Technical Specifications including all relevant supplements/amendments.
- Applicable Indian Standards, and with priority all relevant International Standards.

1.2. Scope

This portion of the specifications covers the design, material selection, manufacture, Shop assembly, intermediate storage, tests at works, packing and forwarding for shipment, intermediate storage, delivery at site (final destination), receipt and storage at site, services for performing on-site assembly, erection, testing and commissioning in a complete shape of 3 nos. Horizontal Shaft, Francis Turbines and auxiliary equipment including governing equipment, auxiliary system such as cooling water, drainage & dewatering system, oil, water and air piping and cabling connected ready to operate, valves and fittings, instrumentation, controls and safety devices, and recommended spares for five (5) year trouble free operation of the plant, special tools etc. as described and detailed in the specification and as considered necessary by the Bidder.

The scope of supply shall include all parts, accessories, spares etc. which are essential for assembly, erection, construction, trial operation, trial run, test run, commissioning and testing of the complete unit even though these are not individually or specifically stated or enumerated. Corresponding components of both the Turbines and associated equipment and spares shall be of the same material, dimensions and finish and shall be inter-changeable.

1.3. Type and Rating

The Turbine shall be of Horizontal Shaft with adjustable Guide Vanes Francis Turbine suitable for coupling to Horizontal shaft synchronous Generator. The direction of rotation shall be anticlockwise when viewed from Non-driving End. The Turbines shall be capable of giving outputs 10% higher than rated outputs. The details of the hydraulic system and basic data for design of Turbines are given below:

1	Turbine	3 Nos. Horizontal Francis Turbine
2	Rated Speed	428.6 RPM
3	Maximum Gross Head	65.73 mwc
4	Minimum Gross Head	65.1 mwc
5	Net Head (Max.)	65.1 mwc
6	**Net Head (Rated)**	**57.1 mwc**
7	Net Head (Min.)	**57.1 mwc**
8	Min. Tail Water Level	319.8 m
9	Forebay Level	FRL – 385.5 m/ MDDL 385.5 m
10	Maximum Tail Water Level	320.5 m
11	Centerline of Scroll	321.30m
12	Permissible Pressure Rise	35 %
13	Permissible Speed Rise	Less than 55%
14	Max. Runaway Speed	1.8 times of rated speed

The rated capacity of the Turbine shall correspond to 8MW at Generator terminals.

The Turbine shall be capable of generating the rated capacity MW at the Generator terminals at rated head with guide vane opening of about 90% such that the overload capacity 10% is satisfied.

The diameter of the unit penstocks is 2200 mm. The tentative layouts of the powerhouse are given in drawings appended to these specifications. Transport limitations & transport details must be investigated by the supplier and be presented with his offer.

The specific speed of the Turbine shall be as per the best modem practice and of proven design and operation. The runner must operate at any load condition without cavitation or undue vibration. The runner should be capable of operating at 50 % discharge with minimum performance of not less than 85% efficiency.

1.4. Outputs, Efficiency Guarantees and Penalties

1.4.1. Output And Efficiency Guarantees

The rated output of the Turbine at rated net head and rated discharge as well as overload output at rated net head shall be stated and guaranteed.

The weighted average efficiency of the Turbine at rated net head for 110%, 100%, 75% and 50% rated output shall also be guaranteed as per the formula.

EvT = K1*E110% + K2*E100% + K3*E75% + K4*E50%

Where EvT is the weighted average efficiency of the Turbines,

E110%, E100%, E75%, E50%, are the guaranteed efficiency of the Turbines at the respective percentage of the operation with reference to the rated head and

K1=0.50, K2=0.30, K3 = 0.10, K4 = 0.10

The weighted average efficiency of the Turbine at rated head for 110%, 100%, 75% and 50% rated output shall also be guaranteed. Weighted average efficiency of Turbine shall not be less than 91.50%. These figures shall be applicable for the purpose of penalties, rejection limits and bid evaluation. In addition, the outputs as per discharge conditions used for calculation of generation shall also be guaranteed. The output of the Turbine at full guide vane and lowest operational guide vane opening shall be stated in the Bid. The guarantee is fulfilled only if it is in accordance to the IEC code 60041.

Bid Evaluation

In the evaluation of bids, equalization on account of differences in efficiencies of the turbine of the various offers will be made at the rate of 2200 US$ per turbine for each one hundredth of 1% (0.01%) by which the weighted average efficiency given in (or computed for) any offer is lower than the highest weighted average efficiency among the various offers. For differences lower or higher than one hundredth of one percent (0.01%), the equalization will be computed on pro-rata basis. The weighted average efficiency of the turbine shall be same as defined previously for penalty purposes. The tolerances for turbine efficiency shall not be considered during bid evaluation.

1.4.2. Penalties

1.4.2.1. PENALTY FOR SHORTFALL IN WEIGHTED AVERAGE EFFICIENCY OF TURBINE

Field acceptance tests shall be carried out by Index test (Winer Kennedy method) as per IEC-60041 to determine the actual output and the efficiency of Turbine vis-à-vis the guaranteed values on any one machine.

For any shortfall in tested value of average weighted Turbine efficiency at rated net head from the guaranteed value, penalty shall be applied at the rate of USD $2,200 (Two thousand two hundred US Dollars only) for each unit, for each one hundredth of one percent (0.01%) by which test figure is less than the guaranteed value of the Contract.

For fractional values of shortfall in percentage of weighted average Turbine efficiency, the Penalty amount will be computed on pro-rata basis.

The weighted average efficiency of the Turbine will be verified after commissioning of the generating units on the basis of field acceptance tests on any one unit, to be decided by the Employer.

Same amount of penalty shall be payable for each of the other Turbine for shortfall of weighted average Turbine efficiency, i.e. the total amount of Penalty shall be equal to “Penalty against shortfall in weighted average efficiency of Turbine for one unit” multiplied by “total number of units”.

1.4.2.2. PENALTY FOR SHORTFALL IN TURBINE – GENERATOR (TG) MAXIMUM OUTPUT

If the Turbine-Generator (TG) Unit does not give the guaranteed rated output at rated net head measured at Generator Terminal for any reason attributable to the Contractor, Penalty shall be applied at the rate of USD $2,200 (Two thousand two hundred US Dollars only) for each unit, for each one hundredth of one percent (0.01 %), by which the test value is less than the guaranteed value of the Contract.

For fractional values of shortfall in Turbine-Generator (TG) rated output, the Penalty amount will be computed on pro-rata basis.

The rated output of the Turbine-Generator (TG) unit will be verified after commissioning of the generating units on the basis of field acceptance tests on any one unit, to be decided by the Employer.

Same amount of penalty shall be payable for each of the other TG unit for shortfall of rated output of the TG unit, i.e. the total amount of Penalty shall be equal to “Penalty against shortfall in rated output of the TG unit for one unit” multiplied by “total number of units”.

No tolerance shall be permissible over the test figures of rated output. In case of efficiency, tolerance will be calculated as per the International Standard IEC code 60041.

1.4.2.3. REJECTION LIMIT

The Employer has the right to reject the Turbine if the test value of either

average efficiency or the rated output is less than the corresponding guaranteed values by 2 (two) percent or more.

1.4.2.4. RECTIFICATION TO MEET GUARANTEES

In case the specified tests prove unsuccessful in meeting the guaranteed values, the Supplier will be given mutually agreed reasonable period to improve or modify or rectify Turbine and Generator as may be required to meet standard guaranteed figures without extra cost to Employer.

If such attempts to improve or modify or rectify fails, taking remedial action by Employer at Supplier's risk and expense without prejudice to other terms and conditions of contract or imposing of penalty or rejection of the equipment as the case may be, shall be applied.

1.5. Cavitation Guarantees

The Bidder shall guarantee the runner against pitting caused by cavitation for 18 months from the date of issuance of preliminary acceptance certificate or 8,000 hours of commercial operation, whichever is earlier.

Excessive pitting shall be defined as the removal of metal from the runner and other hydraulic passages of a weight of

$$W = 0.15D^2 \text{ per } 1000 \text{ hours of operation}$$

Where D = Discharge diameter of the runner in meter and W = Weight in kg.

If the 18-month guarantee period expires before completion of 8,000 hours of commercial operation, the guarantee shall apply to the actual hours of operation.

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 statement of fulfilled modification etc. shall be subject to cavitation guarantee as for the original equipment. In addition, the Supplier shall also be liable to bear the revenue cost lost due to loss of generation.

1.6. Critical and Plant Sigmas

Values of critical sigma as determined from cavitation model tests (existing) / CFD Analysis as per IEC 60193 shall be given by the Bidder in the form of curves for different heads of operation. Plant sigma curves as recommended by the Bidder shall also be plotted on it clearly to show the safety margin available. The Bidder shall determine and indicate the limiting levels for installation of the equipment in his offer.

1.7. Speed Rise and Runaway Speed

The moment of inertia of the unit and the normal guide vane closing time shall be so adjusted that the maximum momentary speed rise of the unit shall not exceed 55 % under any condition of operation. The maximum runaway speed of

the unit under any combination of head and load combinations shall be stated in the tender. The bidder shall satisfy the Employer on the guaranteed speed /pressure rise of the hydro Turbine as being ideal and overall economical. The bidder shall also compute pressure and speed rise using plant parameters and operating conditions and furnish the same in the bid. The Turbine shall be capable of running safely at maximum runaway speed of 1.8 times the rated speed without any damage to its parts for a period of not less than 15 minutes for every such occurrence, without cooling water and lubrication supply on. The first critical speed shall be at least 25% above runaway speed.

1.8. Noise Level

Turbine design shall be such as to ensure smooth & quite operation with low vibrations, pressure pulsation, power fluctuations and noise. Any vibration caused by the machine should not be in resonance with any part of the equipment delivered.

The 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 located in the machine hall.

The vibration amplitude at the shaft shall not exceed the values specified in ISO-20816-5.

1.9. Stresses, Factor of Safety and Guarantee

All parts of Turbine shall be designed and constructed to safely withstand the maximum stresses during normal running, runaway, short circuit conditions, out of phase synchronizing or grid fail condition. The maximum unit stresses of the rotating parts shall not exceed two-thirds of the yield point stress of the material.

For other parts, the factor of safety based on yield point stress shall not be less than 3 at normal conditions.

For over-load and short circuit conditions, a factor of safety of 1.5 on yield point stress shall be permitted. All parts shall be guaranteed to withstand a minimum time of 1,50,000 operational hours, miscellaneous operation equivalent to 1,00,000 operational hours full load.

1.10. Bid Evaluation

In the evaluation of the bids, the equalization on account of difference in the efficiencies of various offers will be made on the basis indicated in Vol and Vol III of this Tender Document.

The basis for selection of the offers shall be the overall economy to the Employer. 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 reasonable cost. The life cycle period for major parts e.g. bearings, runner etc. shall be indicated and guaranteed tby the Bidder.

1.11. Model Test Report / CFD Analysis

The manufacture of any part of a prototype Turbine shall be started only after the efficiency and other guarantees and requirements of the Turbine are established and fulfilled based on existing model test. New model test is not required to be conducted by the Supplier. In case the Supplier has already performed model tests on similar and the Employer can be satisfied that the tests were witnessed by independent experts, the Employer may at his discretion, permit the supplier to proceed with the manufacture after approval by the Employer of the model test report. If the model test conducted is not homologous with respect to the project parameters, semi homologous model can be accepted after including the CFD analysis by transposing the parameters required from the base model. The Hill diagram provided by the Supplier can be based on model test results but will not replace the onsite guarantee measurement procedure according to IEC. Any model test provided by Bidder must fulfil the International Standards as given below:

The performance of the model tests either afresh or that had been done earlier shall be as per IEC 60193 in all respects. Hydraulic performance tests shall be made with several angles of guide-vane openings to determine machine characteristics including regimes of safe operation, zones of cavitation and vibration etc. The phenomenon of cavitation and vibration particularly at lesser guide vane openings shall be specially investigated. These tests shall include determination of capacity, part load operations limits, cavitation limit, hydraulic thrust, runaway speed, guide vane torque relationship etc., and such other details as covered in IEC. Prototype efficiencies shall be derived from model tests by the step-up formula only for information as applicable for the type of Turbine contained in IEC. Model tests shall simulate all possible normal operating conditions of the prototype for entire range of forebay and tailrace levels.

The delivery schedule given by the Bidder shall be reckoned from the date of approval of model test report. As the model test is already available, this shall be submitted within 2 weeks after the date of issuance of notification of award. All relevant information relating to the performance of such tests shall be provided along with the Report. Model test results will in any case be replaced by prototype test, which only shall be valid for performance guarantees.

1.12. Standards

IEC 60041	International code for Field Acceptance Tests of Hydraulic Turbines
IEC 60308	International code for testing of speed governing systems for hydraulic Turbines
IEC 60545	Guide for commissioning, operation & maintenance of hydraulic Turbine
IEC 60994	Guide for field measurement of vibrations and pulsations of hydraulic machines

IEC 60995	Determination of prototype performance from model acceptance test/of hydraulic machines with consideration of scale effects
IEC 60193	International standard - Hydraulic Turbines - Model acceptance tests
IEC 60041	International standard field acceptance tests of hydraulic Turbines
IEC 60609 P 1	Cavitation pitting evaluation in hydraulic Turbines, storage Turbines and pump-Turbines, Part 1.
ASME	Boiler and Pressure Vessel Code, Section VIII
IS 12800	Guidelines for Selection of Turbines, Preliminary dimensioning and layout of Surface Hydro Electric Power house
IS: 1271	Classification of insulating materials for electrical machinery
IS: 2379	Colour code for the identification of pipelines
IS: 5	Colour for ready mixed paints and enamels
IS: 226	Structural steel (standard quality) (fifth revision)
IS: 1538	Cast Iron fittings for pressure pipe for water, gas and sewage
IS: 6392	Steel pipe flange
IS: 2906	Sluice valves for water works
IS: 2002	Medium tensile steel plate used for welding, flame cutting and flanging in hot condition
IS: 2049	Colour code for identification for wrought steel for general engineering purposes
IS: 1030	Cast steel
IS: 28	Bronze
IS: 1239	G.I. pipes Part 1, Part 2

Note: The latest edition of the above codes shall be referred.

1.13. General Arrangement and Construction

The Turbines shall be installed in a setting as indicated in the layout drawing or setting indicated by supplier and approved by Employer. The Generator, flywheel etc. shall be mounted on a suitable chassis/platform mounted over the Turbine floor. The design shall be such that to enable easy assembly and erection at site and the spacing of the equipment should be sufficient for maintenance of Turbine and Generator. The statement of origin of materials shall be confirmed in the bid. The certificate of origin must be handed over when materials are in workshop. A list of sub vendors is provided in the Volume III, Section A2. In case of deviation, the same must be mentioned in the bid and be approved by the client during execution of work.

1.14. Guide Vanes

The number of guide vanes selected shall be well matched to ensure Turbine operation without objectionable vibration. The guide vanes shall be shaped to permit smooth flow of water through the Turbine and shall be so proportioned as to maintain closing tendency under any normal operating conditions of the Turbine.

The Turbine Guide Vanes and stems shall be of die cast 13-4 Cr-Ni stainless steel. Each guide vanes shall be machined smooth and ground to an accurate form and finish.

Each Guide Vane shall be provided with greaseless self-lubricating bush type guide bearings. Each stem shall be provided with a thrust bearing of bronze to carry the weight of the guide vane and withstand hydrostatic thrust. Convenient means shall be provided for adjusting and maintaining the clearances of the Guide Vanes.

The Guide Vane operating mechanism shall be of ample strength to withstand the most severe operating conditions. All working points with relative motion shall be self-lubricated. Means shall be provided for adjusting the position of any individual Guide Vane independently.

Each Guide Vane shall be individually connected to the Guide Vane operating ring through a set of lever and links.

Suitable Safety element shall be provided between each Guide Vane stem and Guide Vane operating ring which shall be strong enough to withstand the maximum normal operating forces but will break or yield due to forces in opening or closing direction and will protect the rest of the mechanism from damage when one or more of the Guide Vanes become jammed. A Safety element failure check circuit shall be provided which shall be electrically continuous if all pins are sound. If any one pin is sheared it shall furnish annunciation in the unit control board. A Safety element break test shall be performed in the shop.

Solid stops and suitably designed friction device shall be provided for each Guide Vane to limit the angle and rate of movement of Guide Vane stem levers while opening and closing on Safety element failure. The loose Guide Vane and its linkage after Safety element failure shall not interfere with the operation of other Guide Vane or Turbine parts or cause progressive failure of adjacent safety element.

1.15. Guide Vanes Regulator

The guide vanes arrangement must be provided with closing tendency when not operated by power pack.

The guide vanes shall be operated by one number of double-acting oil pressure operated, fabricated or cast steel VALVE having adequate capacity to operate the Turbine Guide Vanes to full opening or closing stroke under all conditions. The servomotor shall be capable of moving the guide vanes smoothly during full opening and closing in required time as per pressure rise and speed rise limits given in the bid.

The servomotor shall be provided with suitable adjustable bypass connections for cushioning to achieve retardation in the rate of closure during the portion of Guide Vane travel from slightly below speed-no-load position to the fully closed position to prevent excessive pressure changes in the water passages.

Manual locking devices to hold the guide vanes in the closed or open position against maximum oil pressure shall be provided. Switches for interlocking circuits and lamp indication of the locking device position shall be provided on local panel and on unit control board.

Provision for connecting the restoring cable from the actuator on the piston rod of servomotor shall be provided. A scale calibrated in tenths of Guide Vane position shall be rigidly attached to servomotor position by means of a pointer.

1.16. Runner

The runner shall be Francis type, forged/cast fabricated runner confirming to IEEE – 810 (1987). The runner material shall be DIN EN 10283, Material Nr 1.4317, G-X4 CrNi 13.4 or ASTM A 743 CA 6 NM. The runner shall be forged/Cast Fabricated with integral labyrinths and shall be designed to provide the best hydraulic profile so that it gives the maximum efficiency with minimum cavitation. The composition of the material and the source of runner casting shall be stated in the Bid. The entire runner including the spare shall be interchangeable. A suitable connection shall be provided for attaching the runner to the Turbine shaft. Opening shall be provided through the runner crown or relief pipe in head cover to drain the water and reduce the hydraulic thrust. It shall be housed with bearing bushes to withstand safely all forces during operation as well as during max. runaway speed.

The runner shall be statically balanced in the works and so designed to safely withstand loading due to normal and abnormal operating conditions including effects of blade thickness reduction due to cavitation erosion, introduction of stress due to on site welding of damaged blades, increased pressures at transient conditions and discharge related to maximal guide vane opening. The runner shall be designed to withstand stress due to resonant vibrations. The Contractor shall clearly present his calculation criteria with respect to the maximum possible stresses in the runner, related to mechanical properties of the runner material.

The runner shall be free from internal stresses and casting imperfections. All surfaces of the runner exposed to the flow of water shall be carefully machined and finished smooth to templates. There shall be no hollows, depressions, waviness, projections and/or other surface imperfections that might lead to local disturbance, erosions and/or cavitation. Other highly stressed areas of the runner shall be finished smoothly to judge the quality of the casting or forging and evaluate possible material defects.

The conformity of the blade shape to the design drawings shall be verified by use of templates or other shop control devices. Nominal Templates for guidance in restoring blade and bucket shapes to original contour shall be supplied with the runners. The method for runner removal shall be clearly specified. The special tools and tackle required for dismantling and fixing of runner shall be supplied.

Alternatively, the supplier may propose a runner of cast fabricated construction in accordance with modern fabrication practice if the runner meets the requirements of efficiency and cavitation.

1.17. Shaft and Coupling

The Turbine shaft (if required) shall be of forged carbon steel or alloy steel conforming to ASTM A 668 Class D or equivalent standards. Wherever the flanges are integral with the shaft, the same should conform to International Standard. The Turbine shaft shall be connected to the runner on one side and to the flywheel on the other side. It shall be of ample size to transmit torque at rated speed without any vibration or any distortion. The main bearing concept of runner must be provided in drawings with tender documents. The couple shall be elastic one for operational comfort.

A renewable and removable sleeve of stainless steel shall be provided wherever the shaft passes through a shaft seal or a gland. The sleeve shall be of corrosion-resisting material, accurately machined, polished, and adequately secured to the shaft. The details of sealing must be provided in the bid document.

(However, runner directly mounted on the Generator shaft shall be preferred)

1.18. Bearings

The Turbine bearing (if the Turbine shaft is provided) shall be pedestal mounted journal type oil lubricated thrust cum guide bearing. The Turbine shall be provided with adequate number of bearings. The bearings shall be designed to withstand operation at maximum runaway conditions without cooling water supply (if cooling water is provided) or lubrication system for a period of not less than 15 minutes and for operation at normal speed without cooling water supply for 15 minutes. The bearings shall be provided with a dial type and resistance type thermometer, a pressure gauge together with provision for alarm annunciation / shutdown on excessive bearing temperatures and sight level gauges, valves and piping for cooling water. The bearing temperature should not exceed 55°C under any operating conditions. The number and type of bearings shall be stated in the bid. Type of lubrication system provided shall be clearly indicated in the bid. The bidder may also offer with self lubricating bearing water cooled bearings confirming to the above stated requirements.

1.19. Shaft Gland

The shaft gland shall be of the stuffing box / carbon ring type with self-lubricated packing and lantern ring. Any other suitable type of shaft gland will also be considered. The gland shall effectively prevent leakage of water along the shaft under all operating conditions and at standstill and prevent entry of air. Details for starting and operation of the Turbine and shut-off action shall be particularly provided for in the bid. In case the location of the gland is below maximum tail water level, an inflatable rubber seal shall be provided for attending the main gland without dewatering the draft tube. A stainless-steel sleeve with self-lubricating type shall be provided on the shaft where it passes through the gland.

Arrangement for providing cooling water supply to the gland, if required, shall be made by the Bidder and indicated in his Bid drawings.

1.20. Scroll Case and Stay Ring

The scroll case with runner chamber support, side cover support etc. shall be constructed in accordance with best design practice to provide efficient operation of Turbine. A set of stay vanes of appropriate construction of steel shall be provided. The scroll case shall be provided with an air release cum anti-vacuum valve for evacuation of air.

The spiral casing shall be fabricated from welded steel plate / mild steel plates and shall have suitable sections for ease of shipment and to be within transport limitation. The scroll case and stay ring shall be designed to withstand maximum water pressure including water hammer and shall be complete in all respects with anchors, supports, sole plates, turn buckles, hold-down rods, all types of clamps etc. The Turbine should not communicate vibrations to the building nor any other dynamic load to be burdened.

The stay-ring shall be of cast steel or fabricated from welded steel plate and suitably stress relieved prior to machining. Flanges shall be provided for bolted connections between the stay ring and the side cover, and between the stay ring and the discharge ring. Alternatively, the discharge ring may be welded to the stay ring prior to stress relieving and machining. A flange to receive the pit-liner shall be provided. The stay ring shall be designed to support the weight of the superimposed structures and parts, with spiral case empty, and to withstand safely the forces due to maximum head, including maximum pressure rise. Fabrication of the stay ring in the field will not be allowed.

The spiral casing and stay ring shall be designed for maximum operating pressure including water hammer and shall be tested for 1.5 times the maximum pressure to which spiral casing shall be subjected. The scope shall also include the bulk heads, test ring, the high-pressure generation pump etc. required for hydrostatic testing at Site. Sufficient quantity of electrodes required for site welding of spiral casing for all the units shall be included in the scope of supply as required. The embedding of spiral casing in concrete is proposed to be carried out with the spiral casing under a hydraulic pressure equal to 50% of the maximum operating head including water hammer.

Spiral casing and stay ring shall be manufactured in the same factory. The casing and the joints with the stay ring will be completely welded by the Contractor. All such joints shall be butt welds only. In case of welding joints suitable machined marking faces shall be provided between the different sections to ensure proper matching circularity and other dimensional accuracy during assembly and erection at site. In case of bolted flanged joints, seal welding shall be provided at the joint periphery for tightness.

The spiral casing, stay ring welds shall be 100 percent radiograph tested at T joints while UT can be accepted for other joints. A suitable flanged drain connection, complete with pipe down to a suitable point in the draft tube, with cast steel gate valve etc. shall be provided at the bottom casing inlet. A grill which will follow the original surface of the water passages shall be provided for the drain opening in the spiral casing.

Ample number of machined pads for application of jacks and adjustable tie rods shall be provided for field alignment of the assembled spiral casing and stay ring and for anchoring or holding-down purposes during concreting. Sufficient number of turnbuckles and jacks required for holding the scroll case during concreting shall be supplied.

The Contractor shall furnish all spiders or bracing required to prevent distortion of the spiral casing sections during transportation and erection.

1.21. Draft Tube

The Turbine shall be provided with a draft tube liner of welded construction of structural steel. The draft tube profile shall be designed to gain maximum recovery of velocity head and thus provide high Turbine efficiency. The draft tube cone shall have machined flange for bolting with the runner chamber. The joints of the draft tube shall be designed to allow easy removal of the draft tube elbow for access and runner removal. The design of the draft tube shall be such as to ensure the best overall efficiency for the Turbine and stable and pulsation free operations of the machines. Drainage arrangement for de-watering the tail race shall be provided. The draft tube exit losses must be stated by the Bidder and will be considered for overall efficiency evaluations.

Adequate headroom and space shall be provided around Draft tube for the purpose of handling of components. The liner shall be of fabricated or welded steel plate structure with adequate stiffening ribs and erection brackets, holding down bolts, anchor rods, turn buckles etc. for anchoring the liner securely into the concrete and for leveling it in place. The liner shall be designed for stiffness against vibration and deflection due to hydraulic loads. Piezometer taps shall be provided for connection to pressure and vacuum gauges.

The liner shall be designed for stiffness against vibration and deflection due to hydraulic loads. The liners shall be provided at least up to the water exit velocity of 3 m/sec. The upper portion of draft tube cone liner shall have stainless steel lining or stainless material at least 0.5 m in length for protection from cavitation.

1.22. Side Cover

The side cover shall be of cast steel or welded plate construction suitably sectionalized for ease of transportation. Suitable replaceable labyrinth rings of stainless-steel plate to side cover or similar sealing arrangements shall be provided. The Supplier must detail the concept of sealing. The side cover shall be lined with SS plate (which is in contact with water), designed and constructed to support all necessary seals, bearings, guide vanes assemblies, etc. The setting of the cover and the adjustment of all relevant parts during commissioning must be clearly described by the Bidder in his offer.

1.23. Turbine Frame, Platform, Walkways, Handrails Etc.

A support frame on which to mount the spiral case, bearing pedestals, Generator, brakes, and exciter shall be supplied along with the main equipment. The bidder shall supply all the necessary walkways (Over cable trenches, pits, etc.,), handrails, platforms etc. required from safety point of view as part of this specification and detailed in the Bid document.

1.24. Water Level Measuring Equipment for Tail Race

The level measuring equipment (Piezometric / Ultrasonic type) shall consist of Level Sensing Transducers, Transmitters, Cables, Indicators & Recorder for local monitoring and signal repeater with other equipments for further transmission of signal to plant SCADA. Cables between the Repeater and Powerhouse Control Room shall form part of this package. The level sensing transducer is lowered directly into the water. The output of the level transmitter is fed to the receiver (indicator). The indicator indicates the levels in terms of meters, which can also be recorded on a strip chart indicator. The indicators should have a stabilized power supply and should be capable of providing signals in the Powerhouse Control Room in the PC based MMI system and locally as well. The output of the water level is fed in to the Governor Control circuits, to limit the opening of the guide vanes according to the head as well as for water level control in each unit.

110V DC supply at Powerhouse shall be available for Contractor use.

Similarly, the total measuring equipment as described above shall be supplied, installed & commissioned for the Tail Race Channel also. The necessary cabling and communication along with the protective conduits (GI pipe □ 80mm dia) be provided by the Bidder from Tail Race Channel area to necessary points in the Powerhouse.

1.25. Spares

The spare parts for the Turbine and associated equipment considered necessary for five (5) years of trouble-free operation of the generating units shall be supplied by the Supplier. The unit prices of the spares shall be indicated as per Schedule of Requirement and additional spares, if considered necessary, shall be listed along with unit prices. For all parts and spares, the supplier shall provide a listing of sub-suppliers and their addresses.

1.26. GOVERNOR

The Scope covers the requirements for the design, manufacture, factory testing, transport, delivery to site, storage & preservation, installation, testing and commissioning of Digital Governors including all associated equipments. The Scope covers all accessories and special tools, which though not individually specified are necessary to construct, operate and maintain a complete Governor System.

The design, manufacture, and performance of the equipment along with the accessories shall comply with all currently applicable statutes, regulations, codes and standards in the locality where the equipment will be installed.

However, unless otherwise specified herein, the equipment supplied shall conform to the latest version of the standards/ equivalent international standards listed below:

Standard	Description
IEC 60308	International code for testing of speed governing system for Hydraulic Turbines
IEC 60545	Guide for commissioning, operation and maintenance of Hydraulic Turbines.
IEC 61362	Guide to specification of Hydraulic Turbine Control systems

Note: The latest edition of the above codes shall be referred.

The Governors furnished under these specifications shall be microprocessor based Electro-Hydraulic Governor (EHG) of PID type (Proportional Integral Derivative) and sense the speed of the Turbine rotation, generate a signal proportional to the difference between the Turbine speed and the Governor speed reference, and there from develop a hydraulic control signal of sufficient power to regulate the main servomotors to control the hydraulic Francis type Turbine with the requirements of this specification.

The Governor control actuator rating shall be adequate to operate the Turbine control servomotors in the minimum time specified hereunder, taking into account the pressure drops of piping external to the actuator.

The Governor shall be complete with level sensing, speed sensing elements, Speed Sensing Generator (SSG), associated electronic circuit and special cables, Governor control actuator, hydraulic pressure supply system, and all parts and specified accessories required to control the speed or load or both generating unit.

The toothed wheel shall be mounted on Generator/extension shaft for speed sensing.

1.26.1. Governor Operating Parameters

The speed governing of the generating unit shall be carried out by a combination of proportional, integral and differential actions and non-linear characteristics in order to provide best quality of control.

The Governor shall have high sensitivity, quick response to speed/load changes, least possible dead band times and wide adjusting ranges as given below in respect of the various parameters.

Sensitivity	Not more than 0.01% of rated speed
Speed level setting	Adjustable between (-) 5Hz & (+)5Hz of normal 50Hz (94% to 106%)
Permanent speed drop	Adjustable between 0-10%
Temporary speed drop	Adjustable between 0-100%

Speed dead band at rated speed	Less than 0.02 percent
Governor dead band time	0.2 sec for step load change of 10% of rated load or more
Guide vane closing time	Adjustable to 8-12 sec
Guide vane opening time	Adjustable, 20-40 sec

1.26.2. Protection, Auxiliary and Interposing Relays

Protection Relays shall be numerical type, High Speed and specifically designed for tripping of circuit breaker coil. Relay coils shall be supervised using an external Supervisory Relay. Lockout relays shall be of the latching type resettable with an external pushbutton. Remote resetting is not permitted. Auxiliary, supervisory and interposing relays. Relays shall be rated 10 A continuous 30 A make 5 s at 110 V DC suitable for 100,000 electrical and 1 million mechanical operations and shall be with flag/ LED operation indication. A minimum of 2-3 spare contacts shall be provided for future use.

1.26.3. Governor Electronic Cabinet

The Governor shall be a single-channel (non-redundant) digital electro-hydraulic governor with manual/hydraulic backup. The Governor Electronic Cabinet shall be enclosed in a free standing cabinet and located on the operating floor close to the unit UCB generally as shown in the Drawings. It shall be of the dust tight and drip proof construction in which terminal blocks receives all the field cables from the Governor related equipments. The cabinet shall be of steel construction with front access door and shall provide easy access to internal components.

The electrical components and wiring shall comply with the description made "General Technical Requirements".

The Governor electronic cubicle shall contain the following devices:

- The complete Digital Speed Governor including its power supply.
- Appropriate terminals to receive the field and internal wiring;
- Instrumentation and electrical devices;
- Suitable interior lighting c/w door switch of the cabinet shall be provided; and
- 240 V AC convenience receptacles shall be provided.

The following devices shall be mounted on the front door of the electronic cabinet:

- Man Machine Interface;
- Emergency Stop pushbutton (maintained, mushroom type);
- Turbine Start/Stop pushbutton;
- Governor Auto/manual selector;
- Oil Pump No. 1, Manual-Off-Auto selector; and
- Oil Pump No. 2, Manual-Off-Auto selector.

The status of the selectors shall be sent to the SCADA by direct wiring or read by the Governor and sent to the PLC through the Governor serial communication link.

1.26.4. Governor Operational requirements

The Governor shall be of the digital microprocessor type with fully redundant controllers. The process shall be controlled by a main controller and a hot backup standby controller shall be ready, at all time, to take over without affecting the speed regulating functions nor other functions performed by the Governor. The faulty controller shall cause an alarm to be displayed and logged at the SCADA. A faulty Governor shall cause an emergency stop of the associated Turbine and Generator. The Governor function shall be a dedicated controller and not being part of another controller.

The Governor shall regulate the Turbine Generator unit to a uniform speed free from hunting or instability at all loads. It shall have provision for generated power optimization depending on head race water level, optimization of speed governing parameters, Servomotor positioning parameters & Turbine loading rate. The Governor shall control, without hunting, the Turbine at normal/rated speed when operating isolated from the system and while connected to the system at any load between zero & the maximum load.

The Governor electronic controller shall be powered by two different sources. The first source being the 110 V DC and the second being the 240 V AC, 50 Hz.

The speed controller electronics shall be capable of operating at an ambient temperature ranging from 0 to 60 degrees centigrade with non-condensing humidity of 95%.

An analog input shall be made available for Generator gross output power feedback.

The speed Governor shall communicate with the PLC through an appropriate serial link, preferably over optical fiber in order to completely eliminate the risk of noisy signal.

Guide Vanes control shall be provided on the front door of the electronic cabinet for manual/auto control of Guide Vanes, emergency close, open/close, and Guide Vanes oil supply on/off features. On the front of the panel, a Guide Vane position indicator and balance indicator shall be provided.

1.26.5. Human Machine Interface (HMI)

A Human Machine Interface shall be supplied and installed on the front portion of the electronic cubicle. The purpose of the HMI is to display, in real time, the actual operating parameters of the Turbine and receive commands from a local operator. The HMI shall be a flat LCD, color touch screen of at least 30 centimeters of diagonal dimension. The power source shall come from the 240 V AC inverter located in the electrical room.

The HMI shall communicate with the Governor through an appropriate serial communication link.

All the speed and position indication shall be displayed on the Man Machine Interface screen mounted on the front of the Governor Electronic cabinet.

The real time information displayed at the HMI shall be available and displayed at the SCADA screen located in the control room.

As a minimum, the Governor HMI shall display the following information:

- Speed droop adjustment.
- Temporary droop online/offline;
- Dead band.
- Permanent speed droop.
- Speed level setting control with set point indicator.
- Speed Indicator.
- Combined gate limit setting control with set point Indicator and gate point Indicator.
- Frequency.
- Alarms.
- Head race level.
- Tail race level; and
- Any other essential device, if necessary.

As a minimum, the following graphics shall be created:

- Graphics representing the Turbine and its associated Guide Vanes showing real time operating parameters.
- Alarms page; and
- Graphics with buttons for start/stop of the Turbine, raise/lower of the speed, limiter settings, droop settings, pumps operating modes, etc.

1.26.6. Governor Hydraulic Mechanical Cabinet (HMC)

The hydro-mechanical cabinet of the Governor shall have provision for the automatic/manual control of the Turbine located generally as shown in the Drawing. The cabinet shall be of rigid construction and neat appearance, dustproof and properly ventilated. The hydro-mechanical cabinet shall be a separate panel and shall house the following mechanisms:

- Electromagnetic transducer with hydraulic amplifier, self-closing type main distributing valve, & its feedback mechanism (the feedback mechanisms of the guide vane servomotors are on the on the servomotors), gate limiter, double oil filter, over speed protection device (Hydraulic) , control and measuring instruments, gate limiting according to head, auto/manual changeover solenoid valve for electro-hydraulic transducer, emergency solenoid valve of the Overspeed protection device, Proportional control valve and shutdown solenoid valve.
- It should be possible to open the Guide vanes with the help of manual handle provided on HMC.

The control valves shall be of the “proportional” type and be designed to operate with metal particles up to 70 microns in diameter. All the servo valves provided shall be suitable for Governor oil in Indian conditions; meaning possibility of small particles in oil shall not stop the movement of the gates. Necessary duplex oil filters shall be provided before oil enters the hydro mechanical cabinet.

Both the opening and the closing servomotor velocities shall be independently adjustable. The method of adjustment shall be such that operation of any control, automatic, or auxiliary device cannot cause the Turbine guide vanes servomotors to move at a velocity greater than that set by the adjustments.

All controls on the front of the hydraulic cabinet shall be under lockable covers with instruments and indicating lamps visible at all times.

In case of drop of oil pressure in HMC, the Emergency shutdown of machine shall initiate.

The Governor shall be possible to sense the speed of rotation, determine an error signal and there from, with suitable feedback and stabilization, develop a hydraulic control signal of sufficient power to regulate the guide vanes via the servomotors. The Governor offered shall have the following salient features:

1.26.7. Stability

- The Governor system shall be capable of controlling, in a stable manner, the speed of the Turbine at all power output between zero and maximum power output when the unit is operating in isolated mode, or when the generating unit is operating in parallel with the other Generator or the grid.
- The range of conditions covered by stability requirements includes sustained conditions, load rejection, and sudden changes of isolated load, both large and small. The Governor shall be free from hunting under all such conditions.

Further, the Governor is required to be stable:

- When the Generator is tied to the grid, at nominal load, 2% or greater speed droop adjustment, the peak-to-peak amplitude of frequency variation caused by the Governor shall not exceed plus or minus 0.15%.
- When the Generator is tied to the grid, at nominal load, 2% or greater speed droop adjustment, the peak-to-peak amplitude of power variation caused by the Governor shall not exceed plus or minus 1.5%.

1.26.8. Speed Deadband

The speed deadband at rated Speed shall not exceed 0.02%. The deadband adjustment shall range from 0 to plus or minus 3Hz.

1.26.9. Dead Time

The dead time shall not exceed 0.20 seconds for a step load change of more than 10% of the capacity of the Turbine.

1.26.10. Frequency Sensing

Frequency reference signal shall be taken from two different sources. The primary frequency reference signal shall be taken from redundant, non-contacting speed signal Generator (SSG) installed near a toothed disk mounted directly on the shaft of the main Generator. The magnetic pickups shall be mounted opposite to toothed wheel to detect the speed of the machine and convert into electrical signals. The output of magnetic pickups shall be a square wave and shall be fed to the Governor regulating circuit as well as comparator card to energize various speed relays. The speed signal Generator shall be designed to safely withstand the maximum runaway speed of the Turbine. The secondary speed reference signal shall be taken from a potential transformer.

1.26.11. Power Supply of the Governor

Power supply for the Governor shall be provided by the station's 110 V DC auxiliary supply. A secondary, redundant power source, from the 240 V AC inverter shall power the Governor. The loss of one of these power sources shall be alarmed at the SCADA.

The power supply shall be designed to operate from 90 V DC to 130 V DC without any degradation in performance.

1.26.12. Fault Detection and Repair

- The complete Electro-Hydraulic Governor shall be of modular design facilitating easy and quick fault detection and rectification.
- The health status of each I/O card used in the Governor shall be indicated by a blinking LED located on the front of each module. A green flashing LED indicates a healthy module, a yellow flashing LED indicates a borderline status, and a red flashing LED indicates a faulty module.
- The Governor I/O card shall be easy to remove and replace with power ON and no wiring shall be removed to replace a module.
- The design shall be such that the removal of an Output card shall not disturb or stop the device controlled by this card; and
- The electronic of the Governor shall be of the self-diagnostic type capable to communicate with the associated Unit Controller (PLC) through a serial communication link such as Modbus. In case of Governor failure, a dry contact output shall initiate a unit shutdown and generate the appropriate alarms.

1.26.13. Output Monitoring and Indications

All the necessary Governor functions and indications shall be displayed on a colour LCD type touch screen mounted on the front door of the Governor Electrical Control Panel, located near the HPU (Hydraulic Power Unit).

Various outputs of the Governor shall be available for monitoring of the systems and these outputs shall be of the self-resetting type.

There shall be built in facility to control the movement of Guide Vanes in operation depending upon upstream level to ensure that the maximum possible efficiency is achieved during operation.

1.26.14. Permanent Speed Droop Control

There shall be provision for altering frequency vs. Guide Vanes control relationship by changing the permanent Speed Droop setting to achieve desired regulation. The Governor shall have provision for adjusting the permanent speed droop from zero to 10% while having the load and frequency set-points set to give rated speed at full load.

Speed setting of the Governor shall be easily adjusted through the soft keys provided on the Governor as well as the push buttons provided on the Unit Control Board. The speed set-point and the actual speed shall be displayed on the Governor Man Machine Interface screen.

1.26.15. Temporary Speed Droop Control

The temporary speed droop control shall be provided for controlling the movement of the Guide Vanes without any hunting. The Governor parameters, temporary droop percentage and decay time constant shall be set so as to allow stable operations. This control shall derive its input signals from the Guide Vanes servomotors.

1.26.16. Parallel Operation

During parallel operation of the Turbine in a powerful network, the Speed Governor shall bring into conformity power output and consumer load. The load on the Turbine shall vary automatically to present permanent speed droop depending upon the frequency of network.

1.26.17. Isolated Operation

When the Turbine is operated independently on an individual load, the Speed Governor shall match power output and load under steady state conditions and maintain frequency within limits.

1.26.18. Idling of the Turbine

During idling of the Turbine, the Governor shall automatically maintain the rated speed of the Turbine ensuring steady state operation of the control system.

1.26.19. Remote Operation

The Governor shall ensure the possibility of remote control of speed changes and of the mechanism for adjustable Guide Vanes openings accordingly. Governor control and setting shall be provided from the control room SCADA as well as from the UCB/ PLC.

1.26.20. Manual Operation

The Governor shall also provide for manual control of the Guide Vanes during start-up, shutdown, stopping and on-line of generating unit.

1.26.21. Single Start and Stop Command

The Governor shall be capable of automatic start, synchronization and loading of the Turbine by one command pulse from a start pushbutton. On a normal stop command, from a pulse, the Governor shall automatically reduce the load, open the main breaker and bring the Turbine to a dead stop.

The start and stop commands can come from the control room SCADA screens or from the unit control board MMI.

1.26.22. Normal Turbine Shutdown

Normal shut down shall be used to shut down the Turbine normally. Normal shut down shall be initiated by pressing the “STOP” push button from the unit control board MMI or from the control room SCADA. When “STOP” is initiated, the Governor shall take the following actions.

- Load limit set point is gradually reduced to the no-load value, so that the Generator is brought to speed no-load condition.
- When the actual Guide Vanes opening reached the no-load value, the Governor shall generate a two second pulse on the “Circuit Breaker Open Command Output”, which in turn shall trip the circuit breaker.
- After tripping of gen CB, from its contact the field breaker to be opened. No tripping of field breaker before main CB opens.
- The Governor shall fully close the Guide Vanes to bring the Turbine to a complete stop; and
- In case of far end opening of the line breaker, the Governor shall sense this load fluctuation and try to close the Guide Vanes. This closure of Guide Vane may take time and machine may speed up to runaway speed. For end breaker opening shall be sensed by Governor on sudden load rejection and trip the machine in emergency shutdown mode to avoid runaway speed. Both breakers may be connected for intertripping.

1.26.23. Turbine Emergency Shutdown

Emergency shutdown shall be used to shut down the Turbine abruptly in case of an emergency. Emergency shutdown shall be initiated by pressing the “Emergency Shut Down”, from the Unit Control Panel, in the Control Room and in other appropriate locations in machine hall.

1.26.24. Guide Vanes Closing and Opening Time Adjustment

It shall be possible to adjust the time of closing and opening of Guide Vanes so that Governor operation shall be such that the maximum static pressure at Turbine high pressure reference section shall not exceed specified pressure and speed rise, under any operating conditions with the help of throttle valves.

The control mechanism shall be equipped with means for independent adjustment of the opening and closing times of the Guide Vanes. The adjustments shall be arranged and set securely; so that operation of any control or auxiliary device cannot cause the Guide Vanes to move faster than the time established.

Overload limiter to limit maximum Guide Vanes opening at any preset position in the stroke range shall be provided. It shall be suitable for operation manually by hand or electrically from EHG cubicle or remotely from station DACS.

1.26.25. Governor Sensitivity

The sensitivity of Governor offered shall be 0.01%.

1.26.26. Governor Controls and Indications

The Feedback Position mechanism shall be provided for the governing of the Hydro sets for maintaining of the steady state condition. This shall be achieved with the help of LVDT (Linear Voltage Differential Transformer) or MVDT (Magnetostrictive Voltage Dependent Transducer).

No restoring cable or potentiometer arrangement shall be permitted. Optical encoder shall also be considered.

The Governor system shall have the following control and indication features available on a locally mounted human machine interface:

- Guide Vanes limit and Guide Vanes movement / position indication and control: Guide Vanes limit set point shall be adjusted using the soft keys provided on the Governor or the load/Guide Vanes set point push button provided on the unit control panel/Electronic cubicle. The Guide Vanes opening limit set value shall be viewed on the LED/LCD display window provided on the Governor. The actual Guide Vanes opening position shall be indicated on the display window provided separately on the Governor.
- Governor shall have provision for local-manual, local-fully automatic and remote fully automatic control of the Turbine. The Governor shall have provision to permit transfer from one mode of control to the other, without disturbing the operation of the Turbine. Transfer from local to remote control will be initiated by a two-way position selector switch located in Control Room UCB
- Manual Control: The manual control mode shall be possible and indicated on the Governor with LED/LCD display.
- Servomotor restoring mechanism.
- Speed set adjustment control and indication: Speed set point shall be adjusted using the soft keys provided on the Governor or the speed set point push button provided on the unit control panel. The speed set value shall be viewed on the LED/LCD display window provided on the window. The actual speed shall be indicated on the display window provided separately on the Governor.
- Speed regulation (load feedback): The speed regulation shall be adjusted by incrementing and decrementing the speed set point to the desired value.
- Actuator lock.
- Automatic startup and shutdown: Automatic startup and shutdown shall be possible with a single push button.
- Generator brake control: Generator brake shall be controlled depending on the speed of the Turbine and phase of operation.
- Speed indication.

- Oil Pressure indication: Oil pressure shall be indicated on the OPU with the help of pressure gauge/indicator.
- Mechanical Overspeed protection device: A mechanical overspeed protection device as well as hydraulic overspeed device directly acting on Governor hydraulic system shall be provided to prevent the overspeed of the unit in case of failure of Guide Vanes control.
- The Guide Vanes oil supply on/off should be located on the hydraulic mechanical cabinet.

1.26.27. Governor Control Modes

The Governor shall operate in three control modes as described below. Selection of the operating modes shall be done automatically by the Governor depending on the following three input parameters.

- Guide Vanes Opening Limit set point.
- Speed set point.
- Load set point.

1.26.28. Guide Vanes Opening Limit Control Mode

If the Guide Vanes limit set point is lower than the Guide Vanes opening requirement for attaining the speed set point & the Guide Vanes opening requirement for attaining the load set point, then the Governor operates in Guide Vanes Limit Control Mode. In this mode, Guide Vanes limit determines the opening of the Guide Vanes.

1.26.29. Speed Control Mode

If the Guide Vanes opening requirement for attaining the speed set point is lower than the Guide Vanes limit set point & the Guide Vanes opening requirement for attaining the load set point, then the Governor operates in the Speed Control Mode. In this mode, the Guide Vanes opening is controlled by the speed control loop and speed of Turbine is controlled as per the speed set point.

1.26.30. Load Control Mode

If the Guide Vanes opening requirement for attaining the Load set point is lower than the Guide Vanes limit set point & the Guide Vanes opening requirement for attaining the Speed set point, then the Governor operates in Load Control Mode. In this mode, the Guide Vanes opening is controlled by the load control loop and load of the machine is controlled as per Load limit set point.

1.26.31. Generator Load Transducer Input to Governor

The Governor shall be capable of accepting 4 to 20 milliampere (mA) signal from kW transducer for active power measurement control.

1.26.32. Governor Test Software

PC based software shall be provided along with the Governor that enables to download Governor program from the PC to the Governor and also to verify the existing code in the Governor against the code available in the PC. Programming tools shall be provided for customization of Governor features & shall have password protection facility to prevent unauthorized access and modification.

1.26.33. Governor System Software

The Governor shall use a multitasking operating system capable of running many programs at the same time. The software supplied with Governor shall have facility to allow the user to upload / download the configuration tables form the controller to PC. The user shall be able to examine the configuration tables, step by step and change any parameters if required. In case of any failure in the Governor software or hardware, the "Governor OK" signal will be withdrawn so that the Turbine will be shutdown immediately with the help of an emergency trip relay. Further, the Governor software shall be capable of performing all the functions as described in these specification/documents. The software shall have following functional capabilities:

- Display all meters data, status, alarm and annunciation on screen.
- Perform the start sequence for Turbine.
- The software shall be capable of controlling the voltage regulator to a voltage, VAR and PF set point.
- It shall allow the user to select several different control modes.
- It shall execute shutdown sequence like stop or emergency shutdown for the following conditions:
  - Generator PT Voltage is available, but Generator frequency is not being sensed or is significantly lower than the frequency derived from the speed pulse input signal.
  - Circuit breaker closed feedback in present but the Generator frequency is not being sensed.

1.26.34. SCADA Interface

The Governor shall be capable of interfacing with standard SCADA package with MODBUS interface.

1.26.35. Governor Hydraulic Oil Pressure Unit (OPU)

The pressure oil system shall cater to the both governing system and the main inlet Butterfly Valve for each unit. Each pressure oil system shall comprise of a common pressure oil tank for both generating unit and their respective main inlet Butterfly Valve. The Hydraulic pressure assembly of the unit, i.e., the oil supply equipment for the Governor comprising the control panel, oil/air pressure accumulator, oil pumping unit and sump tank complete with their piping valves etc. shall be supplied as part of the Turbine. The OPU shall be complete with high pressure compressed air system for pressurization of Accumulator.

The Governor shall therefore be suitable for the above oil pressure system offered (The preferred normal SELF CLEANING for the Governor system shall be 100-120 bar).

The Governor shall be capable of supplying a sufficient quantity of oil to the servomotors so as to:

- Operate the Guide Vanes to give the required effective time for a complete opening or closing stroke with a minimum oil pressure of 60% of the nominal and a maximum net head on the Turbine. The effective time shall be measured as twice the period between 30% and 80% stroke
- Open the MIV
- To be able to execute a Close/Open/Close operation of all Guide Vanes servomotors and one opening stroke of MIV Servomotors with pressure not going below minimum oil pressure level, without having the pumps in operation
- For operating the Guide Vanes during erection/maintenance additionally a directional control valve shall be provided in the hydraulic circuit parallel to proportional valve (Moog valve).

The normal operating condition of the governing system shall be designed based on the 80% opening of the Guide Vanes of the Turbine. The velocity of oil in the pipes shall not exceed 4.0 m/sec.

Nitrogen (piston type) accumulators of sufficient capacity shall be provided for maintaining the required pressure in the system. The capacity of the accumulator should be suitable for at least two closures of the Turbine and Generator & also operate the hydraulic brakes if provided.

1.26.35.1. OIL SUMP TANK

The oil sump tank shall be incorporated in the hydraulic cabinet and shall have sufficient capacity to hold all of the oil in the system plus 10%. It shall be equipped with an oil-level sight glass complete with shutoff check valves to protect against breakage, drain valve, oil strainer, manhole, air breather, low oil level float switch for alarm (contacts to close on low level), level transmitter and oil temperature switch wired to cut off the oil pumps in the event of high oil temperature. The sump tank shall be totally enclosed and leak-free. It shall be made of Stainless Steel/ Mild steel.

Oil used shall be such that it should be easily available in Local Market and shall be of same specifications as used in Turbine and Generator bearings (in all three units) and shall contain antioxidant, anti-rust and antifoam additives. The Employer prefers Servoprime 68 (ISO- VG 68).

1.26.35.2. OIL PUMPING SETS

Two motor-driven oil pumping units of the screw/vane/gear type shall be provided for the pressure system. Each pump shall be capable of delivering oil at maximum pressure, for the proposed system, at a rate per minute of not less than 1.5 times the total displaced servomotor volume for a complete Guide Vane/MIV opening stroke and shall be equipped with an unloader valve, idler valve, relief valve, check valves, pilot valves and isolating valves.

The oil pumps shall be controlled primarily by oil level rather than pressure. Pressure overrides shall, however, be included for protection.

The unloader valves shall be operated from the accumulator tank pressure by pilot lines, complete with isolating valves and filters, or by pressure switches and shall be equipped with “Snap” action pilot valves. Both the unloader valves and relief valves shall be adequately sized with respect to the pumping capacity. The start/stop controls and/or valves for pumps shall be arranged to permit the motor to accelerate to full speed before being loaded. The lag pump shall be arranged to start automatically when the oil level continues to fall below the normal cut-in level for the lead pump. The lag pump shall cut out at the same oil level as the lead pump.

A suitable oil strainer shall be fitted in the suction line of each pump. After Pumps, two parallel filters of 10 microns (1 working + 1 standby) of same type shall be provided.

Each pump shall be directly connected to a 415 V, 3-phase, 50 Hz, squirrel-cage, low starting current, induction type motor for full voltage across the line starting, and conforming to the standards of IEC, or equal. Each motor control shall be totally independent and shall be fed by separate power supplies.

1.26.36. Oil Accumulator (Pressure) Tank

The accumulator tank shall be fabricated from boiler quality steel plate, designed and tested as per ASME "Boiler and Pressure Vessel Code" for maximum working pressure of governing system. The accumulator tank shall be sized such that the live storage (i.e. volume between normal high and low level shut-off) shall be minimum operation of C-O-C of Guide Vanes + opening stroke of MIV, without start of pumps. Shutdown and an alarm contact shall be provided when the oil pressure falls below a predetermined value. Design calculations of capacity of oil pressure system shall be provided for Engineer’s approval.

The pressure tank shall be fitted with oil-level sight glass(es) with shut-off and check valves to protect against breakage, pressure gauge, manhole, blow-off valve, safety relief valve, drain valve, low level shut-off float valve and connection for air supply. It shall be equipped for connection of a pressure line to supply pressure-actuated switches mounted in the hydraulic cabinet as follows:

One to close its contacts at and below a pressure below which further servomotor operation is dangerous (low oil pressure shutdown);

One to close its contacts at and below a pressure intermediate between the lag pump cut-in pressure and the shutdown pressure (low pressure alarm);

One to open its contacts at and below the lead pump cut-in pressure and with minimum reset differential for unit start interlock; and

All additional pressure switches required for oil pump and air admission control.

There shall also be supplied MAGNETROL, or equivalent, liquid level devices mounted externally to the pressure tank with piping, valves, and unions to allow for their removal without interruption to the Turbine operation, with adjustable contacts as follows:

- One to close its contacts on high level just above the normal maximum operating level (high level alarm);
- One to close its contacts at a low level at which there is still sufficient oil to operate the servomotors (shutdown);
- One set to close its contacts at a level below the normal minimum operating level but above the shutdown level (low level alarm); and
- All additional level switches required for oil pump and air admission control.

All pressure and level switches shall be provided with individual shut-off valves and bleed valves shall be provided as necessary.

The oil level sight glass (es) shall be protected from accidental breakage by means of suitable guards and shall be provided with automatic means for shutting off air and oil discharge from the pressure tank in the event of breakage of the gauge glass (es) or removal of the assemblies.

The air / nitrogen supply line to the Accumulator Tank shall be equipped with a bar stock shut-off valve and an air bleed valve shall also be provided on the tank to permit ready readjustment of the air pressure. Both valves shall be operable from within sight of the tank pressure gauge and sight glass(es). System shall be designed to prevent entry of air in the oil piping system.

The pressure tank shall be provided with an automatic air admission system to maintain a proper proportion of the air cushion volume. A means of manually adjusting the air supply to the Accumulator shall also be provided at the tank.

The Contractor shall indicate the specification and quantity of the governor system oil and of the bearing oil required for each Turbine and shall supply sufficient oil for the first filling plus 10% extra of each type. Where possible, the specification for the governor oil and for the bearing oil shall be the same.

1.26.36.1. PIPING AND VALVES

The Contractor shall furnish and install all interconnecting piping between oil pumps, sump tanks, accumulator tanks, servomotors and hydraulic actuators, together with all necessary pipe supports and valves. Standard pipe sizes shall be used and be of the seamless type. Long radius pipe bends shall be used instead of standard pipe elbows, wherever feasible. Isolating and relief valves shall be provided to isolate and protect all major pieces of equipment. It shall be noted that all the Governors are intended to be hydraulically independent of each other.

All oil piping shall be socket welded except where disassembly is required. Where disassembly is required, flanged connections shall be used.

Solenoid valves that could stick after long stagnation periods shall be poppet valves by Bosch Rexroth. All solenoid coils will be selected “permanently energized” for longer life, whatever their function.

1.26.36.2. OPU CONTROL PANEL

The OPU shall be operated from a control panel with a PLC controlling the Oil Pumping Sets, the levels and pressures of the Oil Accumulator Tank, the system’s instrumentation and the oil level of the Oil Sump Tank to ensure an adequate hydraulic oil pressure to the Governor and MIV.

The control panel shall be in proximity of the Oil Pumping Set and Oil Accumulator Tank.

The control panel shall include the electric and electronic components, PLC, Human Machine Interface, power supplies, switches, indicating lamps, wiring, terminal blocks and all other control device necessary for the good management of the hydraulic system.

The components must be arranged to facilitate installation and maintenance at site.

The controller must be provided with a minimum of 10% of free inputs and outputs.

The terminal blocks must have a 10% surplus of free terminals.

The test terminals shall be provided to allow the necessary testing during commissioning of the panel and for problems diagnose.

Electronic components must be designed for long-term operation at temperatures between 0°C and 40°C and at a relative humidity of 80%.

The maintenance of the control panel should be simple and easy to perform without the need for a specialist.

1.26.37. Special Tools and Maintenance Equipment

The Contractor shall supply, for hand over to the Employer, one (1) set of special tools and maintenance equipment, recommended by the Supplier of Governor.

The Contractor shall provide one (1) sets of tools and test equipment as described below:

- One (1) complete set of casehardened wrenches above 24mm and special tools that may be necessary or convenient for assembling, dismantling or adjusting the Governor equipment, neatly packed in a metal toolbox for convenient storage;
- One (1) set of test cards extension, dummy loads, and test loads that shall be necessary for Governor electronics testing; and
- Any other testing device for checking performance of Governor may be offered as an optional item.

1.26.38. Shop Assembly and Tests

The equipment shall be completely assembled in the shop and tested insofar as practicable. The complete testing of Micro-processor based Electro-hydraulic Governor, Guide Vane servomotors and hydraulic circuit (oil pumping unit) shall be carried out at works i.e., (guide vane and blade testing, stability, sensitivity, etc., shall be tested with simulating the site conditions). If required, the hydraulic circuit can be tested separately. The Accumulator Tank shall be tested in the shop under a hydrostatic pressure 1.5 times the maximum working pressure. Operational tests shall be made in the shop on controls and instruments to demonstrate that the Specification requirements have been met.

All adjustable devices shall be calibrated and set for the operating conditions anticipated and shall be locked to minimize the need for readjustment at site.

The Governor must be assembled in the workshop of the manufacturer and tested according to IEEE Standard for:

- Stabilization of Governor
- Sensitivity of Governor
- Measurement of electrical consumption at electronic regulator
- Establishment of regulator chart
- Trial run of complete Governor unit for all options

1.26.39. Site Installation and Tests (Pre -Commissioning, Commissioning)

The Contractor shall prepare details of its proposed site installation procedure in which the record sheets for various alignment checks and tests shall be recorded as work at site.

Tests in accordance with IEC 60545 shall be performed by the Contractor on the Governor prior to placing the unit into commercial operation. The Contractor shall assume full responsibility for the operation and safety of the work.

The following tests shall be performed:

- All field tests including operational, pre-start and commissioning tests shall be conducted by the Contractor, in the presence of the Employer's representative in order to assure the proper performance of the system delivered.

- The Governor and all the associated auxiliaries shall be adjusted and tested at site for optimum performances. All necessary instrumentation and equipment for the tests shall be provided by Contractor.
- Operational tests on oil pressure system shall be conducted to verify:
  - Loading and unloading valve settings.
  - Pressure and level control in oil pressure tank in auto/manual mode.
  - Test to verify pump capacity.
  - Low- and high-level alarms/shutdown.
  - Pressure relief valve setting.
  - Dielectric and insulation resistance tests on electrical circuits as per relevant standards.
  - Continuity test of all control loops.
  - Tests to verify number of close/open operations with oil pump.
  - Tests verify stability and response of Governor for 10% to 20% step change and load acceptance and rejection or a combination of these.
  - Tests to verify logic control scheme from local/remote location including start/stop, load control, emergency shutdown, normal shutdown, servomotor lock and other functions.
  - Calibration of instruments, switches and controllers provided in the governing system, oil pressure system and compressed air system.
  - Tests to measure guide vane and MIV opening and closing times and servomotor cushioning time.
  - Tests to verify parallel operation of unit as per droop settings selected; and
  - Other tests to verify the performance as per applicable IEC Code 60308 for testing of speed governing systems for hydraulics Turbines. These shall include the following: Command signal range: servomotor capacity, permanent speed droop range, temporary speed droop range, permanent speed regulation range, deviation time constant, servomotor response time, dead bands, dead time, and other applicable tests as per IEC-60308.

1.26.40. Drawings & Documents for Governor

The Bidder shall submit the following drawings along with the Bid for evaluating the equipment suitability:

- Physical & schematic drawings and descriptive literature on the Governor & Governor mechanism, emergency closing system and provide details of Governor Oil Pressurizing system (OPU);
- A complete List of equipment and auxiliaries etc. covered in the bid.
- A complete list of Sub-Contractors/Suppliers.

After award of Contract, Contractor shall provide all detailed and assembly drawings and material sheets in conjunction with its calculations as well as references, showing the detailed design of all components of the Governor. These drawings and calculations are subject to the Employer's approval.

- Electronic Governor - Technical specifications.
- Electronic Governor – GA & Foundation Details.
- Governor Speed Measurement System - GA & assembly drawing.

- Schematic drawings of piping systems, control systems, and instrumentation with dimensions and ratings.
- Details of recesses and embedment to be provided in concrete for mechanical equipment
- A list indicating the guaranteed Life Cycle period of major parts;
- A Time Schedule for the manufacture, delivery and erection;
- Complete details of Manual/Local controls
- Detailed workshop drawings of wearable/ consumable parts.
- Governor- QAP
- OPU – Schematic & GA drawing along with bill of materials;
- OPU –Calculation and Operation Procedure;
- OPU - QAP
- Drawings/brochures for all parts, equipment, components, and special erection equipment with operating /maintenance instructions.

1.26.41. Mandatory Spare Parts

The following spare parts shall be included in the supply:

S. No.	Description	Type/size	Quantity
I	**ELECTRONIC GOVERNOR**		
1	Control Unit/Cards	each type	1 no.
2	I/O Modules (Digital- 25%, Analogue -25%)	each type	1 no.
3	Signal Insulator		1 no.
4	Speed Sensing card with Auxiliary Relay (ABB/ OEN Make)	each type	1 no.
5	Communication Card		1 no.
6	Proximity Switch with Disk and Speed Switches Magnetic pick-up		1 set
7	Auxiliary Relays (ABB/ OEN Make)	each type	1 set.
II	**OIL PRESSURE UNIT & PUMP**		
1	Governor Oil Pump Motor set		1 set
2	Hydraulic Amplifier	each type	1 no.
3	Diaphragm for Hydraulic Amplifier	each type	1 no.
4	Pressure Relief cum Unloader Valve		1 no.
5	Pressure Relief Valve		1 no.

6	Check Valve	each size	1 no.
7	Servo Valve (Proportional Type)		1 no.
8	Directional Control Valve	each type/size	1 no.
9	Directional Poppet Valve	each type/size	1 no.
10	Coils for Servo/Poppet Valve	each type/size	1 no.
11	Pressure Line Filter		1 no.
12	Return Liner Filter		1 no.
13	Seal and Packing		1 set
14	Temperature Gauge		1 no.
15	Pressure Gauge		1 no.
16	Pressure Transmitter – Digital (4-20 mA)		1 no.
17	Pressure Switches		1 no.
18	Level Switches		1 no.

The spare parts mentioned here are meant for use by the Employer for five (5) years trouble free operation and shall not be used as erection spares required during installation. All the spare parts shall be interchangeable and shall be of the same material and workmanship as corresponding parts of the main equipment.

If any additional spare parts required for a 5-year operation period are recommended by the Contractor, these shall be listed, and the unit price shall be quoted in the Price Schedule. The Employer reserves the right to order any or all of such spares, within 12 months after commissioning.

1.26.42. O & M Manuals

The Contractor shall furnish to the Employer four (4) sets of O & M Manuals for review/ approval. After approval, and incorporating the Employer comments, the Contractor shall submit twelve (12) sets of the final O & M Manuals and one (1) set of soft copy.

1.26.43. As-Built Drawings

The Contractor shall furnish four (4) sets of Governor system drawings for approval. After approval and after work completion at site, six (6) sets of As-built drawings and one (1) set of soft copy shall be supplied.

O & M Personnel Training

The Contractor shall arrange training sessions for O & M personnel at site, using the O & M Manuals supplied.

1.27. COOLING WATER SYSTEM

The scope of work under this specification shall consist of the design, engineering, manufacturing, shop test, supply, loading at manufacturer's works, transportation & delivery of various items along with their spares to the project site, storage at site, erection and commissioning of the complete Cooling Water System, which shall supply sufficient quantity of water for cooling needs of TG units & Service Water Tanks. The cooling water supply system for each unit shall include all Equipment, Pumps, Piping, Valves, Duplex basket type Filters/Strainers, Instruments etc. and associated accessories required for the completeness of the system. Other items not specified above but necessary to complete the system in all respects shall be in the scope of the Bidder.

Cooling Water system for each TG unit shall be of open loop type, drawing water from tailpool and shall comprise of Centrifugal Pumps (1W+1SB) for each unit followed by Duplex basket type Filters/Strainers (1W+1SB) for each unit. The system shall also be equipped with flow meters/flow relays, flow indicators, pressure gauges, pressure switches etc. It's straining element shall be of wedge wire type of stainless-steel SS-304 and shall have screening area not less than 3 times the pipe cross-sectional area. Also, the pressure drop across the straining element shall be less than 50 kPa. Backwash of each strainer shall be controlled by individual differential pressure switches as well as adjustable timer.

The system shall be complete with piping, isolating valves, non-return valves, pressure gauges, flow switches, Local Control Panels etc.

Bidder shall furnish in their technical offer, a proposed arrangement of Cooling Water System, equipment details and suggested pipe routing.

Keeping in view the condition of the water in the river, the maintenance and operational flexibility, it has been decided to provide Duplex basket type Filters/Strainers for each unit. The cooling water system of TG units comprising of Pumps, Strainers, etc shall be placed, as shown in the enclosed Flow Diagram.

The system shall be designed to overcome the loss of head due to friction & static head. The velocity of water in the Heat Exchangers shall be selected so as to prevent sedimentation of silt inside the Heat Exchangers. The maximum fluid velocity in the piping shall not exceed 2 m/sec.

The cooling water system shall operate automatically i.e. starting and stopping in sequence with the units start and stop commands. The stopping operation shall be delayed with the help of timer provided in the circuit to protect the bearings against starvation of cooling water during unit stop operation.

The Contractor shall carry-out data/design of the system and shall include those equipments/devices also which are not mentioned specifically in the technical specification but are necessary for smooth and satisfactory operation of the system and shall prepare schematic/layout drawing and submit along with his offer.

The system shall be designed to meet cooling water requirements of TG units.

The Contractor shall check the exact water requirement restricting temperature rise to 5°C and offer suitable capacity system. Necessary calculations for system capacity and rating shall be submitted for approval of the Employer.

System shall be used for supplying cooling water for following purposes:

- Generator Air Coolers.
- Generator Guide Bearing.
- Generator Thrust Bearing.
- Turbine Guide Bearing
- OPU Oil-Water Heat Exchanger (if applicable)
- Turbine Shaft Seal
- Service Water Tank.
- Generator rotor and stator cooler

1.27.1. Technical Particulars of the Equipment

MOTORIZED AUTOMATIC ONLINE SELF CLEANING STRAINERS

The Strainers shall be of Motorized Automatic Self Online Cleaning type. These shall be of welded steel fabrication conforming to Boiler Quality steel plates with screening elements made of stainless steel (SS 304), wedge wire type. The water Strainer supplied shall be tested at a hydrostatic test pressure of 1.5 times the maximum working pressure. The Strainers shall be provided/ installed having positive pressure at their inlet.

The water Strainer shall be provided with automatic self-cleaning device and connections, pressure gauges, differential pressure switch and draining through automatic motorized purging valve, with its own control panel.

The design of the Strainer shall be such that the Strainer elements can be easily taken out for maintenance purposes. Suitable gasket shall be provided for making the Strainer shell-top cover tight. The Strainer shall be a complete unit. The pressure drop across the Strainer shall not be more than 50 kPa, when dirty and adequate sensing arrangement shall be provided to sense the pressure drop across Strainer for further integration with plant SCADA system. The automatic cleaning shall be initiated through a differential pressure switch (adjusted to a set point) or through a timer, whichever reaches earlier.

Pressure gauges shall be provided to measure the difference in pressure across the Strainer. The technical data of Motorized Automatic Online Self-Cleaning Strainers shall be as under:

a	**For each of Cooling Water Circuit for TG Units**	**-1 no. working + 1 no. as standby for each TG Unit;**

		Filtration efficiency 95% down to 200 microns **-Pressure Drop across Strainers in dirty condition not to exceed 50 kPa.**

1.27.1.1. POT / BASKET TYPE STRAINERS

The Strainers provided for the Turbine shaft seal system shall be of 'Pot Strainer type'. Free Open Area Ratio (OAR) shall not be less than 6 times the pipe cross-sectional area. Suitable vent & drain connections with valves shall be provided. The Strainer element shall be of SS-304/316. The pressure drop across strainer shall not exceed 10 kPa in clean condition and 30 kPa with 50% blocked condition.

The technical data of proposed Pot Strainer shall be as under:

A	For each circuit of Turbine Shaft Seal	-1 no. working + 1 no. Standby (Alternatively 1 no. Duplex Strainer) - Filtration efficiency of 95% down to 50 microns & above particles. - pressure drop across strainer shall not exceed 10 kPa in clean condition and 30 kPa with 50% blocked condition.

1.27.1.2. VALVES, PIPES AND FITTINGS

Control and shut off valves of various types and sizes shall be provided in the system for control & regulation of the cooling water supply to the generating units. Valves larger than 80 mm size shall be of the Spherical type. Reflex or check valves shall be provided at needed locations to prevent reverse flow.

All valves shall be of cast steel body with SS trim as per the requirements and shall have pressure class of PN10. These shall comply with the relevant International Standards.

All cooling water piping shall be of Carbon Steel while embedded piping shall be of stainless-steel material and pressure class PN10. At each point, the piping shall be provided with necessary instrumentation like flow relays, pressure gauges, pressure switches, thermometers etc. All fittings such as elbows, tees, reducing tee's, reducers etc. shall be of carbon steel (seamless). The material of the pipes shall conform to relevant International Standards. Insulation (Armaflex with Aluminum cladding), non-combustible material on the piping surface located in the Powerhouse shall be provided to avoid the problem of dripping of water due to condensation.

1.27.1.3. PUMPS

The Pumps shall be of Centrifugal type conforming to Hydraulic Institute Standards, USA or International Standards with the following characteristics:

- Casing : Cast Steel
- Impeller : Cast Stainless Steel (CF8M)
- Shaft : SS-316
- Seals : Mechanical type
- RPM :1500/2900

The Pumps shall be of self-priming type. The Pumps shall meet the required flow without any cavitations. The operating characteristics of each pump and rated capacity of its motor shall be such that the motor shall not exceed its rated temperature rise.

Each Pump shall be mounted with an electric motor & common base plate. Pumps shall be coupled to electric motor by a flexible coupling.

The equipment furnished with the pump units shall include the required automatic transfer circuits, selector and control switches, motorized valves, non-return valves, pressure regulator valves, bypass valves, pressure switches, pressure sensors, temperature detectors, thermometers and indicating lights for the local fully automatic and manual control of operation of the pumps plus indicating lights and alarms for remote supervision. The motor starter for each pump motor shall be furnished by the Contractor. Any other necessary devices shall also be supplied. All the controls shall be implemented in the control system for each unit. The pumps shall be operated in auto/manual mode from local control board through conventional hardwired operation interface devices or from Central Control Room depending on the position of the remote/local selection switch mounted in LCB.

The cooling water system shall be monitored by SCADA system. All information (such as faults, alarms, measurements, status of equipment, external orders, running time, number of operations) that is necessary for effective and convenient control and Monitoring by the SCADA system shall be transmitted through SCADA local Control Boards.

1.27.2. Site Testing And Commissioning Tests

Contractor's Site Inspection, Testing & Commissioning program for the cooling water system/equipment shall include the following without being limited to:

- That the whole cooling circuit is clean after being washed and rinsed
- That the circuit behaves normal during resistance and leak tightness tests
- Water tanks shall be tested for water fill test. Welds shall be NDT tested
- That the various sensors, instruments etc. operate as per specified & designed parameters (at 50%, 100% and 150% of system capacity).
- That the water flow rates are correctly divided up in each branch of the cooling circuit

All Test procedures, Test results & equipment settings shall be recorded on data sheets and shall be submitted to the Employer as site Commissioning report.

1.27.3. Drawings/ Documents for Cooling Water System

The Bidder shall submit the following drawings / documents at the time of bid submission:

- Flow Diagram
- Technical data sheets of all main equipments
- Catalogues of proposed main equipments

Some of the major drawings/documents to be furnished after award of the Contract are listed below:

- DBR (Design Basis Report), including design calculations.
- Flow Diagram
- Sizing/selection calculations of Pumps, Automatic Motorized Water Strainers, Piping etc.
- Pumps – Performance Curves
- Manufacturing Data Sheet/ Specifications of Pumps, Automatic Motorized Water Strainers etc.
- GA & Foundation Drawings of Pumps, Automatic Motorized Water Strainers etc.
- Control Panel - GA
- Control Panel -Power and Control wiring diagram
- QAP- Pumps, Automatic Motorized Water Strainers, Pressure Reducing Valves
- Pipe routing, Isometric drawings and As-built drawings.
- Piping Supports
- Equipment Catalogues
- Testing & Commissioning Procedures
- & M Manuals

1.27.4. Mandatory Spare Parts

The following spare parts shall be included in the supply:

S. No.	Description	Type / size	Quantity
I	**COOLING WATER SYSTEM**		**TG Unit**

A)	**Pumps (if applicable)**		
1	Impeller		3 nos.
2	Mechanical Seal	each type/size	3 nos.
B)	**Automatic Motorized Self-Cleaning Strainers**		
1	Strainer Element		3 nos.
2	Geared Motor		3 nos.
3	Gaskets		3 nos.
4	Drainage electric Valve with Motor		3 nos.
C)	**Valves & Instruments:**		
1	Valves	each type/size	1 set
2	Pressure Gauge		1 no.
3	Differential Pressure Switch (4-20 mA)		1 no.
4	Pressure Switch		1 no.
5	Flow Transmitter & Switch		1 no.
6	Temperature Indicator		1 no.
7	Components of Starters for Pumps & Control		1 set

The spare parts mentioned here are meant for use by the Employer for five (5) years trouble free operation and shall not be used as erection spares required during installation. All the spare parts shall be interchangeable and shall be of the same material and workmanship as corresponding parts of the main equipment.

If any additional spare parts required for a 5-year operation period are recommended by the Contractor, these shall be listed and the unit price shall be quoted in the Price Schedule. The Employer reserves the right to order any or all of such spares, within 12 months after commissioning.

1.28. LP COMPRESSED AIR SYSTEM

The scope of work under this specification shall consist of the design, engineering, manufacturing, shop test, supply, loading at manufacturer's works, transportation & delivery of various items along with their spares to the project site, storage at site, erection and commissioning of the complete compressed air system as described below with the first Turbine furnished under the Contract. Compressed Service Air system shall be provided complete with starter, control panel and disconnect switch, associated cabling, wiring etc and all the associated items whether or not specified herein.

A common LP compressed air system shall be supplied for the requirement of Service Air of the Powerhouse including compressed air required to operate pneumatic tools.

The Air Compressors shall be of reciprocating type to generate nominal pressure of 7 bars. These Air Compressors shall be alternated after each pre-set operating cycle.

The capacity of the compressor shall be adequately selected to meet the service air requirements of the Powerhouse.

The main technical features of the service air system shall be as under:

Capacity per Compressor	400 LPM at 7 bars
LP Air Receiver	Nominal Pressure: 7 bars Minimum available pressure: 6 bars Capacity: 250 L
Service Air-Piping Header	Nominal Size 20 mm
Nos of Service Air Connections	9 nos. (3 nos. at each floor, 2 nos. in the Service Bay and 1 no. near HydroPneumatic Tank of Service Water System)
Flexible High Pressure Hose with wall mounting bracket.	4 nos, ID 12.5 mm, 20 m long with quick coupling & air gun.

The termination point shall be on wall with provision of about 10 meter of flexible pipe of small diameter, suitable pressure, to be used for cleaning/servises purpose.

Powerhouse service air compressor control shall be done through its Local Control Panel. LP Compressor shall be suitably located so as to minimize its noise level in the adjacent working areas.

The low-pressure condensate from Compressors and LP Air Receiver shall be discharged into the Powerhouse drains. The system & equipments shall be designed, built, tested and installed to the latest revisions of the following applicable standards

IS:6206	Guide for Selection, Installation and Maintenance of Air Compressor plants with operating pressures upto 10 bars.
IS:7938	Specification for Air Receivers for Compressed Air Installation.
IS:11461	Code of practice for Compressor Safety.
ISO:8573-1	Rules for Air Quality.
ASME Section VIII	Pressure Vessel Code.

1.28.1. Piping & Valves

Control & shut-off valves of various types & sizes shall be provided in the system for control & regulation of the Compressed Service Air supply to utility connections and if required to Generator Braking etc.

All the valves shall be of Cast Steel body with trim of SS or Brass. This shall comply with the relevant Indian Standards or equivalent Standard.

All exposed piping shall be Galvanised Carbon Steel material conforming to IS 1239 (Part-I) Heavy Grade or ASTM A 53 Gr B, Sch 80. All fittings such as elbows, Tee's, reducers shall be of carbon steel seamless type, galvanized of class 3000. However, all piping & fittings embedded in the concrete shall be of Stainless Steel.

The necessary instrumentation like Pressure Gauges, Pressure Switches, Pressure Transmitter, Temperature Gauges / Temperature Switches shall be provided as required.

1.28.2. Site Testing and Commissioning Tests

Contractor's site inspection and testing and commissioning program for the compressed air system shall include but not limited to the following:

- Inspection and testing of all lines and connections to ensure their proper installation according to drawings and verification that they are free from debris or obstructions;
- Testing of compressors, receiver, relief valves, valve controls and alarms to ensure operability of all components and correct mutual function or interrelated parts;

All Test procedures, Test results & equipment settings shall be recorded on data sheets and shall be submitted to the Employer as site commissioning report

1.28.3. Drawings/Documents for Service Air System

The Bidder shall submit the following drawings / documents at the time of bid submission:

- Flow Diagram
- Technical data sheets of all main equipments
- Catalogues of proposed main equipments

The major drawings/documents to be furnished after award of contract shall include but not limited to the following:

- DBR (Design Basis Report), including design calculations.
- Flow Diagram
- GA & Foundation Drawings of Compressor & Air Receiver
- Sizing /selection calculations of Compressor, Air Receiver & Piping
- Manufacturing Data Sheets/Specifications of Compressor & Air receiver
- QAP – Compressor & Air Receiver
- Pipe routing, Isometric drawings and As-built drawings.
- Equipment Catalogues
- Testing & Commissioning procedures
- & M Manuals

1.28.4. Mandatory Spare Parts

The following spare parts shall be included in the supply:

S. No.	Description	Type/size	Quantity
I	**LP COMPRESSED AIR SYSTEM**		
1	Safety Valve		1 no
2	Pressure Gauge		1 no
3	Pressure Switch		1 no

The spare parts mentioned here are meant for use by the Employer for five (5) years trouble free operation and shall not be used as erection spares required during installation. All the spare parts shall be interchangeable and shall be of the same material and workmanship as corresponding parts of the main equipment.

If any additional spare parts required for a 5-year operation period are recommended by the Contractor, these shall be listed and the unit price shall be quoted in the Price Schedule. The Employer reserves the right to order any or all of such spares, within 12 months after commissioning.

1.29. DRAINAGE and SYSTEM

The Drainage System shall be designed for drainage of all water discharge, outlets, returns, effluents/ drainage leakages from equipment and any seepages from rock surroundings the Powerhouse, etc.

Other items not specified above but found necessary to complete the system in all respects shall be in the scope of the Bidder.

The automatically operated station Drainage System is required for drainage of all water discharge, outlets, returns, effluents/ drainage leakages from equipment and any seepage from rock surroundings the Powerhouse etc into drainage sump.

All such water will be arranged to be led into a common station drainage sump provided in the Powerhouse adjacent to the Dewatering Sump. The quantity of all effluents at its peak into the sump shall be considered, and the station drainage pumping system shall be sized to handle the same. All such water shall be pumped out from the sump by means of Submersible Sump Pumps / Vertical Turbine Pumps into the tailrace downstream of the tail race gates above High Flood Level (HFL).

The scheme shall comprise of minimum two (2) number Submersible Sump All such water will be arranged to be led into a common station drainage sump provided in the Powerhouse adjacent to the Dewatering Sump. The quantity of all effluents at its peak into the sump shall be considered, and the station drainage pumping system shall be sized to handle the same. All such water shall be pumped out from the sump by means of **Submersible Sump Pumps** / **vertical turbine pump**s into the tailrace downstream of the tail race gates above High Flood Level (HFL).

Pumps of equal capacity for handling station drainage requirement. One of the pumps shall act as main pump and the second pump shall act as standby pump

The pumps shall be capable of handling muddy/turbid water.

Necessary calculations shall be furnished by the Contractor to determine the pumping capacity & the rated dynamic head and shall be got approved from the Employer. The drainage pumps shall be designed for maximum four (4) starts & stops per hour.

The piping shall comprise of the pipe leading from the pumps installed in the sump well in the Powerhouse to the tail race after the closed tail race gates. Fluid velocity in the piping shall not exceed 2 m/sec when one pump is running and 3.5 m/sec with both pumps running.

Drainage and Dewatering Sumps shall be interconnected by piping having Manual Spindle Operated Interconnecting Valve (Normally Closed) and a NRV.

Additionally, a Portable Submersible Sump Pump of capacity 5 L/sec shall also be supplied to evacuate water from various pits/low areas, whenever required.

The automatic operation of the Drainage pumps shall be effected with the help of level switches installed in the sump working on the basis of prefixed water levels. The pump designated and assigned as the main pump shall start with the rise of water level in the sump and cut off when the level in the sump falls to the minimum allowed level.

The second pump assigned for standby duty shall operate and start:

- if the main pump fails to start (through a signal from pressure switch), or
- water level exceeds the start level of the main pump by a prefixed value.

and shall cut off along with the main pump when the water level falls to a minimum allowed level, as mentioned above.

If, for any reasons, the water level keeps on rising due to major leakage / flooding condition of Powerhouse, after a pre-fixed level, a high water level alarm and annunciation shall be sounded at the local Control Panels, UCB at the Powerhouse Operating Floor and Control Room SCADA.

In such an eventuality valve inter-connecting Drainage & Dewatering sump shall be opened through a manual spindle located at Turbine Floor Level and Dewatering Pumps shall work simultaneously along with Drainage Pumps.

The logic of the start-up of these Pumps as well as the size of discharge pipes shall be designed accordingly.

The main & stand-by pumps shall be alternated after each pre-set operating cycle. Also an override selector switch shall be provided for manual switch-over of pumps when required.

1.29.1. Technical Details Of Equipment

1.29.1.1. PUMPING – COMPONENTS/PROTECTION

The pumping equipment shall comprise of Submersible Sump Pumps / Vertical Turbine Pumps with driving electric motors, piping, valves, piping flow instrumentation, level relay for auto start-stop of pumps, high water level alarm, water level gauge, inter connection with control valves including check valve for connecting drainage sump with dewatering sump, motor switchgear, starters, protection and controls etc. complete in all respects.

Details of the system have been shown in the relevant Flow Diagram. The Drainage Submersible Sump Pumps & system shall have the following protection/functional features:

- Protection Class IP-68
- Thermistor protection against winding overheating
- Single phasing prevention
- Overload relays
- Under voltage/reverse phasing protection
- Moisture sensing unit for detecting ingress of moisture/water into oil chamber.

- In-built liquid level controller to avoid dry running of pump.
- External liquid level controllers to start/stop of pumps.

The pump sets shall be complete with special Submersible Cable, Level Switches, Automatic Detachable Pedestal Coupling, Dismantling Joint, Guide Pipes, Lifting Chain of Galvanized Iron (GI) etc.

1.29.1.2. PUMP SETS

The pump sets shall be Submersible Sump type to be installed in the sump.

The pump impellers shall be of cast stainless steel (CF8M) hydraulically balanced. The impeller wear rings shall be of wear resistant stainless steel. The pump shaft shall be made of corrosion resistant stainless steel (SS-410), ASTM A217 and adequately sized to carry torque requirements. The fasteners in liquid shall be made of SS-304.

The suction and discharge casings shall be of rugged cast iron construction/ductile iron. Means for preventing reverse flow shall be provided.

The pumps shall be capable of handling muddy/turbid water.

The motor shall be suitable for 415 V, 3 phases, 50 Hz. AC supply and for control the AC supply shall be 240 V, 1 phase, 50 Hz.

The thrust bearing shall be designed to carry all the thrust and shock load that could be imposed by the pump. Mechanical Seals of suitable design shall be provided to prevent water from entering the motor.

1.29.1.3. PIPING, VALVES & GAUGES

All piping shall be of Carbon Steel electric resistance welding (ERW) type, while embedded piping shall be of Stainless Steel material and pressure class PN10. Various control and check valves shall be of cast steel of pressure class PN10. The valves shall be of Cast Steel body with SS trim of modern sleek design with minimum space requirement for installation & easily operable type.

The piping system shall have pressure gauges, pressure switches etc. Float switches/level relays shall be provided for control of pumps and to sound high water level alarm & annunciation.

Insulation (Armaflux with Aluminum cladding), non-combustible material on the piping surface located inside the Powerhouse shall be provided to avoid the problem of dripping of water due to condensation.

1.29.2. Site Inspection And Performance Tests

Contractor's Site Inspection, Testing and Commissioning program for the Drainage system shall include but not limited to the following:

- Inspection and testing of all lines and connections to ensure their proper installation according to drawings and verification that they are free from debris or obstructions.

- Testing of pumps, level sensors, instruments and alarms to ensure proper operability of all components and correct mutual function or interrelated parts;

All Test procedures, Test results & equipment settings shall be recorded on data sheets and shall be submitted to the Employer.

1.29.3. Drawings/Documents For Drainage System

The Bidder shall submit the following drawings / documents at the time of bid submission:

- Flow Diagram
- Technical data sheets of all main equipments
- Catalogues of proposed main equipments

The main drawings/documents to be furnished after award of contract shall include but not limited to the following:

- DBR (Design Basis Report), including design calculations.
- Flow Diagram
- Sizing/selection calculations of Pumps
- Pumps - Performance curves
- Manufacturing Data Sheets/Specifications of Pumps, Level Sensors
- GA & Foundation Drawings of Pumps
- QAP – Pumps, Level Sensors
- Pipe routing, Isometric drawings and As-Built drawings.
- Pipe supports
- Equipment Catalogues
- Testing and Commissioning Procedures
- & M Manuals

1.29.4. Mandatory Spare Parts

S. No.	Description	Type/size	Quantity
I	**STATION DRAINAGE WATER PUMPS**		
1	Impeller		2 nos.
2	Rotor Shaft		2 nos.
3	Upper Bearing		2 nos.
4	Lower Bearing		2 nos.
5	Upper Mechanical Seal		2 nos.
6	Lower Mechanical Seal		2 nos.

7	Cable Entry Kit		2 nos.
8	O-Ring		2 nos.
9	Fasteners in Liquid		2 nos.
II)	**Valves & Instruments**		
1	Valves	each type / size	1 no.
2	Pressure Gauge		1 no.
3	Pressure Switch		2 nos.
4	Components of Starters for Pumps & Control		1 set

The spare parts mentioned here are meant for use by the Employer for five (5) years trouble free operation and shall not be used as erection spares required during installation. All the spare parts shall be interchangeable and shall be of the same material and workmanship as corresponding parts of the main equipment.

If any additional spare parts required for a 5-year operation period are recommended by the Contractor, these shall be listed, and the unit price shall be quoted in the Price Schedule. The Employer reserves the right to order any or all of such spares, within 12 months after commissioning.

1.30. DEWATERING SYSTEM

The Dewatering System shall be designed for dewatering of Penstock, partial dewatering of draft tube (for Turbine, Runner inspection) and complete dewatering of draft tube. The system shall include the Dewatering Pumps, Piping, Valves, suitable Starters/MCC, Protective devices, Control & Instrumentation etc. and associated accessories required for the completeness of the system. Other items not specified above but found necessary to complete the system in all respects shall be in the scope of the Bidder.

Dewatering system shall be provided in the Powerhouse for dewatering of Penstock, Scroll Case and Draft Tube up to Draft Tube Gate for access to Turbine for inspection and maintenance.

Water to be drained out from the Turbine space and the lowest part of the Penstocks below tail water level shall be drained through unit piping up to Dewatering Sump passing through Dry Valve Pit, from where it shall be simultaneously pumped out of the Powerhouse through Submersible Sump Pumps. The water shall be discharged downstream of the closed tail race gates above High Flood Level. Refer Dewatering System Flow Diagram.

The piping shall comprise of the following:

- Dewatering piping before & after MIV along with valves and compressed air injection ports.

- Draft tube drain piping from each unit at bottom most point shall be provided with stainless steel debris grating and connected to a common Dewatering Sump located at one end of the Powerhouse through piping and having compressed air injection ports.
- For each draft tube, Spindle Butterfly valve connected to the draft tube drain pipe mentioned above shall be located inside the Dry Valve Pit. The spindle gate valve shall be operable from Pit's top level.
- Submersible Sump Pumps (1 no. working + 1 no. standby) for dewatering.
- Delivery pipe leading from the Submersible Sump Pumps installed in the Dewatering Sump in the Powerhouse to the tail race. Fluid velocity in piping shall not exceed 2 m/sec when one pump is running and 3.5 m/sec with both pumps running.
- A Portable type Submersible Sump Pump to evacuate Valve Pit's Floor drains/leakages.

The details of water volumes to be emptied and the expected leakages through Main Inlet Valve (MIV), Draft Tube Gates etc shall be furnished by the Contractor. The leakage through Gates shall be estimated as per latest edition of International Standard. However minimum leakage of 0.1 L/sec/m throughout the Gate perimeter with an additional 0.1 L/sec/m in corner section of 1m length shall also be considered.

The Contractor shall select such designs, constructional features and materials for the dewatering equipment which would resist silt abrasion effects and shall be capable of handling muddy/ turbid water.

The capacity of the dewatering pumps (2x100%) shall be such that with the main dewatering pump working (without aid from standby pump), the Turbine water passage between the downstream MIV and the Draft tube Gate can be emptied within about four (4) hours, considering maximum anticipated leakages through the MIV seals and through the Draft tube Gate seals. Time for partial dewatering shall be considered as three (3) hours.

Necessary calculations shall be furnished by the Contractor to determine the pumping capacity & the rated dynamic head and shall be subject to approval by the Employer/ Engineer. The Contractor shall work out the required pump heads based on details of the system layout.

Drainage Sump and Dewatering Sump shall be interconnected by piping having Manual spindle operated interconnecting valve (Normally Closed) and an NRV. In case of failure of Drainage Pumps, Dewatering pumps can be manually put into operation for emergency drainage by manually opening spindle operated valve from Turbine Floor Level.

In the eventuality of a major leakage / flooding condition of the Powerhouse both Pumps of Drainage System as well as both Pumps of Dewatering System can work simultaneously. The logic of the start-up of these Pumps as well as the size of discharge pipes shall be designed accordingly.

The automatic operation of the Dewatering pumps shall be effected with the help of level switches installed in the Dewatering Sump. The pump designated and assigned as the main pump shall be started after opening of the spindle valves and cut off on receipt of signal from the level switch.

The second pump assigned for standby duty shall operate and start:

- if the main pump fails to start (through a signal from pressure switch),

The pumps shall alternate at each pre-set operating cycle.

If, for any reasons, the water level persists after a pre-fixed time after start of pumps detected through DP switch, a high water level alarm and annunciation shall be sounded at the local control panels, UCB at the Powerhouse operating floor and control room SCADA.

Also necessary instrumentation shall be provided to avoid any dry running of Pumps.

The pumping equipment shall comprise of Submersible Sump Pumps with driving electric motors, piping, valves, piping flow instrumentation, level relay for auto start-stop of pumps, high water level alarm, water level gauge, inter connection with control valves including check valve for connecting drainage sump with dewatering sump, motor switchgear, starters, protection and controls etc. complete in all respects.

Details of the system have been shown in the relevant Flow Diagram. The Drainage Submersible Sump Pumps & system shall have the following protection/functional features:

- Protection Class IP-68
- Thermistor protection against winding overheating
- Single phasing prevention
- Overload relays
- Under voltage/reverse phasing protection
- Moisture sensing unit for detecting ingress of moisture/water into oil chamber.
- In-built liquid level controller to avoid dry running of pump.
- External liquid level controllers to start/stop of pumps.

The pump sets shall be complete with special Submersible Cable, Level Switches, Automatic Detachable Pedestal Coupling, Dismantling Joint, Guide Pipes, Lifting Chain of Galvanised Iron (GI) etc.

1.30.1. Pump Sets

The pump sets shall be Submersible Sump type to be installed in the sump.

The pump impellers shall be of cast stainless steel (CF8M) hydraulically balanced. The impeller wear rings shall be of wear resistant stainless steel. The pump shaft shall be made of corrosion resistant stainless steel (SS-410), ASTM A217 and adequately sized to carry torque requirements. The fasteners in liquid shall be made of SS-304.

The suction and discharge casings shall be of rugged cast iron construction/ductile iron. Means for preventing reverse flow shall be provided.

The pumps shall be capable of handling muddy/turbid water.

The motor shall be suitable for 415 V, 3 phases, 50 Hz. AC supply and for control the AC supply shall be 240 V, 1 phase, 50 Hz.

The thrust bearing shall be designed to carry all the thrust and shock load that could be imposed by the pump. Mechanical Seals of suitable design shall be provided to prevent water from entering into the motor.

1.30.2. Piping, Valves & Gauges

All piping shall be of Carbon Steel electric resistance welding (ERW) type, while embedded piping shall be of Stainless Steel material and pressure class PN10. Various control and check valves shall be of cast steel of pressure class PN10. The valves shall be of Cast Steel body with SS trim of modern sleek design with minimum space requirement for installation & easily operable type.

The piping system shall have pressure gauges, pressure switches etc. Float switches/level relays shall be provided for control of pumps and to sound high water level alarm & annunciation.

Insulation (Armaflux with Aluminum cladding), non-combustible material on the piping surface located inside the Powerhouse shall be provided to avoid the problem of dripping of water due to condensation.

1.30.3. Site Inspection and Performance Tests

Contractor's Site Inspection, Testing & Commissioning program for the Dewatering system shall include but not limited to the following:

- Inspection and testing of all lines and connections to ensure their proper installation according to drawings and verification that they are free from debris or obstructions;
- Testing of pumps, level sensors, instruments and alarms to ensure proper operability of all components and correct mutual function or interrelated parts;

All Test procedures, Test results & equipment settings shall be recorded on data sheets and shall be submitted to the Employer.

1.30.4. Drawings/Documents For Dewatering System

The Bidder shall submit the following drawings / documents at the time of bid submission:

- Flow Diagram
- Technical data sheets of all main equipments
- Catalogues of proposed main equipments

The main drawings/documents to be furnished after award of contract shall include but not limited to the following:

- DBR (Design Basis Report), including design calculations.

- Flow Diagram
- Sizing/selection calculations of Pumps
- Pumps - Performance curves
- Manufacturing Data Sheets/Specifications of Pumps, Level Sensors
- GA & Foundation Drawings of Pumps
- QAP – Pumps, Level Sensors
- Pipe routing, Isometric drawings and As-Built drawings.
- Pipe supports
- Equipment Catalogues
- Testing and Commissioning Procedures
- O & M Manuals

1.30.5. Mandatory Spare Parts

The following spare parts shall be included in the supply:

S. No.	Description	Type/size	Quantity	
I)	**Dewatering Pump**		**Main Pump**	**Portable Submersible Sump Pump for Dry Valve Pit**
1	Impeller		1 no.	1 no.
2	Rotor Shaft		1 no.	1 no.
3	Upper Bearing		1 no.	1 no.
4	Lower Bearing		1 no.	1 no.
5	Upper Mechanical Seal		1 no.	1 no.
6	Lower Mechanical Seal		1 no.	1 no.
7	Cable Entry Kit		1 no.	1 no.
8	O-Ring		1 no.	1 no.
9	Fasteners in Liquid		1 no.	1 no.

II)	**Valves & Instruments**			
1	Valves	each type / size	1 no.	
2	Pressure Gauge		1 no.	
3	Pressure Switch		1 no.	
4	Components of Starters for Pumps & Control		1 set	

The spare parts mentioned here are meant for use by the Employer for five (5) years trouble free operation and shall not be used as erection spares required during installation. All the spare parts shall be interchangeable and shall be of the same material and workmanship as corresponding parts of the main equipment.

If any additional spare parts required for a 5-year operation period are recommended by the Contractor, these shall be listed, and the unit price shall be quoted in the Price Schedule. The Employer reserves the right to order any or all such spares, within 12 months after commissioning.

1.31. LUBRICATING OIL PURIFYING SYSTEM

1.31.1. Description

The lubricating oil purifying system is intended for following:

- Inlet Valve hydraulic system,
- Turbine Governor hydraulic system,
- Turbine/Generator Bearing,

The Contractor shall supply a centrifugal oil purifying system (1000 LPH) which is the standard for this size of plant.

The Oil Purifying unit shall be able to remove contaminants having the minimum size of 1 microns and the de-gasification machine should be able to completely remove the water from oil to zero-free water content or to 50 ppm below saturation level.

1.31.2. Mandatory Spares

The following spare parts shall be included in the supply:

S. No.	Description	Quantity
I	**LUBRICATING OIL PURIFYING SYSTEM**	

1	Oil Inlet Pump	1 no.
2	Motor for Oil Inlet Pump	1 no.
3	Oil Discharge Pump	1 no.
4	Motor for Oil Discharge Pump (Not required in case of Mono Bock pump)	1 no.
5	Vacuum Pump	1 no.
6	Motor for Vacuum Pump	1 no.
7	Gasket & Seals	1 set
8	Flexible Nitrile Rubber hose pipe with flanged end connections on both sides (Length – 10 m)	1 no..

The spare parts mentioned here are meant for use by the Employer for five (5) years trouble free operation and shall not be used as erection spares required during installation. All the spare parts shall be interchangeable and shall be of the same material and workmanship as corresponding parts of the main equipment.

If any additional spare parts required for a 5-year operation period are recommended by the Contractor, these shall be listed and the unit price shall be quoted in the Price Schedule. The Employer reserves the right to order any or all of such spares, within 12 months after commissioning.

1.32. Oil and Lubricants

The Contractor shall indicate the specification and quantity of the governor system oil and of the bearing oil required for each Turbine and shall supply sufficient oil for the first filling plus 10% extra of each type. Where possible, the specification for the governor oil and for the bearing oil shall be the same.

1.33. Turbine Instrumentation, Control and Safety Devices

Each Turbine shall be provided with a complete set of instruments, water level gauges, controls and safety devices required for the unit during standstill, start and stop conditions, normal running and emergencies. These shall permit the unit to be started and brought up to the rated speed during normal running. The instruments and gauges for the Turbine to be supplied shall include all instruments, alarms, safety devices and controls necessary for the efficient and automatic control, monitoring and operation of Turbine and auxiliaries. The safety devices shall comprise monitoring and communication equipment and devices for sensing abnormal operating conditions, for giving visual and audible annunciation and to shut down the unit, if required. The items, quantities and location shall suit the requirements for safe and satisfactory operation of the generating units and the auxiliary system.

All the instruments, indicators, gauges, safety devices etc. shall be complete with necessary detecting elements, auxiliary relays, cables etc. ready to operate. The AC/DC supply and all necessary accessories therefore shall be included.

To meet the requirement of microprocessor based Supervisory Control and Data Acquisition (SCADA) system including facility for auto-start-stop of unit and fault diagnosis, the instruments/transducers offered shall be such that their output can be fed into the system. Indicating instruments, as required, shall be installed on Unit Control Board. Details of instruments offered shall be furnished with the offer. Indicative list of instruments to be provided with the Turbine is given below:

S. No.	Item	Type of Instrument	Qty.	Location
A)	**Pressure:**			
	Penstock (Before MIV)	Pressure Digital Indicator & Transmitter (4-20mA), accuracy ±0.2%	1	Local+ SCADA
	Penstock Pressure (After MIV)	Pressure Transducer	1	SCADA
	Spiral Case	Pressure Digital Indicator & Transmitter (4-20mA), accuracy ±0.2%	1	Local+ SCADA
	Head Cover	Indicating Pressure Vacuum Gauge	1	Local

	Draft Tube	Indicating Pressure Vacuum Gauge	1	Local
	OPU	Pressure Digital Indicator & Transmitter (4-20mA), accuracy ±0.2%	1	Local+ SCADA
	Guide Vane Servomotor	Indicating Pressure Gauge	2	Local
B)	**Level:**			
	Turbine Guide Bearing Oil Reservoir	Sight Gauge	1	Local
	-do-	Level Relay for high & low level and Level Transducer	1	SCADA
C)	**Temperature:**			
	Turbine Guide Bearing Pads	Temperature Transmitter & RTD on alternate pads (Duplex RTD, 4-20mA)	Half the no. of pads	SCADA
	-do-	Dial Type Thermometer with alarm contacts	2	Unit Control Board /Gauge Panel
	Turbine Guide Bearing Oil Reservoir	Temperature Transmitter & RTD (4-20mA)	1	SCADA
	do-	Dial Type Thermometer with alarm contacts	1	Local+ SCADA
	Turbine Bearing Thermal Relay	Vapour Type Thermal Relay	1	Turbine Bearing
	Turbine Bearing Cooling Water outlet	Dial Type Thermometer with alarm contacts	1	Local

	temperature			
D)	**Flow**			
	Generator Air Cooler-Outlet of Cooling Water	Flow Indicator and Flow Transmitter (4-20 mA), accuracy ±0.2%	1	Local+ SCADA
	Generator UGB-Outlet of Cooling Water	Flow Indicator and Flow Transmitter (4-20 mA), accuracy ±0.2%	1	Local+ SCADA
	Generator LGB+ Thrust Bearing-Outlet of Cooling Water	Flow Indicator and Flow Transmitter (4-20 mA), accuracy ±0.2%	1	Local+ SCADA
	Turbine Guide Bearing Outlet of Cooling Water	Flow Indicator and Flow Transmitter (4-20 mA), accuracy ±0.2%	1	Local+ SCADA
	Each Shaft Seal - Outlet of Cooling Water	Flow Digital Indicator & Transmitter (4-20mA), accuracy ±0.2%	1	Local+ SCADA
	OPU for Governor + MIV- Outlet of Cooling Water	Flow Digital Indicator & Transmitter (4-20mA), accuracy ±0.2%	1	Local+ SCADA
	Turbine Discharge	Display/Indicating & Recording Flow, scale in m3/sec. and totalize discharge accuracy ±0.5%	1	SCADA
E)	**Miscellaneous:**			

	Water Detector in Oil (OPU-Turbine & MIV)	Moisture Detector	1	Unit Gauge Panel and/ or SCADA
	Dam/Barrage Water Level and Gate operation	Level Transmitter Analog input and analog output / PLC	1	SCADA through telecommunication network
	Tail Water Level	Level Transmitter	1	SCADA
	Vibration Detector	Displacement Type	1	Unit Control Board, SCADA

1.33.1. Turbine Flow Measurement

One set of apparatus for measurement and recording of the turbine discharge through tappings in accordance with IEC 60041 in SCADA shall be supplied with each Turbine. The apparatus shall be complete with all necessary differential pressure transmitter, integrated instruments, peizometer tappings, interconnecting tubes etc., and shall be calibrated at the time of installation.

The flow measurement shall indicate the instantaneous flow (in cubic meters per second) through the turbine and shall record the flow. The equipment shall be capable of measuring over the entire range of turbine from 10% to 140% of turbine rated discharge.

The apparatus shall be complete with required vent valves, shut off valves, pressure pulsation dampeners, supports. All piping from the tapping to the differential pressure transmitter, all the accessories that may be required and special tools for initial calibration shall be supplied.

The flow measurement shall be calibrated during the field testing of the turbine. Output shall be indicated in the SCADA.

1.33.2. Piezometer Gauges

Piezometer tappings around the Turbine inlet pipe, Spiral Casing as well as Draft Tube shall be provided for measurement of net head/flow in accordance with IEC 60041 Field Acceptance Tests of Hydraulic Turbines and these connections shall be terminated in a manifold at suitable location.

All Piezometer tappings used for pressure measurement shall be made of stainless steel and shall conform to IEC field test code. Stainless steel piping shall be used for connections. The portion of piping to be embedded in concrete shall be enclosed in a conduit to protect the pipe during placement of concrete.

Gauge shall be supplied complete with necessary piping, capillary tubing, valves, fittings, etc. The pressure gauges shall be calibrated to indicate the value in meters as well as in kg/cm2.

1.33.3. Vibration Monitoring System

One (1) no. of common vibration monitor, which can be part of Governor panel shall be supplied for monitoring the vibration level of Generator as well as Turbine points at a single location. All the vibration sensors of Turbine & Generator points shall be connected to this common vibration monitor. The vibration detector monitoring system (displacement type) shall initiate alarm and trip contact and shutdown the unit in case of excessive vibration of the Turbine during operation.

1.34. Spares

The spare parts for the Turbine and associated equipment considered necessary for five (5) years of trouble free operation of the generating units shall be supplied by the Contractor. The unit prices of the spares shall be indicated as per "Technical Specifications" and additional spares, if considered necessary, shall be listed along with unit prices. For all parts and spares, the Contractor shall provide a listing of Sub-Contractors and their addresses.

S. No.	Description	Quantity
A)	**TURBINE**	
1	Guide Vane bearing bushes (top and	1 set
	bottom)	
2	Guide Vane stem packing	1 set
3	Guide Vane bolts	1 set
4	Safety element	1 set
5	Shaft Seal packings	1 set
6	Set of gaskets, seal, 'O' rings of all types and size	2 sets
7	Bushes for regulating mechanism	2 sets
8	Shaft protective sleeve provided at shaft gland seal	1 No.
9	Bearing shell for Turbine Guide Bearing	1 No.
10	RTD	2 sets
11	Level switches	1 set

1.35. Corrosion Protection and Coating

For all structural steel and cast-iron parts including piping for areas in contact with air, oil and water the following applies:

Surface Preparation: On all cast iron and structural steel parts the rust must be removed by mechanical means sandblasting to obtain a bare surface as per international practice.

Prime Coat for all areas:2 layers with "Friazinc R", dry thickness of each layer 40 microns.

Type A: Areas in contact with water: After assembling the mechanical parts in the workshop of all items to be delivered three coats of water-resistant paint must be applied with each layer having a minimum thickness of 100 microns.

Type B: Areas in contact with oil: All those areas will receive three coats with oil resistant paint, for example Keratol, which must be applied as finishing coat.

Type C: Areas in contact with air: All those areas still accessible after assembling on site, receive two prime coats with different colors. The prime coat consists of a preliminary final coat in blue for the Turbine casing and red for all the moveable parts.

Areas in contact with concrete: Cast-in items do not receive any coating but must be free of rust and spunk.

Cast-in items exposed to air and water must be provided with a prime coat to a depth of approximately 150 mm into the concrete.

Pipelines in contact with water: They must be provided with three coats of water-resistant paint.

Oil carrying pipelines: They must be dismantled after assembling on site, pickled in acid solution, neutralized and oiled.

All bare surfaces, which are not in contact with oil, shall be provided with a protection coat (removable with water) after manufacturing.

Parts located in inaccessible areas, which must not be dismantled after workshop assembling must be protected as follows:

The electrical equipment such as electric motors, limit switches, control panels etc. must receive corrosion protection according to specifications in the worst atmosphere.

The color coating will be determined by the client. Any coated surface damaged after or during assembling must be reinstated.

1.36. Drawings

The Supplier must provide all design calculations and All equipment drawings required for manufacturing, delivery and final assembling on site of all items to be provided within his scope of work and these must be submitted for the review/comment/approval of the Employer: -

The Contractor shall submit 2 copies of the following drawings during detail engineering:-

Layout drawings of the powerhouse showing the overall dimensions and layout of the Turbine, governing equipment, butterfly valve, runs of piping, etc., clearly indicating unit spacing, dimensions of Turbine casings, draft tube and important elevations with clearances for erection and maintenance. The drawings will show any provision for shaft seal cooling/lubricating water supply required from others. These drawings will freeze the dimensions of powerhouse and tailrace channel, (minor revisions accepted within 30 days of the award of contact),

- Loads and forces to be considered in the design of concrete structures,
- Physical and schematic drawings and descriptive literature on the governor and governor mechanism, and emergency closing system and provide details of governor oil pressurizing system. Graphs/curves showing performance and cavitation characteristics of the Turbine such as but not limited to Hill chart, sigma and plant sigma curves based on model tests/CFD analysis draft tube exit losses, runaway speed, etc.,
- Details of the shaft seal
- A list indicating the guaranteed life cycle period of major parts.
- A time schedule for the manufacture, delivery and erection of all Turbine components and ancillary equipment,
- A complete list of equipment and auxiliaries etc. covered in the Bid,
- Complete details of manual/local control, shall form a part of the bid,
- A complete list of sub-contractors/suppliers,

- The Contractor shall submit 6 copies of the following drawings after the award of Contract for review and comment by the Employer.
- Details of recesses and embedment to be provided in concrete for mechanical equipment (within 30 days after the award of Contract)
- Drawings clearly showing various components, parts, assemblies of the Turbine, governing equipment, etc. in plan, elevation, and cross section with dimensions and ratings,
- Detailed workshop drawings of wearable/ consumable parts,
- Detailed workshop drawings of the Shaft Seal and Bearings,
- Detailed drawing of the runner showing dimensions and required clearances at sealing surfaces,
- Schematic drawings of piping systems, control systems, and instrumentation with dimensions and ratings
- A list of tests and quality inspections to be carried out on raw materials, sub-assemblies, equipment and systems at the manufacturing facility as well as at site.
- Drawings / brochures for all parts, equipment, components, and special erection equipment; with operating /maintenance instructions

1.37. Special Tools, Slings, Consumables etc.

A standard set of tools required for carrying out dismantling, erection and maintenance work must be provided in a metal, waterproof and lockable toolbox. This toolbox must also contain the required operating and maintenance instructions.

All special tools, slings, lifting devices, jacks, turnbuckles, foundation plates / bolts etc. required for erection of the equipment shall be listed and supplied. Every tool and plant damaged during erection shall be replaced with a new one. All materials, spares, welding electrodes as required for site welding and paint for finishing coat shall be supplied by the Supplier.

1.38. Shop Assembly AND Workshop Tests

1.38.1. General

Relevant IS & International standard recommendations for the selection of materials and testing of plates, cast iron and forged items for hydroelectric power plants must be adhered to. Samples of steel plates shall be tested by the Contractor. Metallurgical strength, crystallographic, ultrasonic, and bore scope shall be performed on the Turbine shaft during manufacture. The results of all tests shall be delivered to the Employer within one (1) month after material has been tested.

Cost of all tests required in the workshop as well as on site including provision of personnel and equipment required to carry out these tests must be included in the offer.

The following assemblies and test shall be carried out on the Turbines and associated equipment at the manufacturer's works before dispatch in the presence of representative of the Employer/Consultant, if desired by the Employer, and test certificate shall be submitted:

- The first Turbine manufactured shall be assembled in the shop in the presence of Employer.
- Static balancing of runners
- Hydrostatic testing at 1.5 times the maximum static / working pressure including water hammer for not less than 15 minutes for the scroll case, servomotor etc.
- Non-destructive testing of weld joint and major castings and forgings.
- Performance tests for individual auxiliary equipment
- Complete assembly and simulation test of governors etc.,

All motors / pumps / compressors etc. shall be tested as per relevant Indian or other international standards.

1.38.2. Manufacturing and Erection of Equipment

The design of the Turbine with all the auxiliary equipment must comply with the acknowledged technical standards. The unit must be free of vibrations with extreme low noise level under all operating conditions. The respective requirements from the authorities must be met. All design work required for manufacturing, delivery and erection upto commissioning of all equipment parts are included in the Supplier's scope of work.

The Supplier guarantees that the assembly of the Turbines will be carried out in an appropriate and faultless manner. Suppliers shall deliver Turbine and its auxiliaries in the assembled condition to the maximum extent possible, subject to transport limitations if any.

1.39. Packing and Transportation

All parts to be delivered must be packed in a proper manner and then loaded and transported to site, unloaded and stored properly.

1.40. Commissioning (Trial Operation), Test Run and Acceptance Tests

After completion of the erection and operational readiness checks of the plant, the components supplied by the Contractor will be commissioned as part of the commissioning of the generating unit and ancillary equipment as a whole. The commissioning will be carried out under the direction of a Commissioning Coordinator. The commissioning will be carried out as per a procedure approved by Employer. 90 days before the anticipated time of commissioning the first unit, the Contractor shall submit to the Employer procedures for the commissioning of his equipment which will be integrated into overall procedures for the unit.

1.40.1. Commissioning Tests (Trial Operations)

The Supplier shall carry out the trial operations / commissioning tests in accordance with IEC 545. The Turbine and its auxiliaries shall be commissioned first and shall be free from problems of leakages, overheating, failure, damage etc.

The commissioning period for each Turbine is considered to be completed after the following tests have been carried out successfully:

- Minimum five start-ups and shutdowns,
- The Turbine with all the auxiliary equipment has been operating continuously over a period of at least 72 hours. During the scheduled 72 hours of operation, the Turbine output should be varied between partial and full load several times. During the period the Turbine should also be operated at overload.
- After successful completion of the 72 hour test run, the machine shall be handed over & the five-year guarantee period comes into force.

1.40.2. Acceptance Tests

These shall include capacity and efficiency tests which shall be carried out on one Turbine selected by the Employer to verify the guarantee provided in accordance to the SCC. These tests shall be carried out in accordance with provisions of IEC-60041.

Tests shall also be carried out to verify all contractual guarantees, which shall include load acceptance and rejection tests, run away tests etc.

The contractor shall provide all necessary provisions on the various equipments supplied for successful completion of such tests including labour and material required for such tests. All test equipment (duly certified by recognized test houses) and instruments for performing the various tests shall be made available by the contractor and shall remain the property of the contractor after the fulfillment of the tests.

A test report shall be furnished by the contractor after completion of the tests for review by the Employer or his representative, and after its approval, shall supply enough copies to the Employer. The report shall include all information, analysis and presentation of results as specified in the IEC.

1.41. Site Erection

The Supplier shall depute his experts for erection, testing and commissioning of Turbine and associated equipment for supervision of erection, testing and commissioning. The rates for the supervision personnel shall be included by the Bidder in his offer for comparison. All costs for supervision of erection shall be deemed to be included in the offer.

The personnel responsible for the erection of the Turbine on site must be experienced in the erection of several similar Turbines and shall be assisted with installation instructions provided from the workshop. Further if person is not found competitive enough, the Employer can ask the supplier for the replacement with more competitive and experienced person. During the erection period of the Turbine, the Employer will provide his personnel for training purposes.

The Bidder's experts will be responsible reporting to the leading expert of the Employer. They will train staff members of Employer, during the erection procedure, by training on the job methodology.

Details must be provided for equipment required during erection together with a time schedule for the erection period.

1.42. Warranty

The warranty period shall be as per the conditions and duration stipulated in the SCC.

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2. MAIN INLET VALVE (BUTTERFLY VALVE)

2.1. Scope Of Work

The scope of work under this section covers the detailed requirements for the design, manufacture, QA, QC, shop assembly and shop testing, packing transportation and delivery at site, storage and preservation, installation, erection, testing and commissioning of three (3) MIV Butterfly Valves.

2.2. Type And Description

A main inlet Butterfly Valve shall be provided upstream of each turbine, in order to isolate each turbine from the penstock during operation/maintenance/inspection of the TG unit. The Butterfly valve shall be of double seal, self-closing type.

The arrangement of the valve, the downstream connecting pipe with the dismantling-cum-expansion joint and the upstream transition section are included in the Scope of Works as also indicated in the Tender Drawings. The jointing/holding with U/s Penstock and D/s pipe (distributor) shall be done by the MIV Contractor.

2.2.1. Codes And Standards

The design, manufacture and performance of the equipment along with the accessories shall comply with all currently applicable statutes, regulations, codes and standards in the locality where the equipment will be installed.

However, unless otherwise specified herein, the equipment supplied shall conform to the latest version of the standards/ equivalent international standards listed below:

Standard	Description
IS 732	Code of practice for electrical wiring installation
IS 1271	Thermal evaluation and classification of electrical insulation
IS 1367	Technical supply conditions for threaded steel Fasteners.
IS 1885	Electrotechnical vocabulary: Part 17 Switchgear and control gear
IS 3043	Code of practice for earthing (First Revision)
IS 7326 (I)	Penstock and Turbine Inlet Butterfly Valves for

	Hydropower Stations and Systems – Criteria for Structural and Hydraulic Design
IS 7326 (II)	Penstock and Turbine Inlet Butterfly Valves for Hydropower Stations and Systems- Guidelines for Design and Selection of Control Equipment
IS 7326 (III)	Penstock and Turbine Inlet Butterfly Valves for Hydropower Stations and Systems- Recommendation for Operation and Maintenance
IS 9409	Classification of electrical and electronic equipment with regard to protection against electrical shock
IS 10422	Requirements and tests for safety of data processing equipment
IS 12065	Permissible limits of noise level for rotating electrical machines
AWWA C-504	American Water Works Association for Butterfly Valve
ASTM A 105	Material Specification for Carbon Steel Flanges.
ASTM A 106	Material Specification for Seamless Carbon Steel Pipes.
ASTM A 193	Dimensions and Thread Pitch for Bolts.
ASTM A 194	Dimensions and Thread Pitch for Nuts
ASTM A 216	Standard Specification for Steel Castings
ASTM A 516	Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
ASTM A 537	Standard Specification for Pressure Vessel Plates, Heat treated, Carbon-Manganese-Silicon Steel
ASTM A743	Specification for Casting, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant for General Application
ASME Section VII Div. I/II	Pressure Vessel Code

2.3. MIV Main Data

The MIV shall be designed and manufactured based on the following parameters:

Sl No	Item	Description
1	Type of Valve	Main Inlet Butterfly valve
2	Valve size	Diameter 2000 mm (tentative to match inlet dia. of spiral casing)
3	Qty required	3 Nos.
4	Max. static water head at the upstream face of the valve disc	57.1 mwc
5	Design Head at the centreline of valve, including pressure rise of 35%	77 mwc
6	Test Head	Body:~ 1.5 x Design Pressure Disc:~ 1.5 x Design Pressure Seal:~ 1.1 x Design Pressure
7	Maximum Discharge	17.45 m^3/s
8	Max. pressure drop across valve	less than 0.25 m
9	Operating Method	Opening: Oil Pressure Closing: 100% by Dead Weight
10	Body type	Fabricated (single / two piece)
11	Disc type	Lattice type disc (Single piece) Cast / Fabricated
12	Material of Penstock/Steel Liner	ASTM A537 class II

13	Bypass Assembly	Minimum dia. 150 mm and equipped with hydraulically operated Needle Valve; Manual Gate Valve for isolation; Flexible Expansion Joint
14	Differential Pressure Gauge Panel	Comprising of DP Gauge with Switch, Pressure Gauge, Pressure Switch, Pressure Transmitter etc.
15	U/s Connection pipe from centerline of MIV	Length: 1500 mm (approx.) Dia: to match Penstock dia.)
16	D/s Connection pipe from centerline of MIV	Length: 1500 mm (approx.) Dia: (to match with inlet of Spiral Casing) with dismantling joint.
17	Penstock Drain Assembly with Gate Valves	Opening Dia: 150 mm
18	Air Release Valve	Suitable Size – 1 no.
19	Anti Vacuum Valve	Suitable Size – 1 no.
20	Min. Corrosion Allowance	2 mm for disc, Valve body, U/s & D/s pipes and transition sections

2.4. Performance Requirements

The Contractor shall design the valve, U/s & D/s transition and expansion sections to achieve minimum head losses. The head loss coefficient for the water passage from the inlet end of the upstream transition section to the outlet end of the downstream expansion section shall be quoted based on the normal flow given in the above table and guaranteed by the Contractor.

The valve shall be designed to operate and seal properly under pressure during all operating conditions, including penstock filling. The valve shall be capable of closing by the counterweights and torque due to eccentricity on the disc.

The design pressures shall take into account the overpressures by water hammer.

The valve opening and closing times required are specified in the clause 1.6 below.

The Contractor shall guarantee that the valve shall be able to close against maximum flow at maximum operating head.

2.5. Operational Requirements

The time to open the valve from the fully closed position to the fully open position shall preferably be around 60 seconds. The time for the closure of the butterfly valve shall not be more than 60 seconds form the initialization of the closing impulse to the actual closure of the disc. There shall also be provision made to increase the time of closure as well as open up to 120 seconds, if and as necessary after operational tests at site. Normal valve opening shall be preceded by approximate balance of the water pressure at its upstream and downstream side via the by-pass valve. The Valve must be secured in the fully open position before Guide Vanes opening is initiated. All Limit switch (IP 65 or better) with minimum 2NO+2NC contacts shall be provided for fully open, fully closed and creep positions. All limit switches shall be hermetically sealed for any moisture ingress.

Both manual and automatic operation modes shall be provided. The automatic control shall be through powerhouse control room SCADA & UCB and the manual control from the valve local control panel provided near the valve. The Contractor shall provide all equipment, apparatus and devices to achieve the specified methods of local and remote operation, indication and control. The Contractor shall give the termination point in its control panel for further cabling up to Powerhouse Control Room (this cabling shall be in Valve supplier scope). Necessary input/signal for turbine operation shall be also co-ordinated for automatic control of valve from the control room. However, the Contractor shall demonstrate the operation of Valve from UCB-SCADA as well as local control panel.

The Butterfly Valve and its control shall be designed to ensure smooth and stable operation without undue vibration under the specified operating conditions during normal opening, normal closing and emergency cut-off conditions, and without inducing excessive shock loads to cause abnormal fatigue with Valve, Penstock, piping and downstream works.

The design of BFV shall for minimum two (2) closures per day along with the Turbine closure.

Limit switches of weatherproof type shall be provided for both bypass and main valve for their open-close status. Limit switches shall also be provided to indicate the status of Butterfly valve rotor in creep operation. These switches must not get damaged due to moisture presence and any variation in temperature conditions.

2.6. Valve Construction

2.6.1. Valve Body

The construction of valve body shall be made in a single/two piece flanged together, reinforced with ribs, brackets and sole plate for anchoring to the foundation. The features of construction shall be as per IS: 7326 (Part I&II)/AWWA C-504. The material for the valve body shall be of carbon steel conforming to ASTM A537 Gr.2 or A516 Grade 70/ASTM A216 or IS:2062 Grade E250BR. The fabrication work shall be done so as to fully meet the provisions of ASME Section VIII Division I or equivalent. The interior of the valve body shall be smoothly finished so as to have low resistance and a free & full flow is ensured through the system. A stainless-steel ring shall be screwed inside the body near the downstream side of the valve to serve as seating ring for the valve disc when the valve is in the closed position. The Tenderer may propose their own design as an alternative for approval. The valve body shall be flanged at both ends, and the flanges shall be shop-drilled and spot-faced. The valve flanges shall match the flanges for transition and expansion sections.

Foundation Pads to be fabricated from suitable thick carbon steel plates shall be welded to the valve body to support the valve and to transmit all loads to the concrete foundation. The body and transition sections shall be so arranged that no weight or vertical thrust from the valve, transition section or contained water is applied to the penstock steel liner. The support pads shall be of a type to permit adequate movement in the upstream and downstream directions of the inlet valve during opening or closing. Suitable means on the valve of adequate strength for its handling/lifting shall be provided.

A stainless-steel nameplate shall be provided and riveted to the valve body at an early visible location with all salient features of the valve etched or stamped on it.

2.6.2. Valve Disc

The valve disc shall be of the biplane lattice type to offer minimum head loss in the fully open position and to sustain the full differential pressure across the closed valve. The disc shall be of streamline section to minimize local eddy currents and sudden velocity changes. All surfaces of the disc in contact with water shall be smooth and free from hollows, depressions, cracks or projections that might cause pitting due to cavitation.

The disc shall be cast-fabricated/fabricated in single piece. The material shall be of carbon steel confirming to ASTM A537 class II or A516 Gr. 70/ ASTM A216 or IS:2062 Grade E250BR, in case of fabricated steel. The disc shall be stress relieved before machining. The centerline of the valve disc shall be slightly off center to the valve body center line to provide a hydro-dynamic closing to the valve.

2.6.3. Valve Shaft, Bearing And Shaft Seal

The valve shafts shall be mounted in horizontal positions. The shafts shall have a minimum diameter extending through the valve bearings and into the valve disc to withstand the maximum torque required to operate the valve. The Contractor shall furnish the calculation to show the maximum stresses in the shaft and any keys or dowels, etc, under the operating conditions specified.

The valve shafts shall be of forged carbon steel construction (In case of fabricated disc) with hardened stainless-steel sleeves. Self-lubricated bearings, to be housed in both ends of the hubs of the valve body, shall be provided. The friction coefficient of shaft bearings to be taken for calculation is to be adjusted so that any increase in friction coefficient due to use/aging shall not be a bottleneck in weight as well as closing of valve, against full flow.

The shaft seal at each end shall preferably be of the gland and stuffing box type. The stuffing box shall be easily accessible for adjustment and replacement of packing without disturbing any other part of the valve.

2.6.4. Valve Seals

The valve shall be provided with two seals –

- one as service seal located downstream of the valve disc

Seal shall be mounted on the periphery of the valve disc and be secured in position by means of clamping rings and screws.

The sealing arrangement shall be Stainless Steel seat ring in body and synthetic nitrile rubber seal with retaining ring on the disc. The leakage at the seals shall be zero to achieve water tight enclosure when the valve is pressurized.

The shape of mating parts (stainless steel ring / profile rubber sealing ring) shall be exactly same on whole circumference. Contact between stainless steel and rubber shall be line contact (i.e. tangent). The design / material of sealing system shall be such that the life of seal shall be not less than 10 years.

Tenderer shall furnish the complete details showing the seal system in the bid submission.

2.6.5. Lever Assembly & Counterweights

A lever arm shall be assembled to each of the valve disc drive shaft by taper drive key with sleeve assemblies. The lever arm shall be connected to the piston rod of a hydraulic cylinder(s). The lever arm shall carry the cast iron counterweights, preferably on both sides, which provides the necessary force to initially move the valve to the closed position. The lever arms shall incorporate locking pins to be retained by a padlock. The locking pin shall be capable of holding the valve in the closed position against full cylinder force.

The counterweights shall be sized to provide necessary closing torque on the disc under all possible operating & severe conditions including cutting off the maximum turbine flow and shall be fabricated of steel or cast iron. The counterweight, preferably located on upstream side, shall be designed for the worst friction coefficient possible in bearings and seals with a 1.5 safety factor.

A mechanical position indicator shall be provided, mounted on the valve body to show the position of the disc from full open to full closed position.

2.6.6. Latch And Trip Mechanism

To prevent the valve creeping from the fully open position, over an extended period, due to hydraulic oil pressure decay in the hydraulic cylinder, creep sensing device shall be provided to ensure that valve is kept in fully open position.

2.6.7. By – Pass Valve Assembly and Drainage System

The Butterfly valve shall be provided with a by-pass arrangement of suitable design for balanced opening of the valve. The same shall be suitable for automatic operation in sequential order. The bypass line shall connect the upstream and downstream companion pipes. The bypass valve shall be sized in such a way that it shall take care of leakages from GUIDE VANES and equalizes the pressure in the present time. In case this time exceeds, we shall get alarm. The bypass line shall be provided with a manually operated isolating gate valve on upstream side, which shall normally be fully opened all times, and a hydraulic cylinder operated needle valve with auxiliaries on downstream side. The needle of the valve shall be of stainless steel and all piping and valve shall be carbon steel/cast steel construction. The Contractor shall provide one flexible coupling in the by-pass line and a dismantling joint in the downstream section of bypass valve.

The drainage arrangement shall be provided on the upstream side of the valve for drainage of penstock. The drainage pipe with necessary valve, piping, fitting, isolating valve (with locking device), energy etc. shall be provided. Isolating valve shall be 2 nos in series. First shall be fixed on valve body and second shall be place on the flange of first valve.

The calculation for sizing, make and catalogue of the needle valve shall be furnished in the bid submission.

2.6.8. Anti vacuum Breaker Valve & Air Release Valve

Anti-Vacuum breaker valve and air valve of suitable size shall be mounted on the downstream companion pipe and shall operate automatically allowing air to enter the penstock to relieve sub-atmospheric pressure which may be induced by closing of Butterfly valve against flow or while the penstock is being de-watered.

The valves shall be flange-mounted and shall be provided with nitrile rubber seal and metal seal. The nitrile rubber seal shall provide leak tight seal, while metal seal shall take load acting on the seal.

The float shall be Stainless Steel lined with ebonite or rubber and the orifice contact joint with the float shall be a leak-tight joint. The float movement shall be governed by spring actuation and initial clearance shall be given between float and seal, allowing the air to escape during the filling operation. During filling operation, the float shall seal based on buoyant force, overcoming the spring pressure. As the water pressure increases the float shall seat on the seal provided in the body. During the draining operation, the float shall move down assisted by spring pressure.

A separate air release valve shall be provided on top of the downstream pipe, so that during filling, the entire penstock air is released through that air release valve.

The maximum and minimum pressure and temperature shall be considered while sizing the valve. Weather-proof type Limit switches shall be provided for monitoring the open-close status. Details of the sizing, selection, sectional drawings etc shall be submitted along with the bid.

2.6.9. Transition Section

2.6.9.1. Upstream Companion Pipe

The upstream transition pipe shall be flanged for connection to the Butterfly valve body and welded to the steel liner/penstock upstream of the valve. Connections for bypass line, pressure gauge and provision for mounting the differential pressure switches shall be provided at suitable locations on this pipe.

2.6.9.2. Downstream Pipe Piece, Dismantling Section-Cum-Expansion Joint

The Butterfly valve shall be flanged on the downstream side to a dismantling-cum-expansion joint of telescopic type, for dismantling of the valve during maintenance. The downstream pipe piece shall be of suitable length & shall be site welded/flange bolted to distributor. The connection for by-pass valve, manhole of 600 mm dia, pressure gauge etc., shall be provided in the downstream pipe.

The upstream and downstream pipe pieces shall be of fabricated steel construction of ASTM A537 class II/ A516 Gr. 70 /ASTM A216 or IS:2062 Grade E250BR and shall be supplied with a trim allowance of minimum 200 mm for edge preparation and welding. The edge preparation & welding of upstream & downstream pipes to steel liner and penstock shall be in the Contractor's scope. All the piping shall be tested to the required pressure before installation.

2.7. Valve Operating Sequences

The Butterfly valve will be operated from the remote UCB-SCADA and the local control panel.

2.7.1. Opening Of the Valve And Opening Sequence

Opening of the valve shall be by hydraulic servomotor. Valve opening sequence is initiated by a push button in the control cabinet or from the remote-control cabinet, which shall initiate the open command to the bypass valve. Once the bypass valve is opened and the pressure is approximately balanced in both the upstream and downstream sides of the valve, the opening of Butterfly valve takes place by energizing the solenoid valve provided in the hydraulic circuit. Once the Butterfly valve is fully open, the limit switch shall trip the motor after ensuring that the valve is held in open position by suitable mechanical arrangement (latch mechanism with a trip cylinder). The speed of valve opening shall be controlled by a control valve. The valve shall be kept open by oil trapped in the cylinder.

The servomotor system shall consist of a servo-piston operated by a pump driven with an electrical motor. During opening, oil will be allowed to flow from the sump to operate the piston. The piston movement shall be transmitted properly by a reliable link mechanism to the dead weight mechanism.

The valve's control logic system should be designed in such a way that in case the valve rotor creeps from the open position, then the tendency should be to retain the valve in fully open position, every time it has creeped beyond a set point. In case the valve continues to creep, an emergency gets created and the unit must trip. One hand pump with suitable hose pipes, adopters etc. shall be provided to manually open the valve in case of the failure of oil pumping unit during emergency.

2.7.2. Closing Of the Valve And Closing Sequence

Closing of the valve shall be by counterweight. The falling dead weight shall be actuated manually or through an electrical solenoid. To close the valve, signal is given to operate a solenoid valve and allow the oil to flow out of the cylinder back to the sump tank. When the valve closes to 80% to 90% closed position (adjustable), another solenoid valve shall actuate to reduce the flow of return oil and slow down the rate of closing the Butterfly valve during the last 20% to 10% of the travel. The tripping mechanism must be actuated hydraulically (oil actuated). Once the Valve reaches the fully closed position, the service (downstream) seal is applied.

A fool-proof mechanical interlock device (locking pin, lever etc.) shall be provided to prevent opening of the valve under unbalanced condition and for safety against accidental opening / closing or accidental energizing of the actuator.

2.7.3. Emergency Closing Sequence

Closing of the Valve in the emergency mode shall be initiated from the following conditions:

1. Emergency closing of TG unit.
2. Alarm from level sensors at MIV floor/ Drainage pit under floor flooding conditions.

2.8. Actuating System

2.8.1. Valve Servomotors

The valve disc shall be actuated by two oil servomotors with orifice fitting integrated into the servomotor body with counterweights for opening & closing of valve in order to reduce the size of servomotor, which shall be provided. When energized, the servomotors shall move the disk to the open position and keep it in that position against the closing force of the counterweights.

The servomotors shall be designed to operate adequately with the normal operating pressure range produced by the turbine OPU. They shall be designed to produce the maximum torque that may be produced by the valve and counterweights in any operating condition, and for the full range of friction coefficients that could prevail in the bearings and trunnion seals. A safety factor of 1.5 shall be applied to the friction coefficients, both ways.

During emergency closing, the servomotor oil flow shall ensure that the maximum allowable overpressure is never exceeded. The oil flow out of the servomotors shall be restricted by replaceable orifice fittings integrated into the servomotor body. The orifice fitting design shall be in a way that the piping cannot be installed without the orifice fitting correctly in place.

The servomotor cylinder shall be fabricated from welded plate or seamless pipe. Flanges shall be of forged steel and shall be provided with suitable gaskets or seal rings designed to remain oil tight at maximum pressures. The cylinder bore shall be honed to a polished finish. The piston material shall be steel and shall be supplied with appropriate seals suitable for the maximum design pressure.

The cylinder shall be equipped with a means of purging trapped air with safe plugging.

The servomotors shall be attached in one of two ways:

- Directly onto the valve body, or
- On the same foundation as the valve housing. In this case, all anchor bolts and accessories for the servo motors shall be supplied by the Contractor.

2.8.2. Actuating Mechanism and Counterweights

The actuating mechanism is a series of levers and rods that transmit the forces between the servomotors, the counterweights, and the rotor trunnions.

The actuating mechanism articulations shall be equipped with self-lubricating bushings and hardened martensitic stainless-steel trunnions.

The closing of the main valve shall be done by counterweights. They shall be designed to close the valve under the most severe conditions, including cutting-off the maximum turbine flow. These counterweights shall be designed for the worst friction coefficient possible in bearings and seals with a 1.5 safety factor.

There shall be appropriate adjustable and lockable stops to ensure that the valve orifice is perfectly aligned with the conduit when in open position, and also to ensure that the seal surfaces on the disk are perfectly aligned with the service and maintenance seal rings when in the closed position.

2.8.3. Command Valves and Hydraulic System For The Servomotors

The pressurized hydraulic oil for the servomotors shall be provided by the high-pressure pumping unit for the associated TG unit. The pipe sizes shall be chosen so that average oil velocity does not exceed 4 m/s.

The Contractor shall supply all the associated steel piping and steel or bronze accessories necessary to connect all components. Threaded connections shall not be accepted for pressurized piping. All joints shall be welded, and all connections between pipe sections or components shall be flanged.

An electro-hydraulic control panel with provision for housing instruments and controls for safe valve operation including controls for opening, closing and emergency closing of valve with provision for indication / annunciation and alarm shall be provided. Valve closure shall be piloted by a Bosch Rexroth poppet valve with heavy duty solenoid. Required controls shall be provided in the valve control panel for operating the valve by remote commands from the Power House UCB-SCADA. The arrangement of the devices on the panel shall be so that the piping is held to a minimum and the devices could be readily removed from service. All the instruments on the panel shall be of flush mounted type.

The entire piping and valve system shall be designed to ensure total safety for plant personnel. The pressurized piping and components shall be well supported and protected from accidental impacts. The piping shall be arranged as so to avoid any risk of overpressure of any component in case of accidental operation of any valve or combination of valves. All manual valves shall be padlock able in closed and open positions.

2.8.4. Electro-Hydraulic Control Panel

An electro-hydraulic control panel housing instruments shall provide controls for the valve safe operation including controls for opening and closing of valve with provision for indication / annunciation and alarm. Requisite controls shall be provided in the valve control panel for operating the valve by remote commands from the Powerhouse UCB-SCADA. The arrangement of the devices on the panel shall be so that the piping is held to a minimum and the devices could be readily removed from service. All the instruments in the panel shall be of flush mounted type.

Name plates shall be provided for each device mounted on the panels and located on or below each device. The name plates shall contain legends which are descriptive of the function performed. Emergency control operations shall be plainly indicated.

2.9. Electrical Accessories And Control Panel

The local control panel shall house the following:

- Lockable type local/remote selector switch for valve control selection. The local/remote selector switch position shall be indicated locally and in the remote position, the MIV control will be taken over by the Unit Control Board and Powerhouse SCADA. The change of position shall be recorded as an event. In local mode, no action can be taken on the valve from the UCB or Powerhouse SCADA.
- Lockable push buttons for valve open/close commands. Commands to the valve shall be indicated and recorded as an event at the powerhouse SCADA.
- LED type indicating lamps for display of Butterfly and bypass valve position.
- Oil temperature digital indicator with dual RTD sensor input.
- All digital indicators shall have a 4 to 20 mA repeating output for local controller analog input.
- The local controller shall have the capability to communicate with the UCB- remote SCADA.
- Sequence control shall be provided in control circuit, so that valve shall open and close as per defined sequence, once open or close command is given either locally or remotely. When the local/remote selector is in remote mode, it shall be possible to command the Butterfly valve from the Powerhouse Control Room SCADA and also from the HMI located in the Unit Control Boards at the powerhouse operating floor.
- The panel shall be fabricated with instruments installed, wired and tested in manufacturer's work. All the controls and push buttons shall be of flush mounted type. All external connections shall be by way of numbered terminal blocks. Terminals will be provided in the control panel for connecting various incoming and outgoing signals and alarms. 20% spare terminals shall be provided.
- The panel shall be of the free-standing type fabricated from sheet steel with a one piece 3 mm thick steel for front and 2 mm thick steel for sides, back and top. The panel shall be supplied with an integral structural steel framework for supporting purposes and panel bracing. Each panel shall be provided with fully gasketed access doors that provide an IP55 degree of protection. Doors shall be provided with three point latches. Latching mechanism shall be key locking type. The outside and the inside of the panel shall be adequately painted to prevent rust. The control cabinet shall include proper interior lighting controlled by a door switch. A 240 V AC utility receptacle shall also be provided in the cabinet. For more details, refer to General Technical Requirements.

- Limit switches mounted on the butterfly valve shall be enclosed in a weather proof enclosure. Watertight cable connectors shall be used at both ends of the cables. The limit switches shall be redundant.
- The hydraulic solenoid valves shall be operated from the 24 V DC source.
- Protection, Auxiliary and Interposing Relays: Protection Relays shall be High Speed and specifically designed for tripping of circuit breaker coil. Relay coils shall be supervised using an external Supervisory Relay. Lockout relays shall be of the latching type resettable with an external pushbutton. Remote resetting is not permitted. Auxiliary, supervisory, and interposing relays. Relays shall be rated 10 A continuous 30 A make 5 s at 110 V DC suitable for 100,000 electrical and 1 million mechanical operations and shall be with flag/ LED operation indication. A minimum of 2-3 spare contacts shall be provided for future use.

2.10. Access Platforms

An access steel structure shall be provided by the Contractor for inspection and maintenance of valve by-pass assembly, air release valve and vacuum valve as well as for the purposes of crossing penstock and approaching manholes. The access steel structure shall consist of a platform, ladders and guard rails designed with sufficient strength and rigidity.

2.11. Inspection And Tests

The following tests shall be conducted in the shop and witnessed by Employer/Engineer:

2.11.1. Performance Test

The valve shall be tested in a fully assembled condition along with hydraulic power pack and control panel. The valve shall be shop operated a minimum of ten (10) times from fully closed to fully open position and ten (10) times vice versa under a no flow condition to demonstrate that the complete assembly is workable. However, if the Employer is not satisfied or would like to test the functioning of the valve even after this, the decision to open and close the valve for more than ten (10) times shall be the Employer's.

2.11.2. Body Hydrostatic Test

Both ends of the valve shall be blanked off (including upstream & downstream sections) so that the valve is subjected to the full pressure stress in all directions induced by the test pressure. With the valve disc in a slightly open position, the entire valve shall be subjected to at least 1.5 times the specified design pressure including pressure rise or twice the maximum operating pressure whichever is higher for at least 30 minutes. Under this pressure there shall be no leakage through the body or any trunnion seals and no parts shall be plastically deformed.

2.11.3. Disc Strength Test

With one end of the valve open to atmosphere and the disc in the closed position, the valve shall be subjected to 1.5 times the specified design pressure or twice the maximum operating pressure whichever is higher for a period of 30 minutes. The test shall reveal no structural damage at any point. There shall be no permanent deflection in the disc near seal, which shall be demonstrated during its testing.

2.11.4. Seal Test

With one end of the valve open to atmosphere and disc in the closed position and valve shall be subject to maximum design pressure for a period of 30 minutes. The leakage from the seals shall be as per IS:7326. Low presure leak test at working pressure shall also be carried out.

2.11.5. Operational Test At Site

After installation at site, the Butterfly valve shall be tested for operation to ensure that the actuator provides sufficient torque for valve opening under approximately balanced water conditions and valve closes by counterweight in the desired time. Initially, this test will be done by selecting minimum time of 45 sec and 60 sec for closure of Butterfly valve. If required, the opening and closing time shall be adjusted at site to meet the system requirements. Further, the valve shall also be tested from the local control panel as well as powerhouse control room SCADA and UCB.

Following tests shall be conducted on accessories.

- Pressure test of all field-installed piping at 1.5 times of maximum design pressure,
- Opening and closing of by-pass valve,
- Operation of all controls/OPU including mechanical locking devices, and
- Other tests as deemed necessary by Engineer.

Butterfly valve / dismantling joint components shall be subjected to non-destructive testing as per relevant standards. Prior to testing, the test procedures and repair procedure shall be submitted for the Employer/ Engineer's approval. All components subjected to testing shall be fully identified and only those which are successfully tested shall be used for the manufacture of the final product. All test results shall be submitted for the Employer/ Engineer's approval.

Inspection and tests on various components of Valve & Accessories :

S.No	Type of Test Witness	Mills Test Certificate (Material Traceability Report)
1. Valve and Flanges: Components		
A	Mechanical and Chemical tests of shafts, seat ring, clamping ring, body, disc, flange and other components	Review of Mills Test certificates and correlation with the material
B	UT & DP of Shaft, UT of plates for body and fillet welds, UT for disc	Mill Test Certificates
C	Air Seal test (Air Release Valve)	Mill Test Certificates
D	Hydrostatic test on body, disc and seat	Witness (CHP)
E	Performance test with actual Power Pack	Witness (CHP)
2. Oil Pressure Unit		
A	Performance test	Witness (CHP)
B	Pressure test at 1.5 times the design pressure for all valves, piping, fittings etc.	Witness (CHP)
C	Functional test for control valves, relief valves, pressure switches, float switch, electrical circuits and other instruments etc.	Witness (CHP)
3. **Tests – Common for all the equipment**:		
A	Mechanical and chemical properties	Review of Mills test certificates and correlation with the material

B	Dimensional check	Witness
C	100% MPI / DP on all fillet joints	Test Certificates
D	100% DP test on welded parts	Test Certificates
E	100% Radiography on welds for flanges fabricated from segments	Witness
F	100% Radiography on all Longitudinal joints as well as all Tee joints of butt welding for Main Valve Body, Disc, Upstream & Downstream Pipes (both for Shop & Site)	Witness

Notes:

1. Post weld heat treatment shall be carried out. QAP and testing plan shall be furnished by the Contractor for review/approval by the Employer / Engineer.
2. Prior to dismantling, each assembly shall be permanently and clearly matchmarked in the shop to facilitate site erection. Dismantling shall be done only to the point required for shipping. In particular, there shall be minimum disconnection of electrical wiring.
3. CHP: "Customer Hold Point"

2.11.6. Test Report

After each test, a report shall be produced by the Contractor and transmitted to Employer for approval. Employer reserves the right to demand modifications to the values and a new series of tests without any extra charge.

2.12. Material Of Construction Standards & Codes

Valve Component	**Material**
Valve Body	Carbon Steel confirming to ASTM A537 class II or A516 Gr. 70/ ASTM A216 or IS:2062 Grade E250BR
Valve Disc	Carbon Steel confirming to ASTM A537 class II or A516 Gr. 70/ ASTM A216 or IS:2062 Grade E250BR
Valve Shaft	Forged Steel BS 29/EN9

Sleeves for Shaft (as per manufacturer std)	Hardened Stainless Steel ASTM A 743 Gr. 6 NM or CA15
Maintenance Seal	Nitrile rubber of shore hardness 75^0 A
Service Seal	EDPM rubber of shore hardness 75^0 A
Seal "O" ring	Nitrile rubber of shore hardness 75^0 A
Seal Retaining ring	SS 410
Retaining Ring (Segments are not permissible)	AISI 316
Body Seat ring	SS 410
Companion Flanges	Carbon Steel confirming to ASTM A537 class II or A516 Gr. 70/ ASTM A216 or IS:2062 Grade E250BR
U/s. & D/s. Pipe Piece	Carbon Steel confirming to ASTM A537 class II or A516 Gr. 70/ ASTM A216 or IS:2062 Grade E250BR
Flange Nuts & Bolts for Valve (Body)	High Tensile Steel SS IS: 1367 CL 12/BS:970 817
Nuts & Bolts for (By-pass Piping)	A 193 Grade B7 / 194 Gr 2H
Bypass Gate Valve & Needle Valve	Cast Steel ASTM A 216 Gr. WCB with SS trims
Bypass piping	Seamless Carbon Steel ASTM A 106
Flanges for Bypass piping	Carbon Steel ASTM A 105

2.13. Power And Control Supply

The Employer shall provide the following at the Power House:

- 415/240 V AC distribution board.
- The 230 V AC UPS System along with auxiliaries for essential loads such as the SCADA module racks.
- 24 V DC Battery Charger, Battery and with DC distribution board.
- The lighting, welding and utility receptacles.
- Cables trays, racks, supports and necessary hardware;
- Earthing System.

The Contractor shall provide the following:

- 240 V AC feeder cable between the 230 V AC UPS distribution and the control cabinet.
- 415 V AC feeder cable from the 415 V AC distribution board and the hydraulic motor Starters/MCC.
- All the necessary control cabling between the valve and the associated control cabinet and SCADA I/O Panels.
- Drawing 24 V DC power supply from Employer's Board for feeding of the SCADA input and output modules.
- The 24 V DC distribution shall be through terminal blocks and rail mounted breakers inside of the valve control cabinet.
- Cabling between MCC/Starters to electrical devices and equipment.
- Welding Socket.
- Earthing System for individual components.

2.14. Surface Preparation & Painting

All un-machined surfaces of ferrous material shall be thoroughly cleaned to base metal by sand blasting or wire brushes to remove all loose scale, grit, dust etc. prior to it painting. The painting shall consist of two coats of epoxy primer with a minimum DFT of 80 microns followed by two coats of coal tar epoxy enamel having a minimum DFT of 100microns on the inside water passage surface.

The external surface of the servomotor and the un-machined surface of the Valve shall be cleaned by sand blasting or with wire brushes to base metal to remove all loose scale and then be painted. The surface shall be applied with two coats of epoxy primer followed by at least two coats of epoxy paint.

The surface preparation of steel surface for painting shall conform to IS:9954-1981(Reaffirmed 1995).The epoxy primer shall conform to IS 14506:1998. The surface paint shall be Light grey in colour conforming to paint no.631 of IS 5: 1994. The epoxy enamel shall confirm to IS 14209:1994.

2.15. Installation Of The Valves

Erection, testing & commissioning of the Butterfly Valve is included in the Contractor's Scope of Supply.

All necessary bolts, studs, nuts, washers and gaskets associated with the upstream and downstream transition sections shall be provided by the Contractor.

2.16. Drawings And Calculations

The Contractor shall provide its drawings in conjunction with calculations as well as references, showing the detailed design of butterfly valve and auxiliaries as required by Engineer for review/approval.

In particular, the following calculations/details shall be submitted regarding:

- Analysis of all loading conditions for stresses in the valve components including FEM analysis
- Calculation of the foundation loads.
- Torque Calculation & Shaft sizing
- Sizing of the hydraulic operating system, including servomotor and Counter weight
- Selection of anti vacuum valve, air release valve, needle valve
- Curves for: opening & closing torque Vs disk angle; head loss Vs disk angle; flow coefficient Vs disk angle

Tenderer shall also furnish the details/write-up/catalogue of expansion cum dismantling joints, seal arrangement, latch mechanism, typical quality assurance program, GA/installation drawings, OPU drawings etc, along with bid.

All the above information is mandatory, and bids without these shall be rejected. Further, during detail engineering all above drawings/documents shall be approved / reviewed by the Employer.

2.17. Safety Mechanisms

Safety mechanisms shall be designed to protect personnel engaged in inspection or maintenance work, especially from the hazard of replacing the working seal from downstream side. Type of locking mechanism shall be mechanical toggle latch or approved equivalent.

2.18. Vibration

Under opening, closure and transient conditions, no detrimental vibrations shall be induced in the equipment and its related mechanisms including the piping. The valve shall be designed to operate under vibrations and noise free conditions.

2.19. Packing & Handling

Each valve shall be provided with lifting lugs for lifting / handling. Supporting legs with suitable fixing arrangement shall be provided so that it can be conveniently supported.

Piping shall be protected for shipment by wooden protectors on all flanges, screwed caps on threaded ends and wooden plugs in plain ends. The piping shall be shop fabricated to the maximum extent possible consistent with erection, handling and shipping requirements so as to reduce field work to a minimum.

2.20. Wiring

All internal electrical wiring for the hydraulic control cabinet and valve control panel shall be completed in the shop and shall be neatly arranged and terminated so that all external connections will be made at a terminal box. All wiring shall be color coded, supplied with markers and suitably numbered for identifications. All wiring shall be neatly formed into flat or rectangular wiring groups and shall be properly supported. There shall be no splices in the wire and all connections shall be taken to prevent cutting into conductors where insulators are removed. For more details, refer to General Technical Requirements.

2.21. Special Tools & Maintenance Equipment, Including Dismantling & Erection

The Contractor shall supply one (1) set of special tools and tackles required for maintenance of the Butterfly valve for handing over to the Employer. The list of such tools shall be specified in the bid and the price shall be indicated in the price schedules. These tools and tackles shall not be used during the erection of the valves and the Contractor shall supply a separate set of tools and tackles for erection and commissioning works. The same may be taken back by the Contractor after the erection and commissioning of the equipment. All necessary instrumentation and measuring devices required during erection shall be supplied by the Contractor. For more details, refer to General Technical Requirements.

Special tools and tackles should include Hydraulic Bolt Tensioner.

2.22. Drawings/Documents For Main Inlet Valve

The major drawings/documents to be furnished after award of contract shall include, but not limited to the following:

- MIV - GA & Foundation Drawing
- MIV – P & I diagram
- Servomotor - GA & Foundation Drawing

- Inlet Pipe – GA Details
- Outlet Pipe – GA Details
- Bypass Piping & Valves - GA Details.
- Operation Procedure.
- Mechanical Design Calculations (FEM) - Valve body, Rotor, and Trunnions, Service Seal & Maintenance Seal.
- Sizing Calculation - Servomotor and Actuating Mechanism.
- MIV - Foundation load Calculations.
- Hydraulic Pipe & Connector - Details
- Hydraulic & Control Panel of MIV – GA Details.
- Hydraulic & Control Panel of MIV – Power & Control wiring diagram.
- Tools, Tackles and Erection Devices.
- Test Equipment for MIV.
- Quality Assurance Plan – MIV, OPU, Control Panel etc.
- Testing & Commissioning Procedures – MIV, OPU, Control Panel etc.

2.23. Mandatory Spare Parts

The following spare parts shall be included in the supply:

S. No.	Description	Type/size	Quantity
1. MAIN INLET BUTTERFLY VALVE			
1	Disc Seals of synthetic Nitrile rubber each for Service Seal and Maintenance Seal.		1 set
2	Clamping Ring/Retaining Ring of each type for the Valve Seal (with Ring Bolts)		1 set
3	Trunnion Bearings		1 set
4	All Packing, Seals etc. for Trunnion Bearings		1 set
5	All Packing, Seals etc. for Servomotors		1 set
6	All Packing, Seals etc. for Bypass Valve		1 set
7	Piston Rings and Bushings for Hydraulic Servomotors		1 set
8	'O' Ring (Nitrile rubber) of Shaft Pin		1 no.
9	Seals ('O' Ring) for Gate	each type/size	2 sets

	Valves		
10	Spares for Air Release Valve		1 set
11	Spares for Anti Vacuum Valve		1 set
12	Spares for Needle Valve		1 set
13	Limit Switch	each type/size	2 nos.
14	Proximity Switch	each type/size	2 nos.
15	Auxiliary Relays/ Contacts (ABB Make)	each type/size	2 nos.
16	Timers	each type/size	2 nos.
17	Power Contactors with Overload Relays		1 Set

The spare parts mentioned here are meant for use by the Employer for 5 years trouble free operation and shall not be used as erection spares required during installation. All the spare parts shall be interchangeable and shall be of the same material and workmanship as corresponding parts of the main equipment.

If any additional spare parts required for a 5-year operation period are recommended by Contractor, these shall be listed and the unit price shall be quoted in the Price Schedule. The Employer reserves the right to order any or all of such spares within 12 months from commissioning.

2.24. O & M Manuals

The Contractor shall furnish to the Employer, 4 (four) sets of operational and maintenance manual (O&M manual) for review/approval. After approval (incorporating the Employer comments) the, Contractor shall submit 12 (twelve) sets of the final O&M manual.

2.25. As-Built Drawings

The contractor shall furnish four (4) sets of MIV Drawings for approval. After approval and after work completion at site, six (6) sets of As-built drawings and one (1) set of electronic versions as a CD shall be supplied.

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3. FIRE PROTECTION SYSTEM

3.1. Scope

This specification includes Design, manufacture, assembly, testing at manufacturers works including type tests, packing, transport, delivery at project site, receipt and storage at site, site assembly, erection, testing, commissioning, trial operation, acceptance testing of the following equipment along with mandatory spares for 5 years trouble free operation, special tools etc.

The scope of the Contractor includes complete design of the system for above meeting the code requirements, covering the entire plant including the Powerhouse and switchyard.

Further, scope also includes preparation of "as built" drawings, instruction manuals, training of Purchaser personnel, assistance to Purchaser for preparation of necessary documentations & procedures for taking necessary insurance for the project (powerhouse complex) against fire risk. All the required accessories, documents & items whether specified herein or not shall be in the scope of Contractor.

Contractor shall supply and guarantee the equipment and services for the Fire Protection System, but not limited to, the following:

Fire Protection System:

a. Hydrant System
b. High Velocity Water (HVW) Spray System
c. Portable Fire Extinguishers
d. Fire Detection System
e. Manual Call Point (MCP)
f. Sign Boards
g. Piping, Pumps and control instruments

3.2. Standards and Codes

The Fire detection alarm and protection system shall comply with all applicable Indian/US codes including the following:

- Tariff Advisory Committee Manual (TAC)
- National Fire Protection Association (NFPA)

3.3. Fire Alarm and Annunciation System

Minimum number of Fire Detectors to be provided:

S. No.	Location	Smoke Detector- Photoelectric	Multi Sensor	Response Indicator	Heat Detector
1	Control Room	1	2	3	-
2	Incharge Room	-	1	-	-
3	Battery Room area	-	-	-	2
4	Electrical Room	2	2	-	-
5	Electrical Workshop	-	1	-	-
6	Mechanical Workshop	-	1	-	-
7	Cable Spreader Room	2	2	-	1
8	Toilets	-	3	-	-
9	Machine Floor	4	4	-	-
	Total	**9**	**16**	**3**	**3**

An automatic fire detection and alarm system with addressable Multisensors & Photoelectric type Smoke Detectors & Heat Detectors shall be provided for Electrical Room, Control Room, Offices, other miscellaneous Rooms to give audio & visual indication of fire in these areas. Manual Call Points (MCP) & Exit Signs shall be provided near each escape. The annunciation system shall operate at 110V DC. Fire detection and annunciation panel shall be housed in the Control Room.

3.4. Fire Extinguishers:

Minimum number of Fire Extinguishers to be supplied:

S. No.	Type	Qty
1	Wheeled Portable Foam Type fire extinguishing units (50 litre)	3 nos.
2	Foam Extinguishers (9 litre)	5 nos.
3	Wall mounted Portable Dry Chemical Power (DCP)- 5 kg	5 nos.

4	Wheeled Portable CO2 type units (22.5 litre)	3 nos.
5	CO2 type Fire Extinguisher (9 kg)	8 nos.
6	Pressurised Water Type Fire Extinguisher	8 nos.
7	Sand buckets with stands to meet the requirements of TAC shall be installed for the Powerhouse. The Bidder to indicate the number, sizes and locations of these extinguishers.	1 lot

3.5. DESIGN & CONSTRUCTION

The firefighting system will be designed to provide specified safety condition for equipment and/or personnel continuously during all modes of plant operation.

3.5.1. WATER SUPPLY SYSTEM FOR FIRE PROTECTION

Water for Hydrant & HVW Spray systems shall be supplied from two sources. The main water supply shall be from the gravity Fire Water Tank located at suitable elevation. The secondary (backup) water supply shall be provided directly from tailrace.

The gravity Fire Water Tank located outside near the surge shaft area shall be filled by two Fire water make-up pumps (1 working + 1 standby) installed in the Tail Race and Automatic Motorised Strainer (1 working + 1 standby).

Operation of all the Firewater make-up pumps shall be manual and the operation of pumps will depend on the water demand and signal from the level switch indicator connected with fire water tank. Manual start/stop provision shall be provided in local control panel.
Design, construction, erection, testing and trial operation of pumps, piping, valves, strainers, hydrant valves, hoses, nozzles, branch pipes, hose boxes, expansion joints etc shall conform to the requirements of the system.

3.5.2. HYDRANT SYSTEM

Hydrant system of fire protection essentially consists of a large network of piping, which feeds pressurized water to a number of hydrant valves, (Single Hydrant and double headed Hydrant). These hydrant valves are located throughout the Powerhouse and Transformer area at strategic locations. Hoses of suitable length to fit with standard accessories like branch pipes, nozzles etc. shall be kept in Hose boxes. In case of emergency, these hoses shall be coupled to the respective hydrant valves through instantaneous couplings and jet of water is directed on the equipment on fire.

The Hydrant system shall be designed such that entire powerhouse complex is effectively covered. Hydrant ring mains shall be provided with isolating valves between various ring mains so that ring mains can be interconnected and water from any of the ring main can flow to other mains. The isolation valves provided at suitable locations shall be such that in each of the ring mains/sub loops to enable to take up any part of ring mains for maintenance without any loss of system in the balance part.

Atleast two hydrant valves shall be provided at each floor, one towards service bay side and one towards opposite end. Each hydrant valve shall be accompanied by hose box & branch pipe with hose reel.

The Hydrant system water supply shall be designed to cater the fire water requirement of HVW spray system & Hydrant system. The hydrant system shall be designed to meet the minimum residual pressure requirement of 350 kPa at most remote 38 mm hose connections and of 450 kPa at most remote 65 mm hose connections.

Three connections for fire bridge line (fire tender) as per standard practice with all accessories at following point shall be provided.

- One fire bridge connection for filling of overhead fire protection tank (located outdoor),
- one for connection at service bay and
- one for connection at transformer area.
-

3.5.2.1. HOSE PIPES & NOZZLES

Sufficient length of hose, subject to a minimum of two lengths of 15 m each with coupling attached, shall be provided in case of each internal hydrant point on risers. In addition, one nozzle of 20 mm size fitted to a branch pipe shall also be provided. To avoid water damage, it is advisable to have reinforced rubber lined hoses for use with internal hydrants.

The number of hose pipes near external yard hydrants shall be such that no part of the floor is more than 15 m from a hose is fully extended & connected to hydrants landing valve.

Hoses, nozzles and branch pipes shall be kept adjacent to the hydrant outlet, in wall boxes or recesses in the wall specially designed to blend architecturally with the buildings.

3.5.3. HIGH VELOCITY WATER SPRAY SYSTEM FOR GENERATOR TRANSFORMERS

HVW spray type fire protection system essentially consists of a network of projectors and an array of heat detectors around the equipment to be protected. The high velocity water spray system employs the principle of oil emulsification. Water, when mixed with oil forms an emulsion, which cannot burn. In addition, the fine droplets striking the hot surface absorb the heat and impart cooling and smothering effect thereby extinguishing fire.

Automatic HVW spray system shall be provided with two (2) separate piping networks. One, a detection pipe network over the protected equipment with quartozoid bulb (QB) detectors located at strategic points. Other will be the water piping network spread over the protected equipment, provided with water spray nozzles located at suitable points to spray water on to the equipment in case of fire. Both these piping shall end at the deluge valve (DV) provided for each equipment. Water supply up to Deluge Valves shall be provided through FW pipe work.

On operation of at least two heat detectors, water under pressure is directed to the projector network through a Deluge Valve (DV) from the pipe network laid for this system.

At the inlet and detection pipe of the DV, two Pressure Indicators, allow the local verification of the pressure level. At the discharge and the detection pipe of each DV, two pressure logical sensor (Pressure Switch), senses the hydraulic pressure and indicates that the "Spray system has operated" and "the equipment is on fire" respectively. These are connected to Fire Alarm Panel.

The system shall be designed to protect all the Transformers and the additional Spare Transformer, if any. However, for the purpose of design it shall be assumed that only one Transformer will be on fire at one time. The system shall be designed for a water density of 10.2 L/min per square meter over the fire area of Transformer

The Electrical clearance between the Emulsifier system pipe work and live parts of the protected equipment shall as per NFPA recommendations.

3.5.3.1. DELUGE VALVE

Each Deluge Valve shall be provided with a water motor gong which shall sound an alarm when water after passing through the Deluge Valve, is tapped through the water motor and suitable strainer.

Each Deluge Valve shall be provided with a local panel, which will enable manual or automatic operation of the valve. In addition to this, each valve shall be provided with local operation latch.

Test valves shall simulate the operation of Deluge Valves and shall be of quick opening type.

3.5.3.2. HIGH VELOCITY SPRAY NOZZLES (PROJECTORS)

High velocity spray system shall be designed and installed to discharge water in the form of a conical spray consisting of droplets of water traveling at high velocity, which shall strike the burning surface with sufficient impact to ensure the formation of an emulsion. At the same time the spray shall efficiently cut off oxygen supply and provide sufficient cooling. The projector shall not be less than 6 mm orifice in size.

Minimum set point of the heat detectors used in the HVW spray system shall be 79ºC. The optimum rating shall, however, be selected by Contractor, taking into account the maximum and minimum temperatures attained at site.

3.6. Construction

The installation of the Firefighting equipment is in the Contractor's scope. The fire safety requirements during construction of the facility shall be the responsibility of the individual Contractor on site pertaining to their area of construction activities.

3.7. Test Reports

Individual components shall be tested as per relevant standards and copies of test report submitted for approval.

3.8. Drawings, Data and Technical particulars

Bidder shall submit following drawing & documents along With BID:

1. Proposed scheme for
- Detection and Alarm System

1. Bill of materials
2. Technical particulars
3. Sample format of Quality Assurance Plan.

The Contractor shall submit following drawing & documents for approval during detailed engineering:

1. Schematic Diagram of Fire Detection System
2. Powerhouse GA locating Fire Extinguishing units.
3. Powerhouse GA locating Fire Detectors
4. Powerhouse GA locating NIFPES units.
5. Technical data & Brochure of major equipment
6. Test Reports
7. Quality Assurance Plan (QAP).

On Completion the Contractor shall submit following drawing & documents

1. As built drawings
2. Manuals for Installation, Operation and Maintenance

3.9. Spares

The Bidder shall include in the Bid spares necessary for trouble free operation of the system for 5 years.

S. No.	Description	Quantity
A)	**FIRE DETECTION SYSTEM**	
1.	Multi-Sensor Smoke Detectors	2 nos.
2.	Photoelectric type Smoke Detectors	2 nos.
3.	Heat Detector	1 no.
4.	Response Indicator	1no.

The spare parts mentioned here are meant for use by the Employer for five (5) years trouble free operation and shall not be used as erection spares required during installation. All the spare parts shall be interchangeable and shall be of the same material and workmanship as corresponding parts of the main equipment.

If any additional spare parts required for a 5-year operation period are recommended by the Contractor, these shall be listed, and the unit price shall be quoted in the Price Schedule. The Employer reserves the right to order any or all of such spares, within 12 months after commissioning.

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4. HEATING, VENTILATION & AIR-CONDITIONING (HVAC) SYSTEM

4.1. SCOPE OF WORK AND GENERAL REQUIREMENTS

The scope of work under this specification shall consist of the design, engineering, manufacturing, shop test, supply, loading at manufacturer's works, transportation & delivery of various items along with their spares to the project site, storage at site, erection and commissioning of the complete Heating Ventilation & Air-Conditioning System (HVAC) system of the Powerhouse.

The Contractor shall supply and guarantee the equipment, materials and services for the HVAC System, but not limited to the following:

- Forced Ventilation System using Wall-mounted supply fans with washable filters
- Hot Air Exhaust Fans/System.
- Ductwork, Insulation, Fittings, Accessories, all types of Supports etc.
- Split type Air-Conditioners.
- Electrical Cabling / Wiring.
- Control & Instrumentations.

The system design shall be based on but not limited to criteria, factors and details outlined subsequently. Other items not specified above but necessary to complete the system in all respect shall be in the scope of the Tenderer.

The Tenderer shall prepare his own P&I Diagram indicating the proposed systems. The Powerhouse layout & sectional drawings are enclosed with the specifications to enable the Tenderer to estimate the quantities & submit his Bid accordingly.

Equipment shall conform in all respects to high standards of engineering, design and workmanship and comply with American Society for Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) norms. The equipment offered shall comply with the relevant International Standards.

Ambient high temperature for design of all equipment shall be considered as 40ºC. Ambient outside DB temperature range for design of the systems shall be considered as 12ºC to 35ºC.

4.1.1. Main Equipment

S. No.	System	Location	Equipment	Capacity / Size	Total Pr. (Pa) Tentative	Qty. nos.	Approx Motor kW(each unit)
1	Ducting		GI Sheet with Zinc coating of not less than 275 g/m^2 as per IS-277 and of min 20G thickness. (No insulation & cladding required)	-	-	1 Lot	-
2	Exhaust Fan	Below Roof Truss Level	Propeller Exhaust Air Fan complete with angular rain cowl & bird screen	10,000 m^3/hr (Ø 610 mm)	FAD*	8 nos.	500 W/6P/ 3 phase
3	Exhaust Fan	Battery Room	Tube Axial Exhaust Air Fan (epoxy painted & spark proof construction with explosion proof motor) complete with angular rain cowl & SS bird screen	4,400 m^3/hr (Ø 480 mm)	150	2 nos.	370 W/4P/ 3 phase

4	Exhaust Fan	Store Room	Propeller Exhaust Air Fan complete with angular rain cowl & SS bird screen	4,300 m^3/hr (Ø 450 mm)	FAD	1 no.	132 W/6P/ 3 phase
5	Exhaust Fan	Mechanical Workshop	Propeller Exhaust Air Fan complete with angular rain cowl & SS bird screen	4,300 m^3/hr (Ø 450 mm)	FAD	2 nos.	132 W/6P/ 3 phase
6	Exhaust Fan	Electrical Workshop	Propeller Exhaust Air Fan complete with angular rain cowl & SS bird screen	4,300 m^3/hr (Ø 450 mm)	FAD	1 no.	132 W/6P/ 3 phase
7	Exhaust Fan	Pantry	Propeller Exhaust Air Fan complete with angular rain cowl & bird screen	~1,000 m^3/hr	FAD	1 no.	--
8	Exhaust Fan	Toilets	Propeller Exhaust Air Fans complete with gravity louvers (Deluxe model)	~1,000 m^3/hr	FAD	3 nos.	--
9	Air Conditioner (Rating 3 Stars min.)	Control Room	Split A/C with Scroll /Screw Compressor	2 TR	-	4 nos.	2.4 kW
10	Air Conditioner (Rating 3 Stars min.)	Office	Split A/C with Scroll /Screw Compressor	1.5 TR	-	1no.	1.8 kW

11	Miscellaneous Items		Hangers, Supports, Hardware, Inserts etc	-	-	1 Lot	-

Notes –

1. FAD – Free Air Delivery.
2. The Motor Control Centre (MCC) and Local Control Panel (LCP), Power & Control Cabling and other miscellaneous items shall form part of the Tenderer's scope.
3. All capacities are Indicative/Tentative & Tenderer shall make their own design & submit it along with the bid.

4.1.2. Auxiliary System and Miscellaneous Items

1. Air duct distribution system for supply of all HVAC systems, with necessary galvanized sheet metal ducts, elbows, tees, supports, fixations, including all necessary grilles, louvers, outside air louvers, adjusting duct dampers, motorizing air dampers, fire dampers, heating and cooling insulations (as required), etc.

2. Necessary Thermostats, Humidity Sensors, Temperature Gauges, Flow Switches etc., as required for satisfactory operation of system.
3. Any additional Fans and other items/ equipment felt necessary during detailed engineering.
4. Special Tools & Instruments, as required.

4.2. SYSTEM DESCRIPTION

4.2.1. Operation Logic of Ventilation System

4.2.1.1. POWERHOUSE VENTILATION

The Forced Ventilation System using Wall-mounted supply fans with washable filters shall supply outdoor air to Machine Hall/Generator Floor, Turbine Floor, MIV Floor areas etc.

4.2.2. Control, Monitoring and Related Items & Services

1. Following fault / indication shall be shown in the Central Control Panel of Powerhouse located in the Control Room.
   - Temperature indication through set of Sensing & Transmitter of Control Room, Electric Room, MIV Floor etc.

The Contractor shall furnish I/O list.

4.3. SPECIFIC PARAMETER AND LAYOUT CONDITIONS

4.3.1. Layout and General Arrangement

The Powerhouse may be divided into individual areas for sake of convenience of operation and maintainability of temperature. HVAC Flow diagram indicating such type of arrangement for guidance of the Tenderer is enclosed, Refer Drg no 1389-MT-3205.

4.3.2. Fire Safety

The Contractor shall coordinate with the firefighting system Contractor for designing the ventilation system by providing necessary fire dampers to stop the supply of air to the affected area and to evacuate smoke and toxic particles from the place of origin to the outdoors in a manner that does not interfere with the operation of plant and to allow for emergency access and egress. The “Fire & Smoke Acting Dampers” shall be provided by the Contractor in the Vertical/Horizontal supply air duct at crossing of each floor/area, as applicable.

4.3.3. Air Changes per hour

All ventilated and air-conditioned areas shall be designed to maintain a positive pressure within the Powerhouse. The minimum number of Air changes shall be in accordance to Table given below/ International Standard applicable for Surface Hydel Power Station, whichever is stringent, shall be applicable for this Powerhouse.

S.No	**Area**	**Outside air change per hour-minimum (consider room height as 3.6 m)**	**Recirculated air change per hour- minimum**
1	MIV Floor	1	4
2	Turbine Floor	1	4
3	Generator Floor	1	4
4	Machine Hall	1	4
5	Service Bay	1	4

Notes:

1) Max. Temperature in the various ventilated areas shall not exceed 35ºC.

4.3.4. Noise Levels

The noise level when measured at 1.5 m from source, caused by operation of the HVAC systems shall not exceed:

- 45 dB (A) in rooms such as Control room and 65 dB (A) in other areas,
- 85 dB (A) for equipments such as Motors, Fans, etc.,
- Acoustic Insulation inside supply air duct after Silencer, as required, shall be provided to guarantee the above-mentioned sound levels.

4.3.5. Air Velocities in Ducts

- In main ducts 6-10 m/sec
- In branch ducts 4-8 m/sec
- In Air Grilles 4-6 m/sec

4.3.6. System Design

Type of Ventilation & Air-Conditioning Systems:

S. No.	Location	Type of Ventilation
1	Machine Hall Floor/ Generator Floor	Forced Air/ Exhaust Ventilation
2	Turbine Floor	Forced Supply Air Ventilation
3	MIV Floor	Forced Supply Air Ventilation
4	Battery & Battery Charger Room	Exhaust Ventilation
5	Control Room	Air-conditioning with Temperature control of 22 ± 2 ^{0}C
6	Office	Air-conditioning with Temperature control of 24 ± 2 ^{0}C
7	Mechanical & Electrical Workshops/ Store/Pantry	Exhaust Ventilation
8	Toilets	Exhaust Ventilation

4.4. MANDATORY SPARE PARTS

Mandatory spare parts to be supplied under this section are as follows:

S. No.	Description	Quantity
1	Air Filter - Bag type	3 sets of total installed quantity
2	V-belts	2 sets of total installed quantity
3	Motor set of Air Handling Unit Fan	1 no. of each size
4	Circuit Breakers & Contactors for Motor Starter Panels	1 no. for Fans etc.

The spare parts mentioned here are meant for use by the Employer for 5 years trouble-free operation and shall not be used as erection spares required during installation. All the spare parts shall be interchangeable and shall be of the same material and workmanship as corresponding parts of the main equipment.

If any additional spare parts required for a 5-year operation period are recommended by the Contractor, these shall be listed, and the unit price shall be quoted in the Price schedule. The Employer reserved the right to order any or all of such spares within 12 months after commissioning.

4.5. CODES AND STANDARDS

The following codes or equivalent International Standards shall be followed for various equipments / services:

Code No.	Code Name
IS: 277	Galvanized Steel Sheets
IS: 325	Induction Motors
IS: 655	Air Ducts - Specification
IS: 659	Safety Code for Air Conditioning
IS: 661	Thermal Insulation for Cold Storage
IS: 900	Induction Motor Installation and Maintenance Code of Practice.
IS: 1239 (Part I and II)	Specification for Mild Steel Tubes, Tubulars, and other Wrought Steel Fittings.
IS: 1545	Specification for Solid Drawn Copper Alloy Tubes for Condensers and Heat Exchangers.
IS: 1885	Switchgear and Control gear.

IS:2312	type AC Ventilating Fans Propeller
IS: 2831	Methods of Test of Air Filters used in Air Conditioning and General Ventilation.
IS: 3103	Code of Practice for Industrial Ventilation
IS: 3588	Axial Flow Fans
IS: 3589	Steel Pipe Specification
IS : 3624	Specification for Pressure and Vacuum Gauges.
IS: 4671	Expanded Polystrene for Thermal Insulation purpose.
IS: 4720	Code of Practice for Ventilation of Surface Hydel Power Stations
IS: 4894	Centrifugal Fans
ASHRAE	American Society of Heating, Refrigeration and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ANSI	American National Standards Institute
ISA	Instrument Society of America
SMACNA	Sheet Metal and Air-Conditioning Contractors National Association
NFPA	National Fire Protection Association
AWS	American Welding Society
ACGIH	Industrial Ventilation- American Conference of Governmental Industrial Hygienists

4.6. EQUIPMENT CONSTRUCTION

Equipment construction described hereunder shall be applicable only for the equipment required/proposed.

4.6.1. Centrifugal Fan

Centrifugal Fans shall be of Double Inlet Double Width (DIDW) type with backward curved blades, designed for continuous operation. All Fans shall be of low speed & AMCA-II rating. They shall be constructed of heavy gauge hot dip/spray galvanized sheet steel. They shall be designed for continuous operation at the maximum rated fan speed and motor horsepower. Airfoil design shall have blades of double thickness.

Fan wheel and shaft shall be selected with maximum operating speed 25% below the first critical and shall be statically and dynamically balanced.

Motor (Variable Speed Drive) shall be of high efficiency, totally enclosed fan cooled NEMA Design B with size, electrical characteristics and protection class as specified. All motors shall have a ±10% voltage utilization range and a margin of 15% over the required BkW. Motor shall be compliant with EPACT wherever applicable.

- Performance Ratings: Fan performance shall be rated and certified in accordance with ARI standard 430.
- Sound Ratings: Manufacturer shall furnish first through eighth octave sound power for fan discharge and casing radiated sound.
- Mounting: Fan scroll, wheel, shaft, bearing, drives, and motor shall be mounted on a common base assembly which shall be isolated from the outer casing with factory-installed 50 mm. deflection spring isolators and vibration absorbent flexible connections at Fan's inlet & discharge.

4.6.2. Ducting for Supply & Return Air

4.6.2.1. DESIGN

The proposed routing and sizes of the complete duct work shall be based on space constraints due to layout of other equipments.

The air ducts shall be securely fixed to structural elements and shall be vibration-free.

Air duct elbows shall be fabricated from galvanized steel with a bend radius of 1-2 times air duct equipment diameter. The air ducts that are to be embedded in concrete shall be fabricated from steel pipes of medium duty.

All items such as angle iron, clamps, fixtures, and hangers etc. to be used for duct supports shall be included in the offer.

4.6.2.2. SHEET THICKNESS

The sheet thickness shall not be less than the thickness indicated in the following table, depending on the length of the longer side of the duct:

- From 150 mm to 500mm 0.63 mm
- From 501 mm to 750mm 0.80 mm
- From 751 mm to 1000mm 0.80 mm
- From 1001 mm to 1250 mm 1.00 mm
- Over 1250 mm 1.25 mm

- For Smoke Exhaust (MS) min. 2 mm
    - (Epoxy Painted both inside & outside)

The cylindrical Spiral Ducts shall have the following thickness:

- Up to 300 mm 0.63 mm
- From 301 mm to 600 mm 0.63 mm
- From 601 mm to 750 mm 0.63 mm
- From 751 mm to 1000 mm 0.80 mm
- From 1001 mm to 1500 mm 0.80 mm
- From 1501 mm to 2250 mm 1.00 mm
- Over 2250 mm 1.25 mm

The seams on duct may be grooved longitudinal seam or continuous welded. Ducts are to be joined with hot dip galvanized nuts and bolts and felt of uniform thickness and width shall be used for sealing the flanged joints.

If necessary, the rectangular elbows shall be equipped with aerodynamically formed guiding vanes. All take-off branches shall be equipped with an adjustable volume extractor, which assists in balancing.

Other features of Ducts not described herein shall be as per equivalent International Standard.

The supply & exhaust air ducts installed in the fire hazardous areas shall be covered with a suitable thickness of fire-resistant board (e.g. calcium silicate board) to withstand damage due to fire for a period of minimum sixty (60) minutes.

4.6.2.3. MAXIMUM DUCT LEAKAGE

Inside the ventilation rooms, duct air leakages for each of the system shall not be greater than ½% of the total air flow indicated at the fan's discharge. In general, for each ventilation network, duct air leakages or increases shall not be greater than 5% of the indicated air flow.

All radius 90□ elbows shall be made with single thickness turning vanes.

4.6.2.4. MATERIAL REQUIREMENTS

The rolled steel before galvanising shall be properly annealed or normalised so as to allow fabrication of ducts without developing cracks and zinc coating on the steel shall not be less than 275 gms/sq.m, conforming to international standard.

The aluminium sheets shall be of grade SIC or NS3 and shall be suitable for grilles / duct fabrication work, conforming to international standards.

4.6.2.5. HANGERS AND SUPPORTS

The duct supports shall be at a distance of not more than 1500 mm or as indicated in the specific action drawings. Wherever the ducts are thermally insulated, the MS angles and supports shall not be in direct contact with ducts. The ducting shall be supported from ceiling/side wall by Friction grip bolts as no inserts are available.

Strap hangers shall be with duct sizes not greater than 400 mm, of the same material as the one used for the duct but with a heavier gauge. Larger ducts shall be carried by structural angles, hanging in rods with adjustable nuts.

Unless otherwise indicated, all ducts connected to masonry shall be fastened with a continuous frame made of 40 x 40 x 5 mm galvanized steel angles.

Angles, Rods and all supporting hardware for support shall be made of hot dip galvanised steel and be conforming to the indications of the following table:

Angle (mm)	**Rod Dia (mm)**
25 x 25 x 3	6
40 x 40 x 3	10
50 x 50 x 5	10

4.6.2.6. FLEXIBLE DUCTWORK

Unless otherwise indicated on drawings, flexible ducts may be used of length not greater than 1800 mm to connect diffusers/ grilles in suspended ceiling.

Flexible duct shall be made of aluminium with 25 mm of factory applied flexible glass fibre thermal insulation, vapour barrior and vinyl or aluminium jacket.

4.6.2.7. ACOUSTIC LINING

Wherever it is essential to reduce the noise level of the fans to a comfortable limit, the ducts shall be acoustically lined.

A noise level of less than 85 dB (A) shall be allowable inside the blower rooms measured at a distance of 1 m from the unit, not more than 45 dB (A) in Control Rooms and not more than 65 dB (A) in all other rooms. Silencer as required shall be provided by the Contractor to guarantee these values.

4.6.2.8. INSULATION FOR DUCTWORK / PIPING

The insulating material & protective covering shall be non-corrosive, vermin proof and shall be guaranteed to withstand continuously and without deterioration, the maximum/minimum temperature to which they may be subjected to. All cold supply air ducts shall be completely insulated with a minimum of 12 mm thick glass wool to prevent condensation and finished with aluminium cladding.

Alternatively, Insulation shall be of Nitrile Rubber, aluminium foil faced of min. density of 40 kg/m2, while its thickness shall not be less than 12 mm for ducts & 25 mm for piping.

4.6.2.9. OUTSIDE AIR LOUVER

Outside Air Louvers of each of the fresh air and exhaust air systems shall prevent the entrance of rain, insects, birds and trash into the ducts.

They shall be stamped & pressed out of aluminium sheet of at least 2 mm thickness & at least 100 mm deep. Insect/bird screen shall be of SS wires of size 25 x 25 x dia. 1.6 mm.

4.6.2.10. AIR DAMPER

The Air Dampers shall be opposed blade type in order to balance the system. The on/off air dampers shall however be equipped with parallel blades. Every Damper shall be accessible and have position indicating device.

4.6.2.11. MOTORIZED AIR DAMPER

The motorized damper blades either modulating or on/off shall be operated by electrical actuators. The modulating dampers shall be equipped with opposed blades and the on/off dampers with parallel blades. Each Damper shall be provided with limit switches with indicators at local & remote position.

4.6.2.12. FIRE DAMPER

The Fire Damper shall have fire withstanding limit of min. ninety (90) minutes.

The Fire Damper shall be motorized and of "**Fire & Smoke type**" complete with its dedicated Local Control Panel. It shall be located in the ventilating openings of various walls/floors.

The Fire Damper shall be equipped with well designed "Control Panel" operating at 24 V AC and its vanes shall be actuated / closed in two different ways:-

- After getting signal from the Central Fire Detection / Alarm Panel or
- After getting signal from duct mounted smoke detector provided in the Fire Damper's air stream itself.

On actuation / closure of Fire damper in any one of the above modes the related fan shall get switched-off and the actuated / closed position of damper shall be shown in the Control Room.

Reopening of Fire Damper shall be possible only after manually resetting the switch provided on the "Control Panel" of the Fire Damper.

4.6.2.13. AIR GRILLE

The supply air Grilles shall be equipped with 45o horizontal fixed fins. Material shall be powder coated aluminium with high surface finish.

The design / colour shade / size has to fit / match the architectural false ceiling and lighting schemes and have to correspond to the fixed noise criterion and false ceiling panel size.

All supply air Grilles / Diffusers shall be fixed with opposed blade volume control dampers at its back. Bearings shall be of the oil retaining porous bronze type...

4.6.3. Axial / Propeller Fan

The fan casing shall be made of hot dip/spray galvanized steel or aluminium. Anti-vibration mountings shall be provided for each fan. All Axial/Propeller Fans shall have motor rating 20% above the required BkW.

Axial air Fans shall be of multi blade vane type. The hub of the impeller shall be directly coupled to the motor shaft and its diameter adapted to the motor frame. The impeller shall be statically & dynamically balanced. Fan shall be selected for 1000 rpm, as far as possible, in order to have low noise level.

All bearings shall be pre-lubricated, self-aligning and selected for a minimum of 40,000 hours average life at the max. design rating. These shall be designed to operate at their max. rated speed, which is below the first critical speed.

Where the impeller is accessible in operation, guards shall prevent injuries to maintenance personnel. Discharge Cowl with Bird Screen of Stainless-Steel wire (size 50 x 50 x 1.6 mm) to be provided, wherever applicable.

4.6.4. Humidifier

The control Room shall be provided with humidifier, Pan Type steam boiler or Ultrasonic High Frequency Oscillator type, to raise and maintain specified level of indoor Relative Humidity (RH). The Humidifier shall consist of insulated Pan, electrical resistance immersion type tubular heating element, water connection and wiring.

The Pan shall be fabricated from stainless steel (SS) sheet with openable top fastened with SS nuts/bolts and thermally insulated. Accessories shall include float switch for low water level cut-out, float valve with SS Ball, thermostat, sight glass and humidistat for sensing/controlling humidity.

The humidifier shall be provided with 0.5 KW heater with thermostat to maintain water temperature.

4.6.5. Split type Air-Conditioner

The Air-conditioners shall be complete with Scroll/Screw type Compressor and preferably shall have all the latest product features. The air conditioners shall have the highest energy efficiency ratio (EER) and low noise level. Package Air Conditioners shall be water cooled type.

The air conditioners shall be complete with automatic temperature control and cut-in and cut-out etc. and shall be provided with adjustable stepless type thermostat of temperature range 16 oC to 30 oC.

The Filter pads should be washable and readily obtainable in the market.

Each Split type Air Conditioner shall be derated for the ambient temperature of site and shall have individual outdoor condensing unit.

4.7. DRAWINGS, DOCUMENTS AND DESIGN CALCULATIONS

4.7.1. Drawings and Documents alongwith Bid.

The Tenderer shall submit following drawing/documents alongwith the bid:

- Flow diagram.
- Technical data sheets of all main equipments
- Catalogues of proposed main equipments

4.7.2. Drawings and Documents after order

The Contractor shall submit all the drawings and documents in accordance with requirements for review/approval of the Employer/Consultant. The list of documents is as under:

1. Drawing/document list
2. Flow Diagram
3. Design Memorandum
4. Ducting Pressure Loss Calculations
5. Cooing/Heating Load Calculations of Control Room/ Offices
6. Technical Data Sheets of main equipment (Fans, Air Conditioners, Bag Filters, Fire dampers, Insulation etc.)
7. GA of Equipments such as Fans, Air Conditioners
8. Equipment Foundation Details
9. Duct Routing Layout
10. Catalogue of all major equipment (one copy in original)
11. Power & Control Cables diagram
12. GA of Electrical Panels.
13. Control Logic & Diagram
14. Quality Assurance Plan (QAP)

The Contractor shall also provide other related calculations, as required by the Employer/Consultant for approval.

4.8. QUALITY ASSURANCE AND INSPECTION

General

Quality Assurance Plans (QAP) for various major equipment such as Air-Conditioners, Air handling Units, Air Filters, Dampers, Air Grilles, Fire Dampers, Insulation etc., shall be submitted for the Employer/Consultant's approval.

Test Ports

For air-flow measurements at each HVAC system, test ports shall be installed in the following locations:

- At the suction and discharge side of each fan.
- At each branch on the main ducts.
- Anywhere else, required to ensure HVAC systems balancing.

For temperature measurements, test ports shall be installed in the following locations:

- At fresh air intakes.
- At mixing boxes.
- Upstream & downstream of heating & cooling coils.

4.9. STANDARD PERFORMANCE GUARANTEE TEST

The Contractor shall ensure testing and commissioning of the complete ventilation and air conditioning system including start-up equipment, sensors, control cabinets, power and control cables, etc. in conformity with specifications.

The Contractor shall guarantee the reliability and performance of the individual equipment as well as the complete system. The Contractor shall prepare and submit all control schemes and drawings of cable connections.

4.9.1. Standard Performance Guarantee (PG) Test Procedure

Relevant codes & standards and approved drawings/documents shall be applicable for conducting test, unless otherwise modified or supplemented by the procedure mutually agreed to between the Employer and the Contractor.

Test Procedures shall be submitted for review & approval of the Employer/Consultant for all the major equipment/systems.

These tests shall include visual checks, review of test certificates, duct leakage /smoke test, verification of free movements of all equipment, air flow at various outlets, system total pressure, pressure drop across filters, relative humidity in control room, voltage, current, insulation resistance, HV tests on various electrical devices, proper functioning of all instruments, control & protection devices etc.

Tests shall be conducted by accredited representatives of the Contractor and the Employer and record test data jointly.

- The responsibility for conducting the tests lies with the Contractor.
- Any instruments required for the PG test shall be calibrated and provided by the Contractor.
- Replacement of damaged parts during the test shall be the responsibility of the Contractor.

If the results of the test deviate from the design values, the Contractor shall be given the opportunity to modify the equipment as required to enable it to meet the acceptance criteria. In such cases the acceptance test shall be repeated for retest and the cost of modifications, including labour, materials and cost of additional testing shall be borne by the Contractor. The chance for repeat testing shall be given only once during the contract period.

4.10. FINAL ACCEPTANCE (FA) TESTS

General

After site testing has been satisfactorily completed, the final acceptance of the HVAC system/equipment shall be subject to meeting the following criteria:

- Heating, Ventilation and Air conditioning system (including electrical equipments) shall be operative continuously for thirty (30) days after commissioning and prior to handing over to the Employer. During this period there shall be no imbalance, vibration & noise in the system.

4.11. TOOLS & TACKLES

One complete set of tools & tackles required for the system maintenance shall be provided. A list of such tools shall be given in the Bid along with item-wise prices.

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5. ELECTRICALLY OPERATED OVERHEAD TRAVELLING (EOT) CRANE

5.1. Scope

This specification covers the design, manufacture, shop assembly, shop testing, delivery to project site, unloading at site, complete erection, conducting tests at site and commissioning of equipment. The bidder is required to submit offer for the 45/10 ton Pendant Control operated Double Girder Electrically Operated Overhead Travelling EOT of the specification as per the description in the following paragraphs.

5.2. Completeness Of Equipment

All the fittings and accessories of the Powerhouse Crane that might not have been specifically mentioned but are necessary for completion of the equipment shall be deemed to be covered by the specification and shall be furnished by the bidder without any extra charges to the Employer. The main supply of 3 phase 415 V Power supply is intended to be used. The bidder shall obtain 110 V AC supply for indicating and metering purposes with the use of 415 / 110 V control transformer which is also in the scope of the Bidder.

5.3. Deviations From Specifications

All the following data pertinent to technical specification of the EOT is as per the proposed layout of the Powerhouse.

All deviations from the specifications should be separately listed in the absence of which it will be presumed that the provisions of the specifications are complied with by the Bidder.

5.4. Rated Characteristics

The rated parameters of the Cranes are as given in the following table. The “Design & Construction” features described subsequently in this chapter are applicable only for the features specified in the following tables for 45/10 Ton Powerhouse EOT Crane(s) i.e. “Rating & Basic Requirement”.

Powerhouse EOT Crane: Capacity 45/10 T

Sl No	Item	Description			
A)	**General Details**				
1	**Crane to be Installed at**	Powerhouse			
2	**No. of Cranes**	1 No			
3	**Capacity of the Crane-** **Safe working Load**	Main Hoist		Aux. Hoist	
		45 t		10 t	
4	**Type of Crane**	Double Girder Electrically Operated Overhead Travelling (EOT) Crane			
5	**Span** (Centre to Centre of Rails), m	15.0 m			
6	**Longitudinal Travel,** m	53.0 m (Tentative)			
7	**Altitude of the Place**	EL 335.00 m (Service Bay)			
8	**Class of Crane as per IS:3177(1999)**	M3			
9	**Class of Hoists & Travel**	MH (Main Hoist)	AH (Auxiliary Hoist)	CT (Cross Travel)	LT (Longitudinal Travel)
	As per IS:3177(1999)	M3	M5	M5	M5
10	**Standards to which Crane conforms**	As per IS:3177(1999) or Equivalent International Standard			
11	**Operational speeds (loaded)**	MH	AH	CT	LT
a)	**Speed in m/min. (Main Motion)**	1.5	5	10	15
b)	Micro Motion	VVVF Control (Stepless speed increase/ decrease			

		Control through Potentiometer for MH only and three steps (10%, 50% & 100%) for other motions.			
12	**Acceleration values in cm/sec^2**	--	--	7	8
13	**Lift of Crane**	MH		AH	
a)	Maximum lift of hook above Service Bay level	10.0 m		10.0 m	
b)	Maximum drop of hook below Service Bay level	18 m		18 m	
c)	Total Lift	27.0 m		27.0 m	
14	**Terminal position (CT)**	Upstream (U/s)		Downstream (D/s)	
a)	of Main Hook from center of rails	1200 mm		2000 mm	
b)	of the Auxiliary Hook from the center of rails	2200 mm		1000 mm	
15	**Maximum Travel (LT)**	Service Bay (S/B)		Other end	
a)	of the Main Hook from the inner edge of walls	2800 mm (approx.)		2800 mm (approx.)	
b)	of the Auxiliary Hook from the inner edge of walls	2800 mm (approx.)		2800 mm (approx.)	
16	**Working clearances required**	Upstream		Downstream	
a)	Between center of rail and the nearest side obstruction in	400 mm (approx.)		400 mm (approx.)	

	the (mm):				
b)	Between the top of Crane beam and the lowest overhead obstruction(mm):	3500 mm			
17 a)	**LT Rail size** (Rails to be fixed on RCC Beam / Gantry Girder)	90 lb/yd			
b)	**Distance between Centre line of MH hook to top of LT Rails (mm)**	1000 mm (maximum)			
18	**Controls**				
a)	Cabin Operated	No			
b)	Radio Control Operated / Range	No			
c)	Type of control & steps	Pendant Control / Radio Control (Stepless speed increase / decrease through Potentiometer within 10% - 100% of main hoist speed and three steps (10%, 50% and 100%) for other motions.			
d)	Warning device provided	Yes			
19	**Tolerance to be confirmed**				
a)	Minimum possible travel (mm), with all Brakes adjusted and Hook carrying rated load shall be :	MH	AH	CT	LT
		1.5 mm	1.5 mm	5 mm	5 mm
b)	The motor speed not to exceed 105% of synchronous speed while lowering a rated	Yes			

	load	
c)	The vertical deflection of the Crane girders caused by the rated load plus all dead loads not to exceed 1/1000 of the Crane span	Yes
d)	Camber Provided (mm)	Yes
B)	**Mechanical Details**	
1	**Crane BRIDGE**	
a)	**Platform**	Full Platform on drive side of Bridge and a short platform at each corner of idle side.
b)	Provision of clamping while in motion during earthquake	Yes
c)	Provision of "Holding Clamps" when crane is not in operation	Yes
2	**Wheels**	
a)	Material / Chemical composition	C55Mn75 (Forged Steel)
b)	Hardness of wheels	300 - 350 BHN
c)	Depth of Hardness	10 mm
3	**Gears Box Details**	
a)	Hardness (Gear/Pinion)	Gears 220-250 BHN / Pinions 260-280 BHN
b)	Materials	Gears EN8/EN9 : Pinion EN19/EN24

	(Gears/Pinion)				
4	**Type of Lifting Hook**	MH		AH	
		Ramshorn		C-Shank	
C)	**Electrical Details**				
1	**Motor Particulars**				
a)	Degree of Protection	IP55			
b)	Class of Insulation/ max. Temperature limit	F/B			
c)	Rating in minutes of continuous operation	60 min			
2)	**Brake particulars**	MH	AH	CT	LT
a)	Type of Brake used. (DCEM brakes shall be shoe type)	DCEM + EHT	DCEM + EHT	DCEM + EHT	DCEM + EHT
b)	Material of Brake lining	Asbestos Free			
3	**Down Shop Leads (DSL)**	Shrouded Copper Bus Bar			
D)	**Other Details**				
1	**Details of Safety Device**	MH		AH	
	Load Cells with Load Limit Switch	only Load Limit Switch		only Load Limit Switch	
2	**Painting on equipment**				

a)	Type of Paint	Primer and Finish coats of Epoxy Based.
b)	Extent	All steel surfaces exposed to weather
c)	Total dry film thickness (microns)	180 - 200 DFT

The data pertinent to approach of hook above the Service Bay may slightly vary as per the TG arrangement. All the equipment should be designed considering the maximum ambient temperature of 45-degree C.

5.5. Standards And Codes

The EOT crane shall be designed, manufactured, erected, tested and commissioned in conformance with applicable Indian, IEC, International Standards.

Code	**Parameter**
IS 325	Three-phase induction motors (Fifth Revision)
IS 732	Code of practice for electrical wiring installation
IS 807	Code of practice for design, manufacture, erection and testing (structural portion) of cranes and hoists (Second Revision)
IS 3177	Code of Practice for Electric Overhead travelling Cranes and Gantry Cranes other than Steel Work Cranes (Second Revision)
Fédération Européenne De La Manutention (FEM)	
FEM 1.001	Rules for the design hoisting appliances
European Standard (en)	
EN 60204-1	Safety of machinery – Electrical equipment of machines Part 1: General requirements
EN 50178	Electronic equipment for use in power installations

CRANE MANUFACTURERS ASSOCIATION OF AMERICA, INC. (CMAA)	
CMAA 70	Specifications for Top Running Bridge & Gantry Type Multiple Girder Electric Overhead Traveling cranes
NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)	
ICS 8-2000	Industrial control and systems crane and hoist controllers
AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)	
ANSI B30	Overhead and gantry cranes
AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)	
NOG-1-2002	Rules for construction of Overhead and Gantry Crane
NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)	
NFPA-70	NATIONAL ELECTRICAL CODE (SOFTBOUND)*** SAME AS IEEE NAT'L ELECTRICAL (NEC)

5.6. Performance Requirements

The Crane shall be capable of raising, lowering, holding and transporting its rated load without any damage or excessive deflection of any Crane component.

The following tolerances shall be maintained in the operation of the Crane.

- Smooth control of vertical movement to within 1.5 mm with hook carrying rated load and all hoist brakes properly adjusted at normal operation.
- The control of Bridge & Trolley motions to within 5 mm.
- The motor speed not to exceed 105% of synchronous speed while lowering a rated load.
- The vertical deflection of Crane girders caused by the rated load plus all dead loads not to exceed 1/1000 of the Crane span.

5.7. Design Requirements

5.7.1. General

The Crane shall be electrically driven, Pendant Control operated, indoor, single trolley, double girder overhead traveling type. The Contractor is responsible for the design of the Crane. The Crane shall be able to operate under full load without abnormal noise and undue vibration. All movements shall be continuous and smooth. Slipping of the load shall not occur at any time.

Mechanical parts of the Crane including trucks and trolley frames shall be designed for the specific loads using a factor of safety of 6 (Six) based on the ultimate strength.

Structural design of the crane shall be done in accordance with IS 807 -2006 or relevant International Standards. The Crane shall be designed as per latest IS: 3177(1999) or relevant International Standards except as otherwise specified in these specifications.

Without in any way detracting from their performance, the Crane shall have an aesthetic appearance with clean lines, and a neat and tidy arrangement of cables and mechanisms.

Crane shall be designed keeping in mind the transportation limits to the project site. The Contractor shall carry out a route survey upto the project site before the finalization of design of main parts of Crane such as girder, bridge etc.,

5.7.2. Service Conditions

The Crane shall be of service Class M5 as defined in the latest IS: 3177(1999).

The mechanism for Main hoist (M.H.) shall be designed as per class M3 and Auxiliary hoist (A.H.) Bridge travel (LT), Trolley travel (CT) and all the components involved in this mode of operation shall be designed as per Class M5 as defined in the IS: 3177(1999).

The Crane shall be required to handle sub-assemblies of the generator, turbine & their auxiliaries and other component part of the generating unit including generator rotor or Powerhouse equipment for erection, repair, disassembly and maintenance.

5.7.3. Inching operation

Inching operation for all motions shall be feasible for achieving slow operation of the Crane for purpose of erection, lowering centering, alignment etc., of the generating units. Inching operation shall be achieved through separate VVVF Drives for each motion.

5.8. Loads

The Crane shall be designed for the loads - Dead load, Live load, Vertical impact load, Braking load, Lateral load due to trolley tractive effort, Longitudinal load due to bridge tractive effort, Earthquake load, and any other loads. The Contractor shall furnish the design calculations based on these loads for review and approval to the Employer.

5.9. Winding Drums

Hoist drums shall be mounted on the trolleys and located so that hoisted load will be transmitted equally to the Crane girders.

The winding drums shall have machined grooves and there shall not be more than one layer of rope on the drum when the rope is in fully wound position and its length shall be such that each lead of rope has minimum of two full turns when the hook is in its lowest position and one spare groove for each rope lead off the drum when the hook is at its highest position. The drums shall be made of seamless pipe as per ASTM A106 GR A / B, Cast steel (ASTM A27), IS 2062 Grade E, rolled steel of welded construction (ASTM A36) and in case of welded drum this should be stress relieved.

The winding drums shall be provided with winding guides to ensure the winding of ropes in the grooves only.

5.10. Main And Auxiliary Hoists

The main and the auxiliary hoists shall be designed in a manner such that the hook movement is absolutely vertical. Auxiliary hoist shall be designed such that it can be operated simultaneously with main hoists without interfering with the main hoisting systems.

5.11. Hooks

The Main Hook shall be Ramshorn type and the Auxiliary Hook shall be Shank type plain hook. All hooks shall be designed to prevent any couple moment on the pulley block.

The Main Hooks shall be easily removable for installation of the lifting devices, if necessary. A locking device shall be fitted to prevent rotation of hook. The hooks shall be equipped with a safety device to prevent disengagement of the slings.

5.12. Hoisting Ropes, Sheaves And Lifting Tackles

The hoisting ropes shall be 6 x 36 construction, flexible plough steel wire type with fibre core and internal lubricant. The factor of safety of the hoisting ropes shall not be less than 6 (Six). Main and Aux. Hoist ropes shall be provided with slack detectors.The Contractor shall furnish suitable long wire rope slings. The slings shall be suitable for use with main and auxiliary hoists. Each sling and shackle shall have a fixed label stamped with the maximum safe lift at 90□ spread. A wall chart shall be provided showing the maximum safe lift of the slings individually and in pairs at various angles.

The lifting tackle shall consist of a safety lower block and hook, necessary sheaves, flexible steel wire rope etc. The lower block shall be a heavy steel housing to support the sheaves and hook. The swiveling hooks shall be mounted on ball thrust bearings and protective skirt shall be provided to enclose the bearings.

Sheaves shall be made of Cast steel/Forged steel/Rolled steel and shall be machine grooved to a depth of not less than 1.5 (one and one half) times the diameter of rope. The sheaves shall be provided with guards to retain the rope in grooves.

All gears shall be constructed of cast steel/forged steel (with low/medium carbon alloy steel & suitably heat treated) of adequate strength and durability to meet the requirements for the intended class of service, and manufactured to AGMA quality class 5 or better.

The gear trains shall be in totally enclosed oil tight gear cases with welded seams. The material of Gear casing shall be cast iron (ASTM grade A48) / cast steel (ASTM A27). All gears not enclosed in gear case shall be properly guarded.

Shafts of material of construction confirming to AISI 1045 / AISI 1055 shall be supported by anti-friction bearings.

Drive couplings shall be of the sealed, grease lubricated, flexible type.

5.13. Girders End Trucks

The trucks shall be designed to distribute the load evenly to each wheel. The carriage (trucks) shall be of cast steel / structural steel / sections or plates (ASTM A36), welded, riveted or bolted together and shall be of box type with openings at each end for receiving the truck wheels. The stops shall be attached at each end of runway. The end trucks shall be designed to contact end stops and the contact faces shall be fitted with spring bumpers.

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.

5.14. Bridge

The Bridge shall consist of two girders supported by 2 (two) trucks (boogies), for bridge movement. The girders shall be of the box type construction. The material of construction shall confirm to ASTM A36. The box section girders shall be reinforced by stiffening ribs etc. Steel stops shall be welded near the end of each girder to engage bumpers on the trolley to prevent it from leaving the bridge.

The heavy rails for the trolley shall be supported centrally on the girders and shall be held in place by rail clips & locks to prevent the rails from creeping.

5.15. Wheels And Axles

The design and construction of track wheels shall be in accordance with IS:3177(1999). The bridge shall be carried on sufficient number of wheels on each side. All wheels shall be double flanged machined or ground to size.

The Crane wheels shall be made of material C55Mn75 Steel or Cast or Wrought Iron. The steel shall not contain more than 0.060 percent of either sulphur or phosphorus. The minimum hardness of the wheel rim should be maintained between 300 to 350 BHN with minimum depth of 10 mm.

The truck axles shall be made of forged carbon, or alloy steel and shall be accurately turned ground and polished at the wheels. All axles shall be forced fit into the wheel and the driving wheels shall be keyed to the axles in addition to the forced fit.

Wheel assembly shall be arranged such that replacement of a wheel can be achieved from the side without undue difficulties.

The journal boxes of all the truck wheels shall be drip proof and shall be provided with roller bearing with high pressure grease lubrication.

5.16. Trolley

The trolley shall be equipped with a main hoist and an auxiliary hoist mounted on trolley framework. The trolley shall consist of a welded frame of structural steel sections adequately braced to withstand vertical, lateral and torsional strains and properly machined to receive the hoisting drums, wheels, axles and motors for hoisting and cross travel. On the bottom of the trolley frame on each side shall be double end spring buffer to engage stops at each end of the bridge.

The trolley shall be powered by a motor mounted on trolley frame.

The trolley shall have a floor with openings only where necessary for the hoist components and providing a safe access to all the equipment. The trolleys shall have a walkway giving access to the light fixtures in the Powerhouse ceiling.

The material of construction shall be as per ASTM A36 and the design shall be in accordance to IS: 3177(1999).

5.17. Runway Rails

Two runway rails along with fixing clamps etc. for bridge travel shall extend to the full length of the Powerhouse and the Service Bay. The rails shall be laid and fixed to the crane runway beam by means of anchor bolts, etc. In case the rails are fixed on the RCC beam, the necessary insert plates & sole plates also shall be part of the supplier's scope. The end stops shall be provided, and they shall be designed such that they contact the face of the end truck and not the wheel.

The rails shall also be supported side way to withstand the starting and stopping of trolley with load. The Contractor shall supply all the materials required for fixing the bridge and trolley rails.

5.18. Operation

The following minimum functions of main Powerhouse EOT crane shall be provided through Pendant:

- Forward and reverse speed control of the bridge travel motion.
- Right and left speed control of trolley travel motion
- Up and down speed control of each hoist motion
- On and off control of the crane's master contactor
- On and off control of the lights on the underside of the crane bridge
- On and off control for the crane's alarm gong

The stepless speed control of various motions shall be provided as specified in the table of "Rated Characteristics".

Step-less Pendant control shall be accomplished with a speed set point tele-metering system utilizing pulse rate, pulse width, or other similar systems. The speed of a motion shall be a direct function of the control lever's position and shall preferably utilize a logarithmic scale for greater control of the slower speeds. A "Jogging" system of controlling a motorized potentiometer or any other system in which the control lever's position corresponds to an acceleration rather than a speed is unacceptable.

5.19. Walkways And Ladders

Ladders, platforms, walkways, hand 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. The walkways shall be of steel chequered plate with sufficient width extending to the entire length of the bridge.

5.20. Controls

The Crane mechanism namely, Main hoist, Auxiliary hoist, Long travel and Cross travel shall be provided with resistance control. Each control shall give the smooth and un-interrupted control of operation. It should be possible to operate all the operations of Crane Main hoist, Auxiliary hoist, Cross travel and Long travel at any given time.

5.21. Brakes

Following type of Braking shall be provided.

	Main Motion	Micro Motion
Main Hoist	EHT & DCEM	VVVF Drive
Auxiliary Hoist	EHT & DCEM	Standard Resistance Control with 3-step speed
Long Travel	EHT & DCEM	Standard Resistance Control with 3-step speed
Cross Travel	EHT & DCEM	Standard Resistance Control with 3-step speed

Bridge Travel Brakes:

The brakes shall be able to stop the Crane at rated load and speed within a maximum distance of 5 mm. Braking during travel shall be gradual and permit precise positioning. Each brake shall have a capacity 1.5 (one and one half) times the full load torque of the bridge travel motors and shall be designed to be secured in position.

Trolley Travel Brakes:

An automatic electromechanical brake capable of bringing the motion of fully loaded trolley safely to rest shall be provided.

Hoist Brakes:

The hoist brakes shall have the following features:

- Braking torque shall equal 150% of the full load torque of the motor.
- The brakes shall be spring operated shoe type with solenoid release.

All the electro mechanical brakes shall have 60 minute rated coils. (While lowering critical components such as rotor and turbine components, the hoists could be held up for longer periods. The electrical operating parts shall consist of AC or DC solenoids, which shall release the brake on energisation (incase of DC solenoids, suitable rectifier unit shall be supplied by the Contractor). Interruption or failure of electric power supply shall apply all brakes immediately.

5.22. Lubrication

Provision shall be made for lubricating all bearings including ball and roller bearings by a pressure gun system and all lubrication nipples shall be readily accessible. High-pressure grease guns shall be supplied with the Crane and the Crane shall be handed over completely lubricated with approved oils and grease.

Contractor shall supply and install a lubrication chart printed on an anodized aluminium plate, at a location on the Crane approved by the Employer. This chart shall include:

the list of lubrication points and the lubrication frequency for each point;

the type and make of lubricant to be used for each point

the name of at least 3 (three) manufacturers for each lubricant.

5.23. Bearings

The shaft bearings shall be placed as close as possible to the points of loading. Unless otherwise specified herein, bearings on revolving shaft shall be of the divided type so that each shaft may be removed from the Crane with its pinions and gears in position.

5.24. Bumpers

Spring / Rubber bumpers shall be attached to the bridge trucks and the trolley. They shall be capable of bringing the Crane and the trolley to a gradual stop when traveling at rated speed in either direction / when the power supply is off and thus eliminate excessive stresses and damage to any part of the Crane.

5.25. Nameplate

All motors, starters, disconnect switches, circuit breakers panels, push buttons controls, relays and instruments shall have name plates indicating the equipment characteristics and identification or function numbers.

The hoisting capacity of the main and Auxiliary Hooks shall be indicated on a sign plate fastened to the bridge.

5.26. Wrenches And Tools

All wrenches and special tools necessary for the proper operation and maintenance as required for assembling, dismantling and for the efficient maintenance, operation and repair of the Crane shall be supplied by the Contractor. These maintenance tools and instruments shall not be used by the Contractor during construction, erection and assembly, without the consent of the Employer. Any breakages shall be replaced without any additional cost to the Employer within the warranty period.

5.27. Electrical Equipment & Controls

All electrical equipment associated with the Crane including runway conductors, cables, motors, push buttons, switches, control panels, starters, control transformers, relays, lighting, wiring conduits, etc., shall be provided and installed by the Contractor. 3 phase 4 wire, power supply at 415 V 5%, 50 Hz 3%, shall be provided by the Employer in Service Bay. Further connection from this switch up to the Down Shop Leads (DSL) is also covered in bidders scope. The bidder shall obtain 110 V AC supply for indicating and metering purpose with the use of 415 / 110 V control transformer which is also in the scope of the Tenderer. The Contractor shall intimate the rating of the feeder required for the Crane. The Contractor shall supply all equipment and devices required thereafter.

5.28. Power Supply Bus For Travelling Crane

Contractor shall supply the electrical system complete with all the electrical equipment / components for the main power supply, for end covers, insulators, clamps and beam connected support arms and other items whether specified here or not, but necessary for the satisfactory operation of the Crane.

The Down Shop Lead arrangement shall consist of Copper Shrouded Bus Bar mounted on the brackets. A suitable current collector shall be provided with the DSL.

The minimum busbar capacity shall be 400 A at 415 V 50 Hz. AC supply.

The Contractor shall supply a main circuit breaker with the padlocking facility. This breaker shall be installed in an accessible location. The interrupting capacity of this breaker shall be 18 kA r.m.s. symmetrical.

The trolley shall receive the electric supply with the use of rubber insulated copper flexible cables of adequate size.

5.29. Conductors

The main Conductors which are to provide electricity to the Crane bridge shall be rigid type. The rating of conductor shall be at least 2.5 times the normal current rating of transformer.

5.30. Motors

All motors shall be 3 phase Squirrel Cage and Variable Voltage Variable Frequency Drive (VVVF Drive) controlled. The motors shall be suitable for frequent reversing, frequent acceleration and braking.

The Crane shall be equipped with motors of ample capacity for perform the duties specified without exceeding the rated full load torque. All motors shall be TEFC type, 415 V, 3 □, 50 Hz, 60 minutes rating, Crane duty with pullout torque at rated voltage and frequency not less than 225 (two hundred and twenty five) per cent of full load torque. The motors shall be selected based on 20% higher rating than the computed kW rating. All motors shall at least be of 60 minutes (40% CDF) rating.

The motor shall have a class F insulation and be operated at a maximum temperature rise limited to Class B.

VVVF drives shall be capable of electronic braking feature through Dynamic Braking Unit (DBU) and resistance connected with DBU. The motion shall be electronically braked from high speed to low speed in the same direction or during reverse direction. Zero speed or near zero speed shall be sensed by VVVF module and mechanical brake shall be applied at that instant only to reduce braking impact and wear/tear of the braking shoes. These parameters shall be programmable and modifiable as per requirement. Further, bypass for VVVF for main motion shall also be provided in case failure or break down of VVVF control.

5.31. Protection

All protective equipment shall be supplied for the Crane including:

One main line contactor to interrupt all power supply circuits to the motors. It shall be opened by operation of any feeder breaker, over current or under-voltage relay or the emergency trip. A pilot light shall indicate that this contactor is energized.

Current monitoring relays for each motor to interrupt the existing sequence and reinitiate the accelerating sequence in the event of a sudden reversal of control;

Fuses for the protection of each control circuit; the neutral wire shall be provided with a dummy fuse.

Each control circuit shall be protected from disturbances in any other circuit;

One emergency stop push-button for all the Crane circuits, having priority over the joint control of the Crane;

Pilot lights to indicate the operation of each mechanism and a push-button to test them;

On each feeder breaker, an auxiliary contact to de-energize the main contactor when the breaker opens; A mushroom head push button for emergency stop shall be so located as to be accessible for use by operator in emergency conditions. This push button shall be connected in the operating coil circuit in case of contactors and under voltage release in case of a circuit breaker.

Electrical interlocking shall be provided to prevent the inadvertent starting of motions without the controller being brought to the off position.

The main supply shall be interlocked so that it is cut off in case of any false tripping on any electric circuit / sub circuit of the Crane.

5.32. Crane Protective Panels

The power supply from the main collectors shall be protected by a three pole main line contactor and totally enclosed circuit breakers with a minimum interrupting capacity of 18 kA at 415 V to switch off power supply to the Crane with provision to lock in open position. The protective panel shall include 1 □ control circuit transformers 110 V, 50 Hz of sufficient capacity for all magnetic control on the Crane, if required. Thermal overload relays with under voltage protection for each motor shall be provided. A double pole fuse switch or 3-phase fuse switch shall be provided for each motor and all control circuits.

The panels shall meet the enclosure protection of IP55.

5.33. Limit Switches

Necessary limit switches shall be provided for all Cranes to prevent over winding, over traversing and over travelling. At least the following limit switches shall be provided for each Crane.

Hoist driven limit switches for the upper and lower hook position;

A back-up failsafe over travel limit switch for the extreme upper position of each hoist;

Lever-operated limit switches for both end positions of all travel motions.

Limit Switches for Slack rope, mechanisms to stop the motor when a sudden slack in the tension or a breaking of the hoist cables occurs. In this case the brake shall immediately be applied;

Limit switches shall be so arranged that they can be readily tested.

Main hoist shall be equipped with a load cell with digital display, allowing the operator to have a continuous readout of the load being lifted and to limit the hoists lifting capacity over the whole operating range of the Crane. The instrument shall be mounted in the Crane's cab. Signal to the instrument will come from a load cell of reliable type.

The auxiliary hoists shall be equipped with a load limit device. All the limit switches shall be capable of reset by reversing the controllers. It shall be possible to over-ride the overload switch and load limiting device during commissioning tests only.

5.34. Cables And Cabling

All power, control, annunciation and alarm wiring in panels and desks shall be as per applicable standards. Consideration to be given to the factors like ambient temperature grouping, disposition of cables and to the limitation of voltage drop while selecting the cables.

All power and control cables shall be of annealed copper stranded conductor and will be 1100 V grade PVC HRFR.

The Contractor may carry out the cabling in totally closed troughs, observing the following requirements:

- Maintain a complete segregation between power and low voltage and/or control circuits. The low current annunciation circuits and the direct current ones must be completely separated from any other type of circuit;
- The trough network shall be continuous with overlapping joints. The covers, required do not have overlapping joints.
- The trough network must allow laying down initial cables or any replacements without pulling on cables.
- They shall allow spare space of at least 20% for each cable category, and also for each sub-trough made up by barrier strips in a common trough.

Bare conductors for the purpose of picking up current shall be placed out of reach or screened to prevent accidental contacts by working personnel.

5.35. Terminal Blocks And Wiring

The terminal blocks shall be provided with identification plates and shall be installed in easily accessible locations. All wiring for protection, annunciation and control equipment shall terminate on terminal blocks. Contractor shall supply and install, in each cubicle, 20% additional terminals.

Contractor shall supply all wiring drawings and schematic diagrams for power, control, protection, metering and annunciation for the equipment.

All wiring shall be in a hot dip galvanized metal conduit. The primary conductors to the motors shall have standard, 'continuous current carrying capacity of not less than 120 % of the rated full load current of the motors.

5.36. Control Equipment

Motors shall be controlled from the Pendant. The controllers shall be of the magnetic reversing type to provide gradual acceleration. One selector switch shall be included in each control circuit to permit independent operation of each mechanism.

Enough space shall be provided for the operation of the controls. A dead man's feature shall be, incorporated for switching off power supply in emergency situation.

5.37. Main And Auxiliary Hoist Controller

The main and auxiliary hoist controllers shall be reversing type suitable for electrical load brake (eddy current type) design. Any other method for reliable control shall also be considered. A reversing primary contactor and adequate number of secondary contactors and timing relays shall also be included for each controller.

5.38. Bridge And Trolley Travel Controllers

The bridge and trolley travel controllers shall be of the reverse plugging design and shall include a reversing primary contactor and adequate number of secondary contactors timing relays for each controllers.

5.39. Electronic Circuits

Fabrication of printed circuit cards shall be done with care. They shall be manufactured of laminated epoxy fiberglass or equivalent and shall have a minimum thickness of 1,5 mm. Each printed circuit card shall have a positioning groove permitting only one mode of connection.

The printed circuit cards shall be easily removable. Their pins shall be gold plated. They shall not be coated with materials, which prevent visibility and repair of components.

5.40. Resistors

Resistors shall be edgewise wound non-breakable ribbon, or stamped plate type for Crane duty. They shall be housed in well-ventilated, non-combustible, dust and vermin proof cabinets with protection against falling water droplets. The ohmic value and the current carrying capacity of the resistors shall be computed according to the actual torque requirements of the motions served and not on the motor size, which is set by thermal requirements. Resistor assemblies shall be so mounted as to ensure an adequate flow of air.

5.41. Collectors

The collectors shall be designed to eliminate the sparking between collectors and conductors. The minimum clearance between live parts and ground parts shall be 80 mm.

5.42. Lighting And Convenience Outlets

The permanent lighting system on the Crane shall consist of four no. 400 W Metal Halide lighting units to illuminate uniformly the area under the Crane, with a convenient outlet at each end of the bridge. A light under the Crane indicating 'in service' shall be provided.

5.43. Grounding

The Contractor shall ground the rails to the Powerhouse grounding system.

Contractor shall ground all motors, starters, control panels, transformers and all other electrical equipment to the Crane trolley and bridge structure. The intended path to ground, for any fault current, is through the Crane wheels and to the Crane rails. If the Contractor considers that fault currents may damage bearing surfaces, he shall submit to the Employer's approval an alternate low resistance path to ground.

5.44. Earthing

The Crane structure, motor frames and metal cases of all electrical equipment including metal conduit guards shall be effectively connected to earth cornplying with the Electricity Rules. The Contractor shall provide an earth system to which all equipment under his scope of supply will be interconnected. This system shall in turn be connected to the earthing mat of the Powerhouse. Traveling Cranes connected to the supply through collectors shall be effectively earthed through a fourth lead or through a set of collectors on the gantry rail.

5.45. Maintenance - Padlocking

The Contractor shall establish and submit to the approval of Engineer/Employer, a table identifying the apparatus to be padlocked.

This table shall reflect the principle that whenever an intervention is required on any apparatus, it shall be possible to isolate the apparatus from its power supply and the power cut off devices shall be padlocked.

5.46. Safety Requirements

In the design of Crane, all safety regulations as applicable with Factory Acts, Electricity Rules etc., as prevailing in the Employer's country and at the site of installation shall be taken into consideration and provided for.

5.47. Interchangeability

The identical components of the Crane shall be interchangeable. Wherever technically feasible, identical components shall be made using a precise jig. The interchangeability shall be extended without any adjustment or modification to the wearing parts and spares.

5.48. Painting

The colour shade of the Crane shall be Golden yellow or as approved by the Employer. The colour code for local control panels/JB/Control boxes shall be smoke gray / Pebble Grey or as approved by the Employer. After final assembly and Load testing at the site the final coat of the paint shall be given. Total dry film thickness shall not be more than 200 microns.

5.49. Safeguards During Earthquake

The Crane shall be designed to withstand seismic forces and as a safeguard against movement of the Crane off the rail during an earthquake, suitable provision to contain the movement of Crane shall be made. Clamping necessary to contain the movement of the Crane during earthquake shall be provided. Also, “Holding Clamps” to keep the Crane in a locked condition while not in operation shall be supplied and arranged.

5.50. Drawings And Technical Data

The Tenderer shall submit with his tender complete specification, detailed description, fabrication details and general layout drawings of components of the Crane. Clearance and loading diagrams, wheel spacing photographs and catalogues covering the general constructions and dimensions of the equipment proposed to be supplied shall also be furnished for all components.

The bid shall include GA drawings of the Crane showing clearances and technical data for all the equipment offered.

After placement of order the Contractor shall furnish the following drawings / documents:

- General arrangement drawing of the Crane showing all the clearances;
- General arrangement drawing of Crab/trolley and of individual mechanisms;

- Preliminary details of hoists, trolleys and main girders;
- Electrical schematics of power supply and controls and instruments and protective equipment panel shall be supplied;
- Dynamic and static loads for structural design considerations;
- A detailed analysis of Crane design showing the loads and load combinations used and the resulting stresses, allowable stresses and the factor of safety for the various component parts of the Crane. The calculations shall cover rating of motors, sizes of ropes drums, sheaves and other structures;
- Erection procedure;
- Supply of the maintenance and user manual
- Quality assurance plan during fabrication, erection and commissioning.

5.51. Shop Assembly, Match Marking And Testing

The Crane shall be assembled and operated in the shop and checked for adequacy of design and suitability for reliable safe and proper operation.

Following tests shall be performed at manufacturer's works;

- All dimensional check shall be carried out at works.
- Full load and 25% overload test shall be done at manufacturer's work on hoisting and cross travels motions.
- Full load and 25% overload test with trolley up to 1.5 meter on either side from centre of the bridge shall be done. Tests to verify specified speeds under load conditions and tests about deflection bridge girders under safe working load at rest and with Main Hook in a central position shall be done.
- Operation of brakes.
- Electrical test on control panels

5.52. Field Assembly

The Contractor is responsible for the site assembly of the Crane and shall supply the erection labour and equipment. Before any work is done, the Contractor shall make sure that work done by others does not hinder the proper installation or functioning of the Crane.

Openings in the Powerhouse roof shall be provided as required and to the extent possible, to facilitate the erection of the Crane.

5.53. Inspection And Tests

After final assembly and erection of the Crane, prior to acceptance of the Crane, the Contractor shall carry out the commissioning tests. The tests shall include the testing of all motions of the Crane and Auxiliary Hoist and Main Hoist under unloaded working conditions. The tests shall demonstrate that all guarantees have been met and that the equipment meets all specification requirements. The Contractor shall supply all personnel and equipment necessary for the tests.

Operational Tests:

The Contractor shall ensure that:

- All clearances and alignments are in order', gearing is sufficiently quiet and lubrication is adequate;
- Operation of all control devices is satisfactory, limit switches operate correctly;
- All circuits, interlocks and sequences of operation are correct;
- All protective devices operate satisfactorily;
- Each movement of the Crane is satisfactory.

5.53.1. Load Tests

The Contractor shall load the bridge with a test load equal to 125 % of rated load with the Main Hook in the center of the bridge span with appropriate measuring instrument. During the above tests, the load shall be lifted, stopped, lifted again and stopped. During the test, specified motion speeds need not be attained but the Crane shall show itself capable of sustaining and moving with this test load to the entire satisfaction of the Employer. **All the necessary slings, cradle, supports, Test Load etc. shall be arranged by Contractor**, However, if required the Employer shall arrange for test load of steel plates at site.

Travel tests:

During travel tests, the trolleys and Crane shall be started, travelled at maximum rate and stopped in both directions. The following tests shall be performed at the rated load of the Monorail Hoist, Auxiliary Hoist, Main Hoist and of the Crane:

- Travel of the trolley over it's full range;
- Travel of the Crane over the maximum distance possible;
- Measurement of the hoists, trolleys and bridge travel speeds.

5.53.2. Deflection Tests:

The deflection test shall be carried out with test load i.e., rated load with the Main Hook in the centre of bridge span. The measurement shall not be taken on the first application of load. Datum line for measuring the deflection should be obtained by placing the crab on the extreme end of the crane span with smaller hook approach.

Brake Tests: All brakes shall be tested under full load condition from maximum speed to rest in less than 5 mm, three times in quick succession without overheating.

Bumper Tests: The Crane and trolley bumpers shall be tested without load and at 30% of the rated speed.

Electrical tests:

These tests, which are in addition to motor and load tests, shall include but not necessarily be limited to the following:

- Routine motor tests as specified in appropriate standards.
- Torque setting and load tests on all brakes.

- Insulation and continuity tests of the complete installation.
- Functional tests of all equipment to prove the proper sequence and limit switch interlock operations.

5.54. Spares

The following specified spare parts shall be supplied by the contractor;

S. No.	SPARE PARTS	Unit	Powerhouse 45/10 t
1.0	**MAIN HOIST**		
a)	Thruster to serve Hoist Brake	Nos.	1
b)	Brake Shoe with lining for the Hoist Brake	Nos.	1
c)	Brake Solenoid coils complete	Set	1
d)	Limit Switches of each type	Sets	1
2.0	**AUXILIARY HOIST**		
a)	Thruster to serve Hoist Brake	Sets	1
b)	Brake Shoe with lining for the Hoist Brake	Nos.	1
c)	Brake Solenoid coils complete	Set	1
d)	Limit Switches of each type	Sets	1
3.0	**TROLLEY DRIVE**		
a)	Fixed and moving contacts & accessories for the Controller for Traverse Drive	Sets	1
b)	Brake Solenoid coils complete	Sets	1
c)	Brake Shoe with lining for Transverse Brake	Sets	1
d)	Limit Switches of each type	Sets	1
4.0	**BRIDGE TRAVEL DRIVE**		
a)	Fixed and moving contacts for the controller of Long Travel motion	Sets	1

b)	Brake Solenoid coils complete	Sets	1
c)	Brake Shoe with lining for Bridge Travel Brake	Sets	1
d)	Limit Switches of each type	Sets	1
5.0	**OTHERS MISC. SPARES**		
a)	Coils of each model for the Starters and Control Switches	Set	1
b)	Rectifiers for each model of Solenoid-operated Brakes	Set	1
c)	Circuit Breaker of each type	Set	1
d)	Springs, O-rings, Oil seals, Gaskets, Packing etc. of each size and type for complete Crane	Set	2
e)	Indicating Lamps each type	Sets	10
f)	Indicating light assembly of each type	Set	1
g)	Couplings complete with coupling bolts, rubber sleeves etc. each type and size	Set	1
h)	Push button each type	Set	1
i)	Control Switch of each type	Set	1
j)	Disconnecting Switch of each type	Set	1
k)	Terminal Block of each type	Set	1
l)	Fuse Block of each type	Set	1
m)	Plug Connector of each type	Set	1
n)	Plug Module of each type	Set	1
o)	Current Collection Assembly (Each Type)	Sets	4
6.0	**VVVF Drive Spares**		
a)	Power Card for MH-1No, AH-1 No, CT-1No, & LT-1No.	Set	1

b)	Control Card for MH-1No, AH-1 No, CT-1No, & LT-1No.	Set	1
c)	IGBT Module MH-1No, AH-1No.	Set	1
d)	IGBT Module CT-1No, LT-1No.	Set	1

The spare parts mentioned here are meant for use by the Employer for five (5) years trouble free operation and shall not be used as erection spares required during installation. All the spare parts shall be interchangeable and shall be of the same material and workmanship as corresponding parts of the main equipment.

If any additional spare parts required for a 5-year operation period are recommended by the Contractor, these shall be listed, and the unit price shall be quoted in the Price Schedule. The Employer reserves the right to order any or all of such spares, within 12 months after commissioning.

5.55. Special Tools

The Contractor shall provide one set of all necessary special tools and maintenance equipment for EOT crane for the purpose of repairs and maintenance.

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6. MECHANICAL WORKSHOP EQUIPMENT

6.1. Scope of Work

Scope of work under this covers the provision of labour, tools, plants, materials and performance of work necessary for the design, manufacture, quality assurance, quality control, shop assembly, shop testing, delivery at site, site storage and preservation, installation, commissioning, performance testing, acceptance testing, training of Purchaser's personnel, handing over to Purchaser and guarantee of all equipment as per the specifications, and complete with all auxiliaries, accessories , spare parts and warranting a trouble free safe operation of the installation.

The scope of work shall, be a comprehensive functional system covering all supply and services/works for Workshop Equipments.

Any other item(s) not mentioned specifically but necessary for the satisfactory completion of scope of work defined above, as per accepted standard(s)/ best international practices shall be part of contract.

6.2. Specific Parameters and Layout Conditions

The layout shall necessarily take in to consideration the repair and maintenance of runner, guide vanes & other equipment and handling of the same in the recommended space allocated.

6.3. Rating and Functional Characteristics

Unless otherwise stated, rating, characteristics, test and test procedures, etc. of the workshop equipment shall comply with the provisions and requirements of the latest applicable International Indian Standards.

6.4. Performance Guarantee

The mechanical workshop equipment along with all auxiliaries and accessories shall be capable of performing intended duties under specified conditions. The Contractor shall guarantee the reliability and performance of the individual equipment as well as of the complete system.

6.5. Standards

The system and equipment shall be designed, built, tested and installed to the latest revisions of the applicable standards. In the event of other standards being applicable they will be compared for specific requirement and specifically approved during detailed engineering for the purpose.

6.6. Machine Tools – Technical Specification

Bidder to include in their scope set of

- Standard Tools,
- Standard Spares and
- O&M Manuals

for each equipment in addition to the accessories listed below.

S. No.	Item Description	Specification	Qty no./set
1.	**Double Ended Pedestal Grinding Machine**		1
	Capacity / Size		
	Grinding discs of max. diameter	300mm	
	Accessories		
	Drill grinding device	1 set	
	Zircon grinding discs	10 nos.	
	Rotary wire brushed	4 nos.	
	Eyes-protection devices / shield etc.	1 set	
	Wheel dresser, water pot, twist drill grinding,	1 set	
2.	**Power Hacksaw**		1
	Capacity/Size		
	Cutting capacity dia / square	300 / 250 mm	
	Stroke per minute	50 to 100	
	Accessories:-		
	Coolant tank (with chips separator) electrically driven coolant,	1 nos	
	Pump with motor and coolant piping and nozzle	1 set	
	Power blades extra	50 nos	

	Adjustable bar rest	1 nos	
	Machine Lamp	1 nos	
	V- Shape vice jaws to cut materials in bundle	1 nos	
	Emergency stop push button	1 set	
3.	**Thyristorised Welding Rectifier (make: Ador Thyroluxe 401 / ESAB – RS400)**		1
	Welding current regulation by modern moving core magnetic shunt design having stepless, smooth and infinitely variable current regulation.		
	Capacity / Size-		
	Rated welding current: (Stepless adjustment)	10-400 A	
	Permitted load at duty cycle of 60%	400 A	
	Rated open circuit voltage	100 V	
	Type:	Forced Air Cooled	
	Class of Insulation	H	
	Accessories-		
	Welding cable 20 m long conforming to		1
	IS 434 (Part –I) or equivalent		
	Electrode holder of suitable capacity conforming to IS 2641 or equivalent.		1
	Earthing cable 20 m long conforming to IS 434 (Part-I) with earthing clamp of suitable capacity conforming to IS 2641 or equivalent.		1
	Goggles face mask, helmet, hand shield & screen conforming to IS 1179 or equivalent.		2
	Gauntlets for welders conforming to IS 2573 or equivalent.		2
	Pair of hand gloves		2

4.	**Bench Drill**		1
	Two speed with electronic control.		
	Capacity / Size-		
	Capacity:	Φ 20mm	
	Spindle traverse	125 mm	
	Distance between centre of spindle and column front:	200 mm	
	Max. distance between spindle & table:	300mm	
	Max. distance between spindle & base:	600 mm	
	Table working surface (with coolant gutter):	dia. 370 mm	
	Accessories-		
	HSS drills of best quality covering the whole Drilling Range.		1
	Spare drill jar socket		1
	Spare key for drill jar socket		1
5.	**Oxygen Acetylene set** with all accessories Cutting set, Hose Regulator etc.		1
	Gas Hose with clamps		50m
	Welding Torch complete with assorted welding Heads, welding range (0.5 - 30 mm).		1
	Cutting head assorted for cutting range: (3-100 mm)		1
	Welding chipping hammer		2
	Welding Armor screen		2
	Welding Armour head screen		2
	Chipping Brush of SS wire, 5rows.		2
	Wheel cart for carrying gas cylinders.		2
6.	**Portable Tools**		

	Portable Electrical Drilling Machines with magnetic base:	Φ 19 mm	1
	Portable Straight Grinder:	Φ 100 mm	1
	Portable Angle Grinder:	Φ 100 mm	1
	Portable type of Electric Oven for welding:	8 kg. rod preheating	1
	Portable Electric Blower:	2.7 m^3/min @ 0.75 bar	1
	Portable Flexible Shaft Grinder:	Collet size -Φ 6 mm	1
	Portable Sander / Polisher:	Φ 180 mm	1
7.	**Vacuum Cleaner (Dust & Wet)**		1
	Volumetric Recovery Capacity:	60 litre	
8.	**Aluminium Double Ladder:**	6 m	2
9.	Workbenches with a rigid steel structure, even surface, hard wood plate of min. 50 mm thickness, air dried hard wood blocks, specially treated, provided with toothed profile, water resistant, edges with steel to resist chipping and general wear & tear. They shall be furnished with suitable drawers and compartments with		1
	doors, both fitted with locks. 2 x 1 m		
10.	Locker cabinets of appropriate size, each having six (6) lockers of size. 305 x 380 x 457 mm		1
11.	**Lot of hand tools and instruments.**		
	Ring-Headed Spanners	M6 - M36	1
	Open Headed Spanner	M6 - M32	1
	Socket Wrench	M6 - M32	1
	Single Headed Spanners	M24 – M6	1

	Double acting wrench	1/0.4",1/2",1"	1
	Universal Joints and Extensions	100, 200 & 300 mm	1
	Torque wrench with adjustable torque setting		
	Torque multipliers		2
	Pneumatic wrench with torque adjustment		2
	Wrench for socket drive	200 mm	3
	Digital Spirit level	± 0.050	4
	Digital Tachometer	0-1000 rpm, ±0.1%	2
	Digital Outside Micrometer	25 – 50mm +1 µm	1
	Digital Outside Micrometer	75-100 mm +2 µm	1
	Digital Inside Micrometer	25 – 50mm ±6 µm	1
	Digital Vernier Calliper	0-450 mm ±0.05 mm	1
	Mechanical Vernier Caliper	0-300 mm ±0.05 mm	1
	Slip gauges		1
	Hydraulic Flat Jack	50 T	1
		20 T	1
		5 T	2
	Depth Gauge (Mechanical)	150 mm	1
		250 mm	1
	Dial Gauge (least count 0.01 mm & 10 mm)		1

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1. GENERATOR & EXCITATION SYSTEM

1.1. SCOPE

This section of the specifications covers the design, material selection, manufacture, intermediate storage, testing at works, packing and forwarding for shipment, delivery to project site (final destination), receipt and storage at site and services for performing on site assembly, erection, testing at site, trial run and commissioning of three numbers Horizontal Shaft synchronous generators for Karbi Langpi Middle II HPP in Assam, India.

The Generators shall be complete with accessories, fittings, instruments, controls, auxiliaries such as neutral grounding cubicle, generator terminal equipment including CT's, PT's, Surge protection equipment, lubricating system, (if required) and cabling, with valves, fittings and safety devices, including mandatory spares for five (5) years trouble free operation of the plant, special tools and testing devices; as described and detailed in this specification and as per the schedule of requirements.

The scope of supply shall also include all parts, accessories, spares etc., which are essential for construction, commissioning, operation and maintenance of the complete generator even though these are not individually enumerated or specifically stated or enumerated. Corresponding components of both the generators and associated equipment and the spares shall be of the same material, dimensions and finish and shall be interchangeable.

Each Generator shall be capable of delivering continuous rated output of 8000 kW (at generator terminal) at 0.85 power factor and an inherent continuous overloading of 10%. The generator is to be directly coupled to the turbine and shall be matched in respect of speed, runaway speed, moment of inertia and overload capacity and other relevant requirements. The coupling between Turbine & Generator is to be covered under generator scope of supply.

The efficiency of the generator shall not be less than 97.5% at rated output, rated speed and rated power-factor.

1.2. TYPE AND RATING OF THE GENERATOR

Following are the technical requirement of synchronous generators required for the Project:

S. No.	Particulars	Description
1	Type	Horizontal Shaft 3 phase Synchronous Generator with Static Excitation System
2	Rated Output and maximum output	8000 kW / 8800 kW
3	Rated Voltage (Generation Voltage)	11kV
4	No. of phase	3
5	Rated Power Factor	0.85
6	Rated Frequency	50 Hz
7	Rated Speed	428.6 rpm
8	Runaway Speed	Less than 2 times of rated speed
9	Runaway Speed withstand (duration)	Not less than 15 min.
10	Insulation Class	Class F
11	Degree of Protection	IP 44
12	Maximum ambient temperature	50° C
13	Rise in temperature over ambient temperature at maximum output (110%) (measured by RTD)	Temperature rise limit as per Class B in accordance with IEC 60034
14	Type of Duty	Continuous
15	Type of Control	Manual / Auto
16	Range of voltage variation between phases	± 5 %
17	Range of frequency variation	±3%
18	Stator winding connection	3 phase Star connected neutral brought out for connection to neutral grounding transformer.
19	Inertia constant	1.0 (min.)

20	Short circuit ratio	≥ 1.0
21	Continuous overload	10%
22	Transient speed rise limit on full load throw off (in co-ordination with Turbine)	< 55% over rated speed
23	Minimum factor of safety of critical part	1.5
24	Maximum shaft vibration limit	≤ 150 micron or as per IEC-34-9 whichever is lower.
25	Cooling	Self-ventilation through rotor mounted fans
26	External Cable corresponding to Voltage	11 kV XLPE cable
27	Direction of Rotation	Clockwise from Turbine End
28	Standards Applicable	IEC 34-1, IEC 34-2, IS –4722, IS – 4029, IS – 4889, IS- 325, IS -1271, IS – 4691
29	Sound Emission	< 90 dB at 1 m distance

Other requirements of generator are given below:

The Generator shall be capable of delivering continuous rated output and maximum output (110% of rated output) at 0.85 power factor, rated frequency, with its temperature rise limit as mentioned above with ambient temperature of 50°C.

The generator shall be designed to withstand any mechanical and magnetic stresses resulting from either a three phase or a single phase fault at generator terminals for 1 second when operating at maximum power output, rated zero power factor and 5 % over voltage.

Starting current surges shall diminish within 5 cycles. The slot areas shall be as high as possible to improve the efficiency of the generator. The rotor and stator shall be constructed to keep the parasitic losses as low as possible at rotor surface to reduce no load kVAR. The generator shall remain stable on sudden application of maximum load or sudden loss of maximum load and during momentary short circuits or sustained ground faults. The moment of inertia shall be so selected that it meets momentary pressure rise and speed rise of turbine.

The generator shall be designed and constructed for easy maintenance and repair/ replacement of stator coils and rotor bars. Suitable provision shall be made in the base frame to facilitate easy withdrawal of stator body by sliding on bed plates. The generator housing shall be proportioned to avoid possibility of resonance at rated frequency and higher multiples of rated frequency.

- Each part of generator shall be proportioned such that the maximum unit stresses of generator resulting from any continuous operating conditions specified shall not exceed one third of the yield point stress or one fifth of the ultimate stress of the material whichever is less. In case of specified runaway speed conditions, unit stresses shall not exceed two thirds of the yield point stress.
- The Short Circuit Ratio shall not be less than 1.0.

1.3. SPEED RISE AND RUNAWAY SPEED

1. The moment of inertia of the generator together with the moment of inertia of the turbine and fly wheel if any, shall be such that the maximum speed rise shall be as low as possible and shall not exceed 55% over rated speed to avoid excessive stress in the generator. The Generator parts shall be so designed to withstand maximum runaway speed without damage to its parts for 15 minutes without water supply to bearings. The value of maximum runaway speed and the duration of the same with reference to the guide vanes closing time as recommended by the turbine manufacturer shall be stated in the offer.
2. The moment of inertia shall be such that speed when full rated load is thrown off, should not be more than 55% of rated speed.

1.4. NOISE LEVEL

The noise level shall not exceed 90dB (A) when measured at a distance of one meter 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 frequency noise shall be avoided.

1.5. INSULATION AND TEMPERATURE RISE

Insulation shall be provided as follows:

- Stator winding - Epoxy Class F
- Rotor winding - Epoxy Class F

Insulation shall have high basic insulation level suitable to withstand system surges on account of switching surges and lightning surges.

Each generator shall be capable of delivering max output of **8800 kW** continuously (at generator terminal) at rated voltage and frequency in the operating range at 0.85 power factor without exceeding the following values of temperature rise limits as specified in the previous clause.

Even though insulation of Class F is specified and must be used, the generator temperature shall not exceed class B temperature rise limit when the generator is operating continuously at maximum continuous output of 110% at rated power factor and at any working voltages and frequency range specified.

1.6. OUTPUT AND EFFICIENCY GUARANTEES

Within the limits of temperature rise specified above, the rated continuous output of the generator shall be guaranteed with a rejection limit of minus two percent (2 %) for the rated generator terminal conditions.

Individual losses shall be established using suitable method as per IEC 32-2 and the efficiencies shall be determined according to the international code, IEC 34-2. The excitation equipment losses shall be included in the generator losses. The bearing loss shall be indicated separately and shall be included in the generator losses for computation of efficiency. The Bidder shall propose the method to determine the losses and efficiencies in the bid.

No tolerance shall be permitted over test figures of output. Tolerance in determination of efficiency shall be as per relevant International Standards.

The rated output of the generator at rated power factor shall be stated and guaranteed.

The guaranteed weighted average efficiency at rated voltage and frequency as determined from the following formula shall not be less than 97 percent.

$E_{vg} = K_1*E_{110}\% + K_2*E_{100}\% + K_3*E_{75}\% + K_4*E_{50}\%$

Where,

E_{vg} is the weighted average efficiency of the generator.

E110% = Efficiency at 110% rated MVA & 0. 85 pf,

E100% = Efficiency at 100% rated MVA & 0.85 pf,

E75% = Efficiency at 75% rated MVA & 0.85 pf,

E50% = Efficiency at 50% rated MVA & 0.85 pf,

K_1=0.50, K_2=0.30, K_3 = 0.10, K_4 = 0.10

The weighted average efficiency of the generator for 110 %, 100 %, 75 %, and 50% rated output shall also be guaranteed. These figures shall be applicable for purpose of penalties, rejection limits and bid evaluation.

Field acceptance test as per IEC shall be carried out to determine the actual output and the efficiencies of the generator at various points of operation.

Penalties levied for any shortfall in the tested values of rated generator output and of the weighted average efficiency of generator vis-a vis the guaranteed values shall be computed as follows:

a.	Output: for each one hundredth of one percent (0.01%) shortfall in test value of rated output vis-à-vis guaranteed value.	US$ 2200
b	Weighted Average Efficiency: for each one hundredth of one percent (0.01%) shortfall in test value of weighted average efficiency vis-à-vis guaranteed value.	US$ 2200

For fractional values of the shortfalls in percentage, the penalty amounts shall be computed on pro-rata basis.

The penalties on account of shortfalls of output and the weighted average efficiency shall be computed separately. The generator not fulfilling the guarantees will be subjected to penalty by multiplying the penalties for one generator by the no of generators and the total amount of penalty shall be the sum of these two.

The tolerances for guaranteed generator efficiency shall be as per relevant IEC. If the test values are less than the corresponding guaranteed figure by 2% or more, it may be liable for rejection after allowing the tolerances for generator efficiency as per latest IEC. No tolerance is acceptable for computation of output of generator.

The supplied equipment is liable for rejection if the test values of rated or maximum output or the weighted average efficiency is less than the corresponding guaranteed values by two (2) percent or more and also if either of stator or rotor winding temperature exceeds specified limits under maximum output conditions.

Bid Evaluation

In the evaluation of bids, equalization on account of differences in efficiencies of the generator of the various offers will be made at the rate of 2200 US$ per generator for each one hundredth of 1% (0.01%) by which the weighted average efficiency given in (or computed for) any offer is lower than the highest weighted average efficiency among the various offers. For differences lower or higher than one hundredth of one percent (0.01%), the equalization will be computed on pro-rata basis. The weighted average efficiency of the generator shall be same as defined previously for penalty purposes. The tolerances for generator efficiency shall not be considered during bid evaluation.

1.7. COOLING SYSTEM, BRAKES & PAINTING, CORROSION PROTECTION AND COATING

1.7.1. COOLING SYSTEM

The generator will be equipped with air/water heat exchangers connected to open loop cooling water supply system. Cooling water shall be taken from common tail pool. The cooling system shall be complete with air water heat exchangers, cooling water pipes, fittings, flow indicating devices, flow relays and other accessories.

The generator supplier shall coordinate with the cooling water system supplier for the interface with the cooling water system and inform the cooling water supplier about the required quantity of water.

1.7.2. BRAKES

Each generator shall be provided with hydraulically operated brakes which will be operated automatically or manually. The Generator brake system shall consist of suitable number of brake shoes. Oil from OPU at required pressure will be made available from the turbine oil pumping unit. A pressure gauge which shows the braking pressure during automatic braking shall be connected to the pressure pipe. The brakes shall be capable to be applied at maximum speed. It shall be possible with the braking equipment to retard the unit, to standstill within 2 minutes from time when brake impulse is transmitted.

1.7.3. PAINTING, CORROSION PROTECTION AND COATING

For all structural steel and cast-iron parts, the following applies:

- Surface Preparation: On all cast iron and structural steel parts the rust must be removed by mechanical means (sandblasting) to obtain a bare surface according to International Standard.
- Prime Coat for all areas: 2 layers with "Friazinc R", dry thickness of each layer 40 microns.
  Type A: Areas in contact with oil (if required): All those areas will receive three coats with oil resistant paint, for example Keratol, which must be applied as finishing coat.
  Type B: Areas in contact with air: All those areas still accessible after assembling on site, receive two prime coats with different colours. The prime coat consists of a preliminary final coat in blue for the generator casing and red for all the moveable parts. The applicable RAL colours will be provided after placing of contract.
- Areas in contact with concrete: Cast-in items do not receive any coating but must be free of rust and spunk.
  Cast-in items exposed to air and water must be provided with a prime coat to a depth of approximately 150 mm into the concrete.
- Oil carrying pipelines (if required): They must be dismantled after assembling on site, pickled in acid solution, neutralized and oiled.

All bare surfaces, which are not in contact with oil, shall be provided with a protection coat (removable with water) after manufacturing. Parts located in inaccessible areas, which must not be dismantled after workshop assembling must be protected as follows: -

The electrical equipment such as electric motors, limit switches, control panels etc. must receive corrosion protection according to specifications in the worst atmosphere. The colour coding will be determined by the Purchaser.

Any coated surface damaged after or during assembling must be reinstated. Internal and external surfaces of the casing and all metal parts shall be painted with epoxy paint that will resist corrosion due to ambient conditions. The colour of external paint will be confirmed during detailed design and must be of non-hazardous and non- toxic nature.

1.8. CONSTRUCTION

1.8.1. STATOR

The stator frame shall be of fabricated steel construction. 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. The stator core shall be built up of segmental punching of low loss, non-oriented steel sheets and end plates. Each punching shall be carefully de-burred and insulated on both sides with high quality varnish to reduce losses in the core.

The stator winding shall be of electrolytic copper (99% purity) which shall be of multi-turn preformed type and shall be insulated with Class F insulation. The stator winding shall be star connected with both ends of conductors of each phase brought out of the stator. The outlets shall be enclosed, and the outlet box shall be adequate for connection of specified power cable.

For each generator, for stator winding (located between top and bottom coil sides) symmetrically located embedded resistance temperature detectors shall be provided. The connections on the resistor elements shall be well insulated and extended to a connection box on the outside of stator frame.

1.8.2. ROTOR

The design and construction of rotor shall be in accordance with the best modern practice and is of cylindrical construction. The factor of safety at maximum runaway speed based on yield point stress of material shall be not less than 1.5.

The rotor bars shall be short-circuited with end rings by an appropriate method like induction brazing method. The copper end rings of the rotor shall be well supported by steel retaining rings to make the rotor sturdy to withstand runaway speeds and other operating conditions specified under this specification. Field winding shall consist of fabricated field coils or any other type with adequate provision for cooling purpose. The field poles shall be provided with adequate damper windings to ensure stability under fault conditions and to meet I^2t value of 20.

1.8.3. TERMINAL BOX

The terminal box shall be located on either side of the generator-one for phase connection and other for neutral connection. A separate terminal box for RTD's and space heater terminals shall be provided. The terminal box shall be suitable for taking 11kV cable of adequate size and specification.

1.8.4. PHASE MARKING

Appropriate phase marking as per IS 325 shall be provided inside the terminal box. The markings shall be indelible.

1.8.5. SHAFT

The generator shaft shall be made of the best quality carbon steel forging properly heat-treated conforming to ASTM A 668 class D or equivalent material for which approval shall be taken from the Owner. 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.

1.8.6. BEARINGS

The generator bearings shall be preferably anti friction ball / roller bearings oil/sleeve bearing (forced lubricated) 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 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 DE bearing shall be of thrust cum journal bearing and NDE bearing shall be journal bearing. The thrust bearings shall be suitable to take axial thrusts in both the directions. The bearings shall be designed to withstand operation of runaway speed for 15minutes. Thermometers, oil/grease-lubricating points, speed relays 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 may also be provided with resistance elements. Wires shall be run from thermometer and resistor element to the instruments and the junction box mounted on the outside of the stator frame.

1.8.7. VIBRATION

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 as specified in IEC 60034-14. The vender shall guarantee the vibration values at rated operating condition.

1.8.8. HEATERS

The generator shall be provided with anti-condensation heaters. Spare heaters of adequate rating shall be provided for maintaining stator surrounding air temperature above the ambient temperature during prolonged shut down period.

1.8.9. OIL & GREASE

The bidder shall indicate the lubrication requirement and give his recommendations with detailed specifications regarding type of grease to be used and frequency of refilling required for lubrication of generator bearings. The oil, if used for generator bearing lubrication shall be, as far as possible, identical with that used for the turbine pressure oil system. The first filling of oil with 10% extra quantity shall be supplied along with the generator.

1.9. SPEED RELAY, TOOTHED WHEEL & MECHANICAL OVERSPEED

A toothed wheel arrangement is to be mounted on the shaft of the generator and a photo interceptive pick up must 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.

1.10. BRUSHLESS SYSTEM

The excitation of the generator will be applied via a brushless excitation system. Brushless Excitation system shall have microprocessor-based controls. The excitation equipment shall comprise of rectifier, excitation transformers, thyristors, field breaker with discharge resistor, field flashing circuit, automatic voltage regulator and protection and control devices along with accessories to make it a complete system.

The excitation system for each unit will consist of the following:

i) Dry type Excitation transformer.

ii) A Set of Thyristor converters of suitable numbers such that even in case of one bridge failure, the remaining bridges shall cater to the maximum continuous and ceiling current requirements.

iii) Field flashing (both AC & DC) for excitation start up.

iv) Field breaker and field discharge and suppression equipment.

v) Digital Automatic voltage regulator with auto and manual channels with all standard limiter functions.

1.11. NEUTRAL GROUNDING SYSTEM (NGS)

All three phases from Generator terminal will be brought to Neutral Grounding Cubicle. These three phases will be shorted in NG cubicle. Current transformers will be mounted on neutral side before shorting of three phases. The neutral point of the star connected stator of each generator shall be grounded through 11kV/110 V single phase, dry type distribution 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. The Generator terminal CTs shall be mounted in this cubicle. All the above neutral grounding equipment will be housed in a drip proof enclosure. The rating of the grounding transformer, secondary resistor and isolating switch shall be indicated in the tender. Calculations for working out the ratings shall be submitted by the successful bidder to the purchaser/consultant for their approval.

The following design parameter shall be considered:

- The transformer shall be of cast resin type
- The insulation level shall be adequate for rated system voltage.
- 95% of stator winding are to be protected.
- The load resistor shall be selected that the total losses of the resistor are equivalent to the generator/transformer capacitive reactive losses when phase/neutral voltage is applied to the primary side of the transformer.
- All the generator neutral earthing equipment including CT's as shown in the Single Line Diagram shall be installed in the sheet steel cubicle. The technical data of the equipment such as ratio/accuracy shall be coordinated with the protection system.

The equipment shall be housed in a floor mounted cubicle, suitably compartmentalized with steel frame and bolted panels. The cubicle is arranged and built to provide adequate natural ventilation of the equipment. The cubicles shall be complete with base mounting arrangement. The internal illumination for cubicles shall be provided with guarded lamps with on/off switch. Copper conductors of appropriate size shall be used for connections in the cubicles. The cubicle shall be dripping proof. The Three phase compartment shall be at the top and shall be separated from the neutral grounding transformer and resistor.

1.11.1. CURRENT TRANSFORMER

The current transformers will be epoxy cast, dry type units conforming to IS: 2705. The current transformers shall be designed to withstand the thermal and magnetic stresses from the maximum short circuit current. The accuracy class shall be 0.2 for metering and Class 5P20 and Class PS (as applicable) for protection. The CT locations, rating, accuracy class shall be suitable for adequate metering and protection.

1.12. LAVT CUBICLE

One no LAVT panel for each generator shall be provided. 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 with on/off switch. 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 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, bolted to the frame. No part shall be subject to excessive heat rise and natural ventilation shall be supplied. Doors shall be equipped with key operated locks. Clearances between live items and the mass shall provide adequate insulation. Suitable tapping connection shall be provided for metering & protection PT and AVR power & sensing PTs.

1.12.1. 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 and shall have parameters as indicated in legends sheet.

1.12.2. LIGHTNING ARRESTORS

The lightning arrestors shall be heavy duty, indoor station class and 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 IS: 3070 (latest edition) part- I. The nominal discharge current of lightning arrestor shall not be less than 10 KA.

1.12.3. 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.

1.13. PROTECTION

Following protections shall be provided on each of the generators:

- Reverse Power (32G)
- Negative Phase sequence (46G)
- Loss of Excitation (40G)
- 95% Stator Earth Fault Relay (64GS)

- Generator differential relay (87G)
- Generator over voltage relay (59G)
- Generator under voltage relay (27G)
- Rotor Earth fault relay (64GR)
- Instantaneous & IDMT over current relay (50/51G)

All the protective relays shall be of microprocessor based numerical type with high reliability. The protective devices are only indicative. Any other protection recommended by the Supplier may be given. The Supplier shall suggest suitable scheme required for the generator protection keeping modern trends in view. The final scheme will be decided by the Purchaser/Consultant in consultation with the Supplier during final design. All signals of protection instruments shall be available for back feed signal contacts, potential free and interchangeable.

1.14. CONTROL, INSTRUMENTATION AND SAFETY DEVICES

1.14.1. UNIT CONTROL BOARD (UCB)

Each turbine generator shall be provided with a complete set of instruments, gauges, control and safety devices on unit control board, provided for monitoring the conditions of the unit during normal operation and emergencies. The instruments and gauges for the unit include pressure gauges, level indicators, temperature and flow indicators, position indicator, indicating lamps for status indication etc. These shall be placed near the locations of equipment and in the unit control board UCB. The safety devices shall comprise equipment and devices for sensing abnormal operating conditions, for giving visual and audible annunciation and shut down of the unit when required. The items, quantities and location of the instruments are to suit the requirements for safe and satisfactory operation of the generating units and the auxiliary systems. Generating units may be started manually from this board. This manual mode will be used only in emergency or failure of the auto start system.

1.14.2. PROGRAMMABLE CONTROLLER

The control & monitoring system for the generating units shall be microprocessor based digital control. Microprocessor based automatic sequence control equipment with self-diagnostic features shall be provided for each unit. Automatic sequential control of each unit shall be connected to centralized automatic control system in control room through coaxial cable and Man Machine Inter-face (MMI). The unit level programmable controller shall be capable of performing the functions required for logic control to provide the automatic start and stop functions and be capable of doing governor control using suitable PID function. The unit controller shall be capable of communicating to the master programmable controller to transfer data and enable supervision of the PC based supervisory and control station.

Sequential control equipment shall be designed to provide controls for sequential stat up, shutdown of machines and overall sequence operation. Necessary programmers for functional drive /individual drive control, monitoring feedbacks, system disturbance feedbacks etc, shall be built into sequence control equipment.

The unit programmable controller should have sufficient input/output capacities and program memory space to enable complete control of the unit. The governor control action through PID should be independent of the sequential control action. The unit controller shall be capable of functioning independent of the other controllers and shall have the facility of changing the logic program when required.

Unit control board shall be local control centre for overall sequence of operation. At start-up or shutdown, it will execute a set sequence programme. Based on process criteria, it shall generate commands for drive control or functional group for execution of programme. It shall check for presence of all required criteria before it shall issue a particular command. The execution time shall also be monitored and if execution time exceeds the stipulated time limit, a trip or an alarm command shall be issued. It shall be possible to control the unit from unit control board in fully automatic mode, step by step mode and manual mode.

The system shall have the following features incorporated.

- Checking of start criteria
- Automatic start up
- Monitoring of acceleration up to synchronous speed
- Automatic synchronizing
- Loading up to full load
- Electrical isolation of the unit
- Quick complete automatic shutdown of the unit
- Emergency shut down of the unit
- Manual Control and Interruption of Auto Control at any stage

The system shall provide flexibility in operation and shall enable the operator to select any mode/step of parallel operation at any stage. In case of any abnormalities arising at any stage/step during run up of the machine, the system shall run back and take the machine to the previous/safer step. The system shall be compact, reliable and self-contained, with self-checking facility and maximum reliability shall be built into the system. Adequate status indicators shall be provided to keep the operator informed of the sequence status, unsafe conditions, malfunctions and incorrect operations of the system. Adjustable set points for field adjustments shall be provided so that these can be matched with the operation of the unit as well as the logic system. The system shall be flexible enough for the operator to provide set points as required from time to time.

The control room shall be remote control centre and shall have integrated control (MMI) and Data acquisition system (DAS). MMI/DAS shall be capable of performing following functions:

- Supervision of plant processes.
- Processing of plant information & presentation.
- Analysis of plant events.
- Keyboard based control of the plant.

- Long-time storage of data for analysis of plant performance.
- Monitoring of plant performance by periodic calculations.

MMI/DAS system shall be processor based and shall be operated through Operators Workstations (OWS) consisting of display units, functional keyboards or processing unit. Any of the workstations shall be capable of controlling all three units and other shall be in standby mode.

The software for following function shall be included in MMI/DAS System.

a) Display Function
   Plant Schematic displays
   Control displays.
   Alarm Displays.
   Unfilled Criteria Displays.
   Plant Summary Displays.
b) Recording/Logging Functions
   Alarm and event log.
   Post trip log.
   Plant status log.
   Daily Log.
   Hourly Log / Shift Log.
c) Data Acquisition and processing Functions
   Analog Inputs
   Binary Inputs
   Analog outputs

d) Control Functions

Control functions for control of groups/individual drives shall be provided. These shall be suitable for execution through CRT displays using identification of control elements with numbers and issue of control commands. The movement of the cursor, selection of control element, progress of command error status, if any, shall be displayed. Dedicated keys shall be provided on the function key-board for performing these functions.

The data list for the switchyard programmable controller shall include at least the following:

- Powerhouse data input/output
- Circuit breaker positions,
- Disconnect switch positions,
- Earthing switch positions,
- Circuit breaker alarms,
- Circuit breaker orders,
- Disconnect switch order,
- Current inputs,
- Voltage inputs,
- Analog inputs,
- Relay fault detections.

Alarm and trips.

The protective gear shall include the following minimum alarms and shall be provided on the turbine and governor equipment.

1. Governor system	-	Low oil pressure
2. Governor oil pump	-	Failure
3. Turbine bearings	-	High temperature
4. Governor oil pumps	-	Intermittent failure
5. Governor sump tank	-	High and Low oil level
6. Nozzle opening	-	Malfunction.

The following minimum tripping with alarm shall be provided on the turbine and governor equipment:

1. Hydraulic Gates(upstream)	-	Emergency closure
2. Turbine bearing	-	Very high temperature
3. Turbine over speed	-	110 percent (in manual mode)
4. Governor oil pump	-	Failed
5. Turbine over speed	-	115 percent (in auto mode)
The following minimum alarm & trip contact shall be provided for the generator:		
1. Generator bearing	-	High temperature (Alarm & Trip)
2. Fire detection	-	Operation (Alarm)
3. Exciter faults	-	Operation (Alarm & Trip)
4. DC control supply failure	-	Alarm & Trip
5. Generator over speed	-	Alarm & Trip
6. Generator winding	-	High temperature (Alarm & Trip)

1.14.3. PC Based Supervisory and Control Station

The supervisory and control station shall be one IBM compatible PC-AT operator station connected to the master controller through proper communication network.

It shall perform the following functions:

- acquisition of analog and digital inputs from the master controller.
- management of man-machine interface.
- control of units from supervisory station.

The PC based supervisory system should provide the man machine interface for the acquisition and control of digital and analog data. It should offer complete management information system facilities with periodic and on demand reporting along with powerful graphic utilities for drawing mimic diagrams, plotting trends and historical measurements.

The system should support a menu driven user-friendly package to monitor and control the operations of the plant.

1.14.4. Operator Interface

The operator workstation should be based on a 35 cm colour monitor, its associated keyboard and a mouse.

The display screen for mimic views shall be divided into several areas as follows:

The title area should contain the date, time and the title of the mimic.

The mimic area should represent the pictorial view of the process plant depending on the title of the chosen view. The relevant measurements and field statuses must also be available in this area. It should be possible to send commands from the views using mouse as well as from the command menu. The dialogue area must give various messages explaining the operator what is to be done.

1.15. ANNUNCIATION SYSTEM

Luminous multipoint annunciation with suitable number of windows for projecting visual and audible signals in case of faults shall be provided on the front panel wherever specified. The audible alarm shall be provided by alarm hooter / buzzer or bell. Trip and non-trip facia shall be properly distinguished by providing trip facia in red colour and non-trip facias in white colour. Separate audible alarm shall also be provided for trip and non-trip functions by using hooter for trip alarms and bell / buzzer for non-trip alarms. The annunciator system shall be suitable for operation on 220V D.C. supply. A separate voltage check relay shall be provided to monitor the failure of supply to above scheme. On detection of the same, visual & audible annunciation operated through 240 V AC supply shall be given.

1.16. MIMIC BUS DIAGRAM BOARD

A mimic bus diagram shall be provided on the control, metering and protection panels (CMP). Mimic diagram shall be screwed on to the desks and shall be made of anodized aluminium or plastic of approved fast colour. The mimic shall be 10 mm wide for horizontal run and 5 mm wide for vertical run.

The semaphore indicators for disconnect switch/circuit breakers positions, shall be so mounted in the mimic, that disconnect switch or circuit breaker closed position shall be part of the mimic. The mimic diagram shall incorporate red and green lamps for disconnect switch position indication and controlling switches with indicating lamps for circuit breakers.

Alternatively, automatic semaphore indicators for disconnect switches and built in hand operated semaphore and position indicating lamps for circuit breaker control switches may be provided.

The lamps will remain steady where the hand operated semaphore position does correspond with the circuit breaker position.

The lamps shall flicker with a time delayed alarm if the semaphore position does not correspond with the circuit breaker position.

1.17. Spare Parts and Special Tools

The spare parts mentioned hereunder are meant for use by the employer for 5 yrs trouble free operation & shall not be used as erection / commissioning spares required during installation. All the spare parts shall be interchangeable & shall be of the same material and workman ship as corresponding parts of the main equipment.

If any additional spare parts required for a 5-year trouble free operation period are recommended by contractor, these shall be listed and the unit price shall be quoted in the price schedule. The employer reserves the right to order any or all of such spares.

All spare parts shall be suitably packed, clearly marked and ready for long term indoor storage.

Mandatory Spare parts:

The following spare parts shall be mandatorily included in the supply. A set in the list below, shall imply quantity provided for one (1) generator & Excitation System:

S.No	Item	Quantity
	Generator	
1	Upper Guide Bearing Pads	2 sets
2	Thrust bearing pads	2 sets

3	Lower guide bearing pads	2 sets
4	Brake lining / Brake pads	Four (4) sets
5	Stator Cooler unit	1 set
6	Oil cooler for lower guide bearing	1 set
7	Oil cooler for combined thrust and guide bearing	1 set
8	RTD for cooling air inlet	1 set
9	RTD for hot air outlet	1 set
10	RTD for upper guide bearing	1 set
11	RTD for combined thrust and guide bearing	1 set
12	Dial type thermometer	1 set
13	Water flow relay for cooling circuits	1 set
14	Gasket for brake cylinders	Two (2) sets
15	Gasket, washer for air coolers	Two (2) sets
16	Friction Brake (Cushions) Pads	4 sets
17	Gate valves & valves for water & oil pump	two (2) for each type
18	Vibration sensor	1 set.
19	Oil moisture detector	1 set
20	Coils, contacts, spring for relays, contractors, breaker, switches	1 set
21	Level switch, pressure switch, pressure gauge with electrical contacts	2 sets each type
22	Bearing oil level indicator for LOS	2 sets
23	Rotor collector assembly (slip ring) with all insulation material	2 sets
24	Generator speed sensor	2 Nos.
25	Hydraulic over speed device	2 Nos.
26	Air cooler water flow indicator	2 sets

27	Automatic air vent valves for Bearing oil coolers, Air coolers etc.	2 sets
28	Air gap sensor (if opted)	1 set
Excitation System		
1	Modules of DVR like DC-DC converter, ac-dc converter, digital control unit, pulse supervision unit, pulse final stage unit, analog input-output modules, etc.	1 set
2	Spare parts of field discharge breaker comprising of : • Opening coils • Closing coils • Main contact • Discharge contact	2 sets
3	Field discharge resistor • Latch and trigger assembly • Auxiliary contact block	2 sets
4	Spare Parts of Rectifier bridge: : Complete Thyristor bridge c / w racking components	2 nos

5	Spare Parts of Rectifying equipment: Thyristors • Thyristors fuses • Cooling fan for thyristor bridge • Field flashing contactor • Fuses of various ratings • MCBs of various ratings • Air flow sensor • MCCBs of various ratings • Micro terminal for MMI Aux relays / contactor • AC and DC isolator with micro switch • Heat sinks for Thyristors • Clamps for Thyristors • Snubber Assemblies for Bridge • Pulse transformers • Power transistors	1 Set
6	Protection Relays • Rotor earth fault relay (I / II stage) • Transformer O / C relay	1 No 1 No
7	Spare Parts for circuit breakers: • Closing Coil • Tripping Coil • Arcing contact • Arc Chute • 4 Pole aux. Switch	2 Sets
8	Varistor Discs	1 set
9	Plug in Circuit cards	1 set
10	Terminal Blocks (100 Nos)	1 Lot
11	Contactors • DC Contactors • AC Contactors	1 set
12	Spare parts for Excitation Transformer such as temperature scanner, insulator, braided connector etc.	1set

Special Tools and Maintenance Equipment

Contractor shall supply, for hand over to Employer one set of special tools and maintenance equipment, recommended by Contractor for generator & Excitation System. The list of these tools shall be approved during detailed engineering.

However, it shall include at least the following maintenance equipment for repairs and maintenance with descriptions and quantities of the following:

- Two (2) sets of all spanners including D ring and box type of all sizes,
- Two (2) sets of torque wrenches of each size and hydraulic bolt tensioner for coupling bolts having the complete set of drives / boxes mounted on the cabinet,
- One (1) set of all precision tools required for assembly, alignment and maintenance of the hydro generator as per the indicative list mentioned below:
  - Ten (10) Dial indicators (accurate to 0.01 mm) with magnetic base,
  - One (1) set of 200 mm and 300 mm master block level (least count 0.02 mm / m) each,
  - One (1) complete set of micro meters (inside and outside) (0-50, 50-100, 100150, 150-300);
  - Two (2) sets of Height gauges,
  - One (1) set of vernier callipers (150 mm to 1000 mm),
  - Three (3) sets of knife-edges up to 1 m,
  - Three (3) set of Straight edge 1000 mm,
  - Six (6) sets of feeler gauges from 0.05mm to 1mm in denomination of 0.05 mm, 300 mm long,
  - All special tools for measurement of magnetic axis, air gap, rotor and stator from, etc,
  - Any other special tool required for erection and maintenance.
- One (1) set of special turning and lifting devices along with hardware, .for stator, rotor, rotor poles, etc.
- One (1) set of pole assembly and removal devices / tools,
- Two (2) set of brazing / soldering equipment / device for stator bars / rotor including all tools, etc. (may specify the list of included items),
- Three (3) sets of all types and sizes of eye bolts and D shackles and special slings.
- Two (2) sets of removal / assembly arrangement devices and tools for all of the thrust and guide bearings,
- Two (2) sets of coupling assembly and dismantling arrangements, special devices, tools, elongation measurement, instruments, including hydraulic and mechanical jacks, etc,
- Any other tools / special devices specially required for erection and maintenance of the proposed design of the generator,

- Any special tools & maintenance equipment required for maintenance of Thyristors / Excitation equipment in Hot & Cold state shall form part of this specification & shall be supplied for handing over to employer. The list of these items shall be furnished with offer & finalized during detailed engineering.

1.18. TESTS

Each generator shall be tested in assembled condition as detailed below

1.18.1. TESTS AT SUPPLIER'S WORKS (SHOP TESTS)

The generator shall be completely assembled at manufacturer's works and following type tests as per IS 4722- 1992 standards or equivalent International Standards are to be carried out on first generator only. Test shall be carried out in presence of Purchaser/Consultant.

- Measurement of winding Resistance.
- Insulation resistance test.
- High Voltage Test
- Measurement of open-circuit Characteristic.
- Measurement of short-circuit Characteristic.
- Temperature rise test by indirect method.
- Measurement of shaft Voltage.
- Dielectric strength test.
- Moment of Inertia test.
- Occasional Excess Current Test; 150% of rated current at short circuit condition for 15 sec.
- Phase Sequence Test.
- Measurement of voltage waveform distortion factor at no-load.
- Run-away speed test shall be done on 110% of rated speed for 2 min.
- Efficiency test by summation of loss method.
- Additional tests as recommended by manufacturer, as mutually agreed between Purchaser and supplier.

1.18.2. ACCEPTANCE TESTS

Following acceptance tests shall be carried out for three generators in assembled condition after shop tests:

- Measurement of winding Resistance.
- Insulation resistance test.
- High Voltage Test
- Measurement of open-circuit Characteristic.

- Measurement of short-circuit Characteristic.
- Measurement of shaft Voltage.
- Dielectric strength test
- Moment of Inertia test
- Phase Sequence Test.
- Pressure Test on Coolers for closed circuit cooling, if required.
- Additional tests as recommended by manufacturer, as mutually agreed between Purchaser/Consultant and Supplier
-

1.18.3. SITE TESTS

After delivery and installation of the generators at site, following tests shall be carried out during commissioning:

- Phase sequence and direction of rotation
- Mechanical run
- Measurement of winding insulation resistance (before and after HV tests)
- High Voltage dielectric test
- Measurement of shaft voltage
- Measurement of winding resistance
- Measurement of vibration & noise level
- Synchronizing Test
- Excitation system response test / check
- Load acceptance and rejection tests at selected load from "no load" to "full load".
- Any additional tests as mutually agreed such as measurement of slip / power factor etc.

1.18.4. OUTPUT TESTS

Load test shall be carried out at site for eight weeks to show rated output on each generator before releasing for commercial operation.

1.19. TESTING EQUIPMENT

All testing equipment including HV test kit and vibration measurement equipment required for testing of the generator at site shall be provided by the Supplier free of charge and taken back after testing is completed.

The torque for onsite test must be measured as well. In the event repeated testing becomes necessary, the entire expenditure on such repeat tests shall be borne by the Supplier.

1.20. CHARACTERISTIC CURVES

The generator characteristic values for determination of performance shall be arrived either through circle diagram method or equivalent circuit method after conducting all required tests on the generator even though they have not been specifically mentioned above.

After testing the machine, the equivalent circuit of the generator, phase diagram and the performance characteristics like load versus efficiency; load versus power factor or load versus magnetizing kVAR, kVA and kW output and load current shall be determined and furnished to Purchaser/Consultant by the Supplier.

Tests on other equipment like auxiliaries, CTs, PTs, LAs shall comply with the routine tests etc. as per relevant standards.

1.21. INDICATING INSTRUMENTS, CONTROLS AND SAFETY DEVICES

A list of indicating instruments, controls and safety devices is given below. The bidder shall also include those instruments, controls and safety devices necessary for safe and efficient operation of unit even though not specifically mentioned in the Schedule.

S.No	Description	Quantity
	A. For Generator Indicating / Recording Instruments	
1	Dial thermometer for generator, bearing temperature indication to have contact for alarm / trip	1 Lot
2	10 points indicators for stator winding temperature and bearing temperature	-do-
3	Generator heater ON/OFF indicating lamps	-do-
4	Brakes ON/OFF indication	-do-
5	Flow meter (water) / Pressure (oil) for bearing cooling (if applicable)	-do-
6	Unit output meter (kW)	-do-
7	Unit kVAR meter (with center zero)	-do-
8	Unit Voltmeter	-do-
9	Unit Ammeter	-do-
10	Unit Power factor meter (with center zero)	-do-

11	Unit frequency meter	-do-
12	Unit energy meter (kwh)	-do-
13	Elapsed time meter	-do-
14	Indicating lamps for generator circuit breaker, open/ close/ test position	-do-
B. For Generator (Safety Devices)		
1	Generator Winding temperature	1 Lot
2	Generator bearing temperature	-do-
3	Machine Shutdown under various faults	-do-
4	Emergency Shut Down	-do-
5	Machine Over Speed shutdown	-do-
6	DC Control Supply failure indication	-do-

1.22. ERECTION, TESTING AND COMMISSIONING

The Supplier shall depute his experts to carryout erection, testing and commissioning of generators and other associated and auxiliary equipment connected with the powerhouse and duly hand over the same to the satisfaction of the Purchaser. This work shall be included in the scope of contract and nothing extra shall be paid on this account. The Supplier shall train the staff of the Purchaser on the job and instruct them during mounting period.

1.23. DRAWINGS

Contractor shall furnish six (6) sets of all the drawings for approval. After approval and after work completion at site six (6) sets of as built drawings and one set of reproducible print sheets shall be supplied. Drawings to be submitted for approval are as follows:

- GA and Layout drawings, Generator Sectional Arrangement
- Single line Diagram (for Electric Circuit)
- Arrangement of stator Terminals (Phase + Neutral)
- Gen. Outline & lifting Arrangement
- Excitation and Auto Sequencer Controls Drawings
- Cable Schedule, cable trays layout drawings for Generator & Auxiliaries
- Rotor assembly drawing
- Loads and moments during short circuits to enable civil foundation design with details of foundation frame.

- Load efficiency curve for generator.
- Design calculations for arriving at important parameters of the generator.
- Erection method and any special grouting procedures to be followed for Base Frame for erection of generator.
- Any other drawings as required at the time of detail engineering.

1.24. GUARANTEED TECHNICAL PARTICULARS

The guaranteed technical particulars of generator and associated equipment shall be furnished in the bid.

1.25. MISCELLANEOUS ACCESSORIES

- The generator shall be supplied with foundation frame, sole plates, foundation bolts, jack bolts and pads for on-site erection and alignment.
- Two earth terminals shall be provided for earthing the generator.
- An anti-condensation heater to prevent condensation of moisture during shut down periods shall be provided.
- Generator shall be provided with lifting hooks and base frame extensions to unload and handle at site.
- Heavy duty cabling to connect with grid station and transformers.
- Light cabling for monitoring and communication cable shall be included in scope of Supplier.

1.26. DETAILS OF SUB-ASSEMBLIES

Each generator shall be equipped as follows in accordance with the specifications described in the preceding clauses:

Item	**Quantity**
Generator stator complete with frame, sole plates, core, winding with accessories and terminals	One No.
Generator caged rotor complete with shaft, spider rim, poles with windings and accessories	One No
Anti Condensation space heaters	One Set
Air guides	One Set
Fabricated base plate, sole plates, foundation bolts for generators and its bearings	One No
Resistance type temperature detectors (RTD's)	One Set
Dial thermometer with electrical contacts for alarm and trip for bearings	One Set
Multi-point temperature indicator	One Set
Neutral grounding cubicle (if applicable)	One No

Line terminal cubicle (if applicable)	One No
Oil operated brakes with necessary piping (if applicable)	One Set
Space heater	One Set
Shaft mounted fans	One Set
Instruments, control and safety devices if required	One Set
Air coolers (if applicable)	One Set
Bearing Oil coolers, (if applicable)	One Set
Toothed wheel, photo interruptive pick-up cable, speed relay & tachometer	One Set
Permanent magnet generator with speed relay & tachometer (if applicable)	One Set

1.27. WARRANTY

The warranty period shall be of 12 months from the date of operational acceptance of the plant or eighteen months from the date of dispatch, whichever is earlier.
The warranty period is extended by each single shut-down period in excess of one month caused by damages of parts supplied by the Supplier which are under guarantee.
For any required and / or replaced parts the initial guarantee conditions apply with a minimum guarantee period for such parts of over 12 months.

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2. AUXILIARY TRANSFORMERS

2.1. GENERAL

The scope of this tender covers design, fabrication, testing, supply, loading, transportation, insurance, unloading, storage, handling, erection, testing & commissioning of three numbers of three phase Generator Step Up Transformers, One no. of three phase SST, three nos. three phase Unit Aux Transformers and other auxiliary transformers for Barrage and Colony along with its accessories. The transformers shall be of core type and suitable in every way for operation on the system and under the conditions specified in this specification.

The transformers shall be designed, manufactured, and tested in conformity with the latest issue of Indian Standards, IEC 76 and / or BS 171. The transformer and associated auxiliaries and equipment's shall be designed to facilitate operation, maintenance and repairs. All apparatus shall be so designed to ensure satisfactory operation under such sudden variations of load and voltage as may be met with under operating conditions on the system, including those due to short circuit.

All marshalling kiosks and other required auxiliaries, as required are included in this contract.

2.2. SCOPE OF REQUIREMENT

1. One (1) Nos., 800 KVA, three phase, 33/0.415 KV Dyn11, 50 Hz., ONAN type Station Service Transformer with "off-circuit" taps in steps of 2.5% from +2.5% to -10% of the rated voltage on H.V. side, neutral CT on LV side, instrumentations and complete with accessories and fittings, as specified and suitable for outdoor mounting.

2. One (1) No., 250 KVA, three phase, 33/0.415 KV Dyn11, 50 Hz., ONAN type Auxiliary Transformer for Barrage with "off-circuit" taps in steps of 2.5% from +2.5% to -10% of the rated voltage on H.V. side, neutral CT on LV side, instrumentations and complete with accessories and fittings, as specified and suitable for outdoor mounting.
3. Three (3) No., 250 KVA, three phase, 11kV/ 0.415 KV, Dyn11, 50 Hz.,dr y type Unit Auxiliary Transformers with "off-circuit" taps in steps of 2.5% from +2.5% to -10% of the rated voltage on H.V. side, protection CTs on H.V. side, neutral CT on LV side, instrumentations andcomplete with accessories and fittings, as specified and suitable for indoor mounting
4. One (1) No., 500 KVA, three phase, 33/0.415 KV Dyn11, 50 Hz., ONAN type Auxiliary Transformer for Colony with "off-circuit" taps in steps of 2.5% from +2.5% to -10% of the rated voltage on H.V. side, neutral CT on LV side, instrumentations and complete with accessories and fittings, as specified and suitable for outdoor mounting.

Power Transformer is rated to suit the output of one generator. Power transformer and Station Service Transformer shall be located in the outdoor rail mounted, near the Powerhouse and separated by fire walls as per prudent practices. Unit Aux Transformers shall be located indoor in the Powerhouse. The Bidder shall provide the clearances required for the transformers as per relevant latest IS Codes / IEC / BS Codes, keeping in view the availability of space in Switchyard. Bidder shall clearly indicate the same in the drawings.

The High Voltage side of power transformer shall be at 33kV and shall be suitable for connection to the 33 KV switchyard equipment. LV side of the Power transformer shall be connected through 11 kV XLPE cable to Generator. Suitable connection for the HV side and LV side of all the transformers shall be the responsibility of the Contractor and the same shall be clearly specified in the Bid Document.

The Power transformer shall be oil immersed type with ONAN/ONAF type of cooling and shall be complete with all accessories and auxiliaries. Station Service Transformer shall be cooled by using oil natural and air natural (ONAN) cooling system and shall be supplied complete with all accessories and auxiliaries as specified in the technical specification. Special devices, tools, maintenance equipment etc. required for installation, testing and commissioning and maintenance of transformers shall be supplied.

Power Transformers shall be transported dully filled with oil with tanks sealed.

It is not the intent to specify completely all details of design and construction of equipment. However, the equipment shall conform, in all respect, to high standard of design, engineering and workmanship and be capable of performing in continuous commercial operations up to the supplier's guarantee in a manner acceptable to Engineer in-charge who will interpret the meaning of drawings and specifications. While designing the transformers, the site elevation as well as transportation limitations shall be kept in view.

2.3. OPERATING CONDITIONS

The maximum flux density in any part of the core and yoke at the rated MVA,

voltage and frequency shall be such that under 10% continuous over voltage condition, it does not exceed 1.9 Tesla. Lower flux densities will be preferred if these result in lower noise levels. The Bidder shall clearly indicate additional cost, if any, if low flux density is adopted.

The average sound level due to operation of the transformer and accessories shall not exceed the applicable limits specified in NEMA Standard Publication TR-1. The transformer shall be free from undue or harmful vibration of the transformer or accessories or any vibration, which will cause avoidable noise.

Transformer shall be capable of operating at over voltage due to sudden load rejection, approximately 25% above the rated voltage for a period of one minute and 40% above the rated voltage for a period of 5 seconds.

The transformers shall be designed with particular attention to the suppression of harmonics voltage especially 3rd & 5th so as to eliminate waveform distortion and from any possibility of high frequency disturbances, inductive effects or of circulating currents between the neutral points of different transformers reaching such a magnitude as to cause interference with communication circuits.

The Power transformers shall be capable to operate satisfactorily in parallel with each other and shall be interchangeable.

Transformer shall be capable of withstanding without damage, the thermal and mechanical stresses caused by symmetrical or asymmetrical faults on any of the windings, i.e. HV or LV.

2.4. TECHNICAL PARAMETERS OF TRANSFORMERS

The rating and electrical characteristics of the transformers shall be as follows: These shall be suitable for installation at an altitude < 1000 meters above mean sea level.

Sl No.	Particulars	Unit Auxiliary Transformers	Station-Service Transformer	Aux. Transformers
1	Rated Output	250 KVA	800 KVA	500 KVA and 250 KVA
2	Type of Transformer	Core Type	Core Type	Core Type
3	No. of Phases	3 (Three)	3 (Three)	3 (Three)
4	Quantity	3	1	1
5	Frequency	50 Hz ± 3%	50 Hz ± 3%	50 Hz ± 3%

6	Cooling medium	AN	ONAN	ONAN
7	Duty	Continuous	Continuous	Continuous
8	**Rated Voltage**			
	a) H.V. Winding	11 kV	33 kV	33 kV
	b) L.V. Winding	0.415 kV	0.415 kV	0.415 kV
9	Taps	Full capacity taps on H.V. winding to give variation of +2.5% to -10 % of rated voltage in steps of 2.5%.	Full capacity taps on H.V. winding to give variation of +2.5% to -10% of rated voltage in steps of 2.5%.	Full capacity taps on H.V. winding to give variation of +2.5% to -10% of rated voltage in steps of 2.5%.
10	Type of Tap changing gear	Off-circuit Type	Off-circuit Type	Off-circuit Type
11	Connection Details	**HV** Through 11 kV, 3Cx 25 sq mm Copper Conductor XLPE Cable **LV** Through 1.1kV grade, 2RX3.5Cx150 Sqmm, XLPE insulated, armoured Copper conductor cables	**HV** Through 33 kV, 3Cx 35 sq mm Copper Conductor XLPE Cable **LV** Through 1.1kV grade, 4RX3.5Cx400 Sqmm, XLPE insulated, armoured Copper conductor cables	During Detailed Engineering
12	Highest Voltage, HV	12 KV	36 KV	36 KV
13	**Method of System Earthing**			
	a)H.V.	--	--	--
	b)L.V.	Effectively Grounded	Effectively Grounded	Effectively Grounded

14	Class of insulation	**A**	**A**	**A**
15	**Connection**			
	a) H.V.	Delta	Delta	Delta
	b) L.V.	Star	Star	Star
16	Vector group	Dyn11	Dyn11	Dyn11
17	Neutral Terminal to be brought out	On L.V. Side	On L.V. Side	On L.V. Side
18	Percentage Impedance	5%	5%	5%
19	Details of Auxiliary supply	220 V D.C. -10 & + 10%, and 3 phase 415 V ± 10%	220 V D.C. -10 & + 10%, and 3 phase 415 V ± 10%	-
20	Minimum creepage distance in air	31 mm/kV	31 mm/kV	31 mm/kV
21	Type of installation	Indoor, Dry Type	Outdoor, ONAN type	Outdoor, ONAN type

2.5. APPLICABLE STANDARDS AND CODES

The equipment and materials covered by this specification shall conform to the latest edition of following Indian Standards or equivalent IEC standards except where specified otherwise in this specification:

Equipment and Material	**Code**
Power Transformer	IS: 2026 (Part I to IV)/IEC 76
Transformers bushings	IS: 2099/IEC 137

Current transformers	IS: 2705/IEC 185
Transformer oill	S: 335
Gas and oil operated relay	IS: 3637
Fittings and accessories for power transformers	IS: 3639
Dimensions for porcelain transformer bushings	IS: 3347
Loading guide for oil-immersed transformers	IS: 6600/IEC 354
Lightning Arresters	IS: 3070
Cable Box for Transformers	IS:9147
load tap changers	IEEE: C 57.1311995

Transformer, accessories, etc. meeting any other authoritative standard, which ensures equal or better quality than the Standards mentioned above, shall also be acceptable. However, where the equipment offered conforms to any other standards, the salient points of difference between standards adopted and provision of this specification and standards referred above shall be clearly brought out in the Bid. Copies of such standards in English language or fair English Translation shall be attached with the Bid.

2.6. SPECIFICATION FOR TRANSFORMER

2.6.1. CORE MATERIAL

All transformer cores shall be fabricated from high grade non-ageing, high permeability, cold-rolled super grain-oriented silicon steel lamination known as HI-BI steels trade name or other approved steel having low-loss characteristics and preferably leading to low noise levels. The thickness of the sheet shall be 0.23 mm or less. However, the Bidder shall indicate the thickness of the sheet in the Bid Document.

2.6.2. CORE CONSTRUCTION

The magnetic circuit shall be of core/shell construction designed to avoid static discharges and the development of short circuit paths within itself or to the earthed clamping structure and the production of flux component at right angles to the plane of lamination, which may cause local heating. After shearing, the laminations shall be treated to remove all burrs and remove residual stresses so that the laminations are flat and the finally assembled core is free from distortion. Laminations shall be coated with a durable baked enamel insulation coating, which shall be inert to the action of hot transformer oil. Paper and varnish insulation will not be accepted. The nature of insulation shall be stated in the Bid. Mitred joints between cores and yokes shall be employed on all sizes of transformers for which this technique is practicable. The mitred joints in the core shall be interleaved. On no account must `butt' joints be offered.

All parts of the core shall be of robust design which is capable of withstanding mechanical shocks during normal lifting, transportation and handling of the transformer, and bracing of the core and winding assembly must be adequate to prevent any movement of core and winding relative to the tank during the conditions mentioned above. The clamping structure shall be so constructed that eddy currents are minimum. All structure members of the assembled cores shall be of steel except where conventional core-bolt clamping is replaced by taping or banded-clamping or epoxy fibre technique.

Adequate fitments, eyes and lugs, shall be provided for lifting the completed core and windings, and suitable accommodation, attached to each transformer, shall be provided for the storage of any removable parts of the lifting gear.

All castings shall be fettled, and structural steel shall be adequately painted before being built into the structure. Any non-magnetic or high-resistance alloy included in the design shall be subject to approval. All painting designed to be under oil or in contact with oil shall be subject to approval.

The supporting framework of the core shall be designed to avoid the presence of pockets which would prevent complete emptying of the tank through the drain valve, cause the trapping of air during filling, or cause the tripping of gases which evolve during in-service faults. All steel sections used for supporting the core shall be thoroughly sand blasted or shot blasted after cutting, drilling and welding.

2.6.3. CORE OIL DUCTS

Suitable axial oil ducts shall be provided where necessary to ensure appropriate cooling by free circulation of oil. The winding structure and main insulation shall not obstruct the free flow of oil through such ducts. Where the magnetic circuit is divided into pockets separated by more than 0.25 mm by cooling ducts parallel to the plane of the laminations or by insulating material, tinned copper strip bridging pieces shall be inserted to maintain electrical continuity between the pockets. Where oil ducts or insulating barriers parallel to the plane of the laminations divide the magnetic circuit into two or more electrically divided pain, the ducts or barriers shall be bridged as stated previously and the magnetic circuit shall not be regarded as being of sectional construction.

2.6.4. CORE INSULATION

Individual laminations shall be insulated with material, which will not deteriorate due to the action of pressure and hot oil.

With the earthing removed, the magnetic circuit shall be insulated from the clamping and supporting structure and all structural parts, and insulation of core to bolts and core to clamp plates shall withstand a test voltage of 2kVrms at 50 Hz for one minute.

The class and type of insulation and the method of applying it on the core bolts and nuts and side plates shall be stated in the bid .

2.6.5. CORE EARTHING

All metal parts of the transformer except individual core laminations core bolts and side-clamping plates shall be maintained at earth potential.

The magnetic circuit shall be earthed to the clamping structure through one removable core-insulation-test link only, placed in an accessible position beneath the inspection opening in the main-tank cover. The connection to the link shall be on the same side of the core as the main clamping-structure earth connections to the tank and shall be taken from the extreme edge of the top yoke.

Magnetic circuits having an insulated sectional construction shall be provided with a separate link for each individual section and the arrangement of the connections shall be subject to approval.

Where clamping ring of coil are of metal at earth potential, each ring shall be connected to the adjacent core clamping structure on the same side of transformers as the main earth connections.

2.6.6. WINDING CONDUCTOR MATERIAL

The conductor windings shall be of high-conductivity electrolytic grade copper free from scale and other defects. Transposed winding conductors shall be employed where appropriate.

The transformers shall be designed to withstand the impulse & power frequency test voltages in accordance with IS-2026.The windings shall be designed to reduce to a minimum the out-of-balance electromagnetic forces in the transformer at all voltage ratings / tapings and the voltage between adjacent coils shall be kept as low as consistent with the good design.

All permanent current carrying joints in the windings and leads shall be brazed. The windings shall be designed to reduce to a minimum the out-of balance forces in the transformer at all ratios and special care shall be given to design and construction of tapped coils and connections.

The construction of the windings shall be such as to ensure uniform voltage and stress distribution on the windings in the event of high frequency impulses applied to the windings and the means adopted for the same shall be stated in the Bid.

The insulation of transformer's windings and connections shall be surge proof and should be free from insulating composition liable to soften, ooze out, shrink or collapse and be non-catalytic and chemically inactive in transformer oil during service.

The windings shall be so designed that all coil assemblies of identical voltage rating shall be inter-changeable and field repairs to the windings can be made readily without special equipment. The coils shall be supported between adjacent sections by insulating spacers and barriers. The windings shall be dried by vapour phased system.

2.6.7. WINDING CLAMPING AND BRACING

The windings and connections shall be adequately braced to withstand mechanical shocks and electromagnetic impulsive force, which may occur during handling, transportation, and transient current surges. Bracings and other insulation used in the assembly of the windings shall be arranged to ensure free circulation of the oil and to reduce hot spots in the windings.

The stacks of windings shall receive adequate shrinkage treatment before final assembly so that any further shrinkage during service is not possible. However, adjustable devices shall be provided for taking up any shrinkage of coils in service.

The coil-clamping arrangement and the finished dimensions of any oil ducts shall be such as this will not impede the free circulation of oil through the ducts.

Coil-clamping rings shall be of approved material (preferably steel) but axially laminated material other than bakelised paper shall not be used. Metal clamping rings will be earthed. Clamping assemblies shall be arranged to prevent deterioration of the core characteristic.

Any metal pieces in contact with non-metallic clamping rings shall be so designed and secured that they do not weaken the electrical or the mechanical properties of the rings.

If the winding is built up of sections or disc coils, separated by spacers, the clamping arrangements shall ensure that equal pressure is applied to all columns of spacers. All such spacers shall be of approved material and shall receive adequate shrinkage treatment before assembly.

2.6.8. WINDING INSULATION

All windings of Power Transformer shall have non graded insulation. All neutral points of star windings shall be insulated for the voltages as specified in IS: 2026. Use of enamel as sole conductor insulation shall not be accepted.

The insulation of windings and connections shall be free from insulating composition liable to soften, shrink or collapse and in case of oil filled transformers shall be non-catalytic and chemically inert in transformer oil during service.

For oil immersed transformers the insulating media shall be of Class- A material as defined in IEC 85.

2.6.9. WINDING CONNECTIONS

The transformers should be connected in accordance with the IEC group of symbols.

2.6.10. TANK CONSTRUCTION

Each transformer shall be enclosed in a suitably stiffened welded steel oil-tight tank of Bell type construction. Tanks shall be of welded construction and fabricated from tested qualify low carbon steel of adequate thickness. The weld procedure & performance shall be in line with ASME-BPV -IX. The thickness and bracing of the tank shall be such that the tank together with core and oil can be lifted and transported without damage or loss of oil tightness. All seams and those joints, not required to be opened at site, shall be factory welded and wherever possible they shall be double welded. All welding shall preferably be stress relieved.

The base of each tank shall be so designed that it shall be possible to move the complete transformer unit by skidding in any direction without injury when using rollers, plates or rails. The transformer tank shall be suitable for movement in both directions during shipment. The main tank body including tap-changing compartment shall be capable of withstanding full vacuum (760 mm of mercury). Aluminium tanks shall not be considered. Suitable guides shall be provided in the tank for positioning the core and coil assembly. The tanks shall be so designed that with the cores and windings in position there shall be no possibility of formation of pockets where air or gas being trapped when filling the tank with oil, and so that water shall not be trapped on the exterior of the tank. Where pockets cannot be avoided, pipes shall be provided to vent the gas into expansion pipe. The tanks shall be fitted with pockets for a thermometer and the bulbs of a winding temperature indicator and an oil-temperature indicator in maximum temperature zone and it shall be possible to remove the bulbs without lowering the oil in the tank. Protection shall be provided as necessary for the capillary tube. Tank stiffeners shall be provided for general rigidity, and these shall be designed to prevent retention of water. Adequate space shall be provided at the bottom of the tank for collection of sediment.

The tank shields (if provided) shall be such that no magnetic field 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. Bidder shall confirm use of tank shields in the additional information schedule.

2.6.11. PRESSURE RELIEF DEVICE

Each tank of transformer shall be fitted with an approved pressure relief device to release any pressure that may be generated within the tank due to internal fault and which may cause damage to the equipment. An extension pipe shall be fitted above the device such as to direct the major flow of ejected oil down wards and shall be fitted so as to permit its removal without disturbing the device or its flange fixings. The device shall be so located as not to interfere with the electrical clearances for any overhead connections. The device shall fully reseal after release of excess pressure.

The device shall operate at a static pressure, which shall be less than the hydraulic test pressure of transformer tank. Means shall be provided to prevent ingress of rainwater.

One set of electrically insulated contact shall be provided for alarm / tripping. A mechanical indicator, manually reset-able type and clearly visible from a long distance shall be provided to indicate that the valve has operated.

2.6.12. TANK LIFTING AND HAULAGE

Each tank or enclosure shall be provided with the following handling facilities the first three of which must each be capable of lifting and/or moving the transformer complete and filled with oil (where applicable):

- Lifting lugs or eyes of ample dimensions designed so that standard lifting shackles can be readily attached. The lifting eyes, lugs or hooks shall have a factor of safety of not less than 2 (two) to allow for possible unequal lifting forces.
- A minimum of four jacking pads shall be suitably located in accessible positions to make it possible to change the direction of wheels through 90□, when the transformer, complete with oil, is lifted on jacks to permit movement of the transformer both in longitudinal and transverse directions. A convenient track gauge in both longitudinal and transverse direction shall be chosen. Means shall be provided for locking the swivel movements in positions, parallel to and at right angles to the longitudinal axis of the tank. Suitable stoppers for the track wheels shall also be supplied. The pads shall be adequately braced and project a sufficient distance from the transformer side to enable a standard jack to be properly located. The minimum height of the lugs above the base shall be 500 mm excluding the under base dimensions, if detachable.
- Four anchor points shall be fitted to each transformer tank or frame at not more than 760 mm from the base to enable the transformer complete (and filled with oil) to be slewed or hauled in any direction. Suitable haulage holes shall be provided for transformer wheeling in all four directions.
- Lifting handles on the tank-lid or enclosure handhold covers where the size and weight of such covers would make manhandling difficult.

The transformer tanks (where applicable) shall be supported on a strong structural steel base equipped with forged steel or cast steel single flanged wheels suitable for moving the transformer filled with oil. The number and the spacing of wheels shall be specified in the Bid. The wheels shall be provided with grease nipples. Arrangement for clamping of the wheels with the rails, capable of being put on and off easily, shall also be provided. The structural steel supporting base shall be so designed that the centre of gravity of the transformer, with or without oil, will not fall outside the base support members for a tilt of the base of 15 degrees from the horizontal.

2.6.13. TANK COVERS

At least two adequately sized inspection openings of suitable design, one at each end of the tank, shall be provided on the tank cover. The openings shall be of sufficient size to afford easy access to internal connections of bushings, current transformers winding connections and earth link for testing, etc. The design should be such that water shall not collect near the gasketed joints. Tank covers or enclosure panels shall be so constructed that they can be removed and replaced without sustaining damage. Inspection covers shall also be fitted and these shall not be more than 25 kg in weight.

The tank and cover shall be provided with sufficient and properly spaced bolts and gaskets with metal inserts.

All joint faces shall be machined or ground and arranged to prevent the ingress of water or leakage of oil with a minimum of gasket surface exposed to the action of air or oil. Oil resisting synthetic rubber gaskets are not permissible except where the synthetic rubber is used as a bonding medium for cork or similar material. Gaskets, of resilient material which will not deteriorate under the action of hot oil, are to be as thin as possible consistent with the provisions of a good seal and full details of all gasket sealing arrangements shall be shown on the plant drawings.

Enclosure covers and inspection panels shall be accurately fitted and robust to prevent distortion. Countersunk screws may be used for fixing. Gaskets shall be used to deaden vibration where necessary.

The tank cover shall be sloped to prevent retention of rainwater and shall not distort when lifted. Bushings, turrets, cover of inspection openings, thermometer pockets etc. shall be designed to prevent ingress of water into or leakage of from the tank. Turrets and other parts surrounding the conductors of individual phase shall be non-magnetic. Necessary provisions shall be provided to drain out leakage oil/water at the lowest points of the bushing flange wherever required. The tank cover shall be fitted with thermometer pockets (on position of maximum oil temperature at MCR) for bulbs of oil and winding temperature indicators. The thermometer pocket shall be filled with a captive screw top to prevent ingress of water.

2.6.14. EARTHING OF TANK

Two substantial earthing terminals / pads suitable for connecting 50x8 mm mild steel flat capable of carrying the maximum possible earth-fault current shall be provided at positions close to the two diagonally opposite bottom corners of tank. The terminals shall be designed to carry this current without damage for duration at least equal to the short circuit period for which the main windings are designed, in accordance with IEC 76. These grounding terminals shall be suitable for bolted connection. Two earthing terminals shall also be provided each on cooler, marshalling box and any other equipment mounted separately.

2.6.15. BONDING

Substantial bonding-connection studs must be provided to permit the bonding of transformer ancillary equipment and housings not forming an integral part of the main transformer tank.

2.6.16. BUSHING INSULATORS

All bushings shall have the current rating, voltage rating, basic insulation level, creepage distance etc. as per IS: 3347 / IS: 2099 / IEC 37. The standard dimensions shall be kept in view so that transformer can accept any bushing of parameter and dimensions. The bushings shall be subject to snowfall. Proper care of the increase in weight due to snow shall be taken care of while designing the bushings. Any change in ratings due to the same shall be intimated by the Bidder in the Bid document.

All porcelain is to be sound, free from defects and thoroughly vitrified. The glaze must not be depended upon for insulation. The glaze is to be smooth, hard, of a uniform shade of brown and shall cover completely all exposed parts of the insulator. Outdoor insulators and fittings are to be unaffected by the specified atmospheric conditions.

The porcelain must not engage directly with hard metal and, where necessary, gaskets are to be interposed between the porcelain and the fittings. All porcelain-clamping surfaces in contact with gaskets are to be accurately ground and free from glaze. All porcelain insulators are to be designed to facilitate cleaning. Bushing shall also be provided with oil level indicator, suitably placed.

Each porcelain bushing or insulator is to have marked upon it the manufacturer's identification mark. Each porcelain part is, in addition, to be marked to indicate the date of firing. These marks are to be clearly legible and visible after assembly of fittings and are to be imprinted and not impressed. For porcelain parts the marks are to be imprinted before firing and for paper bushings before varnishing.

Bushing insulators are to be mounted on the tank in a manner such that the external connections can be taken away clear of all obstacles. Arcing horns shall be provided on the bushings (33KV side) except the neutral bushing. Neutral bushings are to be mounted in a position from which a connection may be taken if required to a neutral current transformer mounted on a bracket secured to the transformer tank.

2.6.17. BUS BAR AND CABLE CONNECTION

Bus bar Connections:

The bidder shall ensure that bushings are provided to connect “XLPE cable on HV side of the Power transformer, SST and other auxiliary transformers.

The bushings shall be arranged in such a fashion that the bus bar connections can be made conveniently and safely.

Cable Boxes for connecting supply cables & Marshalling Kiosk:

The bidder shall give the provision for connecting the suitable no. of XLPE cable connections and PVC cable for transformer. The power cable and control cables shall be terminated in Marshalling Kiosks to be provided with transformer.

2.6.18. CONSERVATOR, VESSELS AND BREATHER

1. **Conservator:**
   A conservator shall be mounted above the highest point of the oil-circulating system of each oil filled transformer. Connections between the main tank and the conservator shall be such that air or gas is not entrapped, and Buchholz relays can be correctly installed. Conservator shall be provided in such a position so as not to obstruct the electrical connections to the transformer. Conservator shall be complete with sump and drain valve. The oil connection from transformer to the conservator shall be arranged at a rising angle of 3 to 9 degrees to the horizontal and to the Buchholz relay and shall consist of pipe of 80 mm inside diameter.

Conservator shall be designed so that it can be completely drained by means of the drain valve provided, when mounted as in service. One end of the conservator shall be fixed by bolts so that it can be removed to enable the tank to be cleaned.

The capacity of each conservator tank shall be adequate to accommodate the oil preservation system and volumetric expansion and contraction of oil in the whole system, over the extreme range possible in operation.

Conservator shall be fitted with:

- At least one magnetic oil-level indicator / gauge of direct reading prismatic glass type visible from ground level and indicating oil levels over the range specified above. The oil-level indicator shall be marked to indicate the correct oil level with the oil at a temperature of 15degreeC, 30degreeC and 90degreeC.
- Filling orifice with an air-tight captive-screwed cap,
- Low oil level alarm initiating device.

2. Breathers:

Transformers shall be provided with a silica-gel breather of an approved type complete with oil-seal, oil-seal oil-level indication window and a sight glass for inspection of the silica gel. A visual indication of the extent to which the drying agent has absorbed moisture is preferred, showing how much active material remains effective. The unit must allow simple cleaning and replacement of the desiccators and sealing oil without the use of tools, by using wing nuts or similar forms of corrosion-resistant hand-tightening devices. The breather should be mounted at approximately 1,400 mm from ground level and must, together with its connecting pipe, be firmly fixed to the main tank by means of substantial brackets. One spare charge of silica gel shall be provided with each transformer.

Breather shall be designed so that passage of air is through silica gel.

3. Valves and Flanges:

Valves and flanges shall be in accordance with the relevant Indian / International Standard / Manuals.

Inside surface of valves shall be clean and valve ends shall be suitable blanked at the time of dispatch. Asbestos / graphite packing material shall not be used for gland packing / gasket material. Valves and flanges shall be painted from inside and outside as per relevant IS codes. Machined and flanged surfaces shall be suitably protected against rusting and transit damage. All hardware used shall be cadmium plated / electro-galvanized.

Each oil filled transformer shall be fitted with the following valves and plugs / flange with standard screw connection:

- One filter valve located near the top of the tank.
- One filter valve located near the bottom of the tank and diagonally opposite to the valve specified above.
- One valve of adequate size together with such arrangements as may be necessary inside the tank to ensure that the tank can be completely drained and / or the oil can be sampled.
- One valve in the oil-actuated relay connection.
- One drain valve so arranged on the conservator tank that it can be completely drained of oil as far as practicable. Size of drain valve shall be in accordance with IS: 3689.
- One valve between the transformer and relay and another between the relay and conservator.

All valves shall be provided with flanges having machined faces.

Every valve shall be provided with an indicator to show clearly the position of the valve. All valves shall be provided with flanges having machined faces. Means shall be provided for pad locking the valves in the open and closed position.

The oil circuit shall be provided with a valve at each point of connection to the tank.

2.6.19. TEMPERATURE INDICATING DEVICES

The indications of temperature & oil measurement shall be taken to the marshalling box as well as to the control room also. The bidder shall ensure that suitable no. WTI & OTI & other parameters are provided to ensure that the operator in the control room is able to watch the parameters of the transformer.

2.6.20. WINDING TEMPERATURE INDICATOR (WTI)

A device for measuring the hot spot temperature of the winding of transformers shall be provided. The accuracy class of winding temperature indicator shall be ± 2°C or better complete with a winding temperature indicator with separate alarm and trip contacts of approved design. They shall be fitted with a dial-type indicator calibrated in degrees Celsius and fitted with a hand-reset pointer to register the highest temperature attained. The tripping contacts of WTI shall be adjustable to close between 60°C and 120°C and alarm contacts to close between 50°C and 120°C and shall reopen when the temperature falls by 10°C.

The winding temperature indicator shall be so mounted in the transformer marshalling kiosk attached to the main tank that the dial is not more than 1600 mm from the ground level, and the cover shall be equipped with a viewing aperture of adequate size, fitted with clear glass. Mechanical protection shall be provided for the capillary tube, and sharp bends avoided.

It shall comprise the following:

a) Temperature sensing element

b) Image coil the bushing current transformer

c) Auxiliary CTs if required to match the image coil, shall be furnished and mounted in the marshalling box.

150-mm dial type local indicating instrument with maximum reading pointer mounted in marshalling box shall be provided. It shall have two adjustable potential free contacts, one for winding temperature high alarm and one for trip, in addition to the contacts required for control of cooling equipment. There shall be Automatic ambient temperature compensation.

All contacts shall be adjustable on a scale and suitable for connection in 220V DC Circuit. These shall be accessible on removal of the cover.

The WTI shall have a full-scale deflection of at least 240°C and shall have linear graduations to read every 3°C.

The winding temperature indicator shall be energized from a current transformer connected to a heater coil and actuating on to a bulb and capillary tube. Terminals and links shall be provided in the marshalling box for checking the output of the current transformer on load and disconnecting the current transformer from the heater coil to enable the instrument to be used as an oil temperature indicator. A test winding shall be incorporated in the current transformer and the connection brought down to suitable terminals in the marshalling box to enable the operation of the instrument to be checked electrically.

2.6.21. OIL TEMPERATURE INDICATOR (OTI)

Transformers shall be provided with oil-temperature indicators complete with alarm and trip contacts of approved design. They shall each be fitted with a dial type indicator calibrated in degree Celsius and fitted with a hand-reset pointer to register the highest temperature attained.

Transformer shall be provided with a 150 mm dial type thermometer for top oil temperature indication. The thermometer shall have adjustable, potential free alarm and trip contacts, maximum reading pointer and resetting device and shall be mounted in the Marshalling Box. A temperature-sensing element suitably located in a pocket in the top oil shall be furnished. This shall be connected in the OTI by means of Capillary tubing. Accuracy class of OTI shall be ± 2°C or better. The OTI shall have a full-scale deflection of at least 240°C and shall have linear graduations to read every 3°C.

Each oil-temperature indicator shall be so mounted in the marshalling box that the dial is not more than 1600 mm from the ground level, and the cover shall be equipped with a viewing aperture of adequate size, fitted with clear glass. If the temperature-measuring device makes use of a capillary tube, mechanical protection shall be provided and sharp bends avoided where the tube enters the marshalling box.

2.6.22. BUCHHOLZ DEVICES

A double float type Buchholz relay conforming to IS: 3637 shall be provided. All gas evolved in the transformer shall collect in this relay. The relay shall be provided with test cocks suitable for a flexible pipe connection for checking its operation. The device shall be provided with two potential free contacts, one for alarm on gas accumulation and the other for tripping on sudden rise of pressure.

A suitable gas collecting device shall also be provided with each transformer, which shall be mounted in a conveniently accessible position. The gas collector of the relay shall be connected to gas sampling device with a copper tube, the purpose being to carry out gas chromatography. The above should also have a proper arrangement for draining the oil from the relay.

Each oil-containing equipment i.e. transformer tank, tap changer tank, connection chamber etc. shall be fitted with approved vibration-proof gas and oil-actuated relay equipment preferably of the Buchholz type, having alarm and tripping contacts which close following the accumulation of gas, loss of oil or on the occurrence of an oil surge.

An isolating valve shall be mounted on either side of the relay so that it can be easily removed for testing purposes.

A machined surface shall be provided on the top of each relay to facilitate the setting of the relays and to cheek the mounting angle in the expansion pipe and the cross level of the relay.

A straight run of pipe work shall be provided for a length of five times the internal diameter of the pipe on the tank side of the oil-actuated relay and three times the internal diameter of the pipe on the conservator side of the oil-actuated relay.

The design of the relay mounting arrangements and the associated pipework and the cooling plant shall be such that mal-operation of the relays will not take place under service conditions. The oil circuit through the relays shall not form a delivery path in parallel with any circulating oil pipe, nor shall be connected through the pressure relief vent. There shall be no sharp bends in the pipe work.

The Bidder shall submit full details, including pipe sizes, oil-operating velocities, etc., and the size and run of each proposed relay with his Tender.

2.6.23. TAP-POSITION NUMBERING

All tap-position indicators shall be marked with one numeral integer for each tap position, beginning at number 1. Adjacent taps shall be numbered consecutively in such a manner, that when moving a tap to a new tapping position, which has a higher number, the no-load output voltage of the untapped winding increases. The marking of tapped winding which may be reversed shall be based on that connection which gives the highest effective no. of turns for the winding connected to the tap changer.

The terminal marking and their physical position shall be in accordance with IS: 2026 / International Standards unless specified otherwise.

2.6.24. MARSHALLING KIOSKS

Marshalling box of sheet steel weather, vermin and dust proof with sloping/ domed roof with water tight hinged and pad locked door of a suitable construction with interior and exterior duly painted shall be furnished. Sheet used shall be at least 2.5 mm thick.

The box shall be freestanding floor mounted type. The degree of protection shall be IP: 55 in accordance with IS.2147 / International Standards.

The marshalling box shall have a glazed door of suitable size for convenience of temperature indicators reading.

The marshalling kiosk shall accommodate the following equipment or alternatively weatherproof instruments can be mounted outdoor:

1. Temperature indicators mounted at a height not more than 1600 mm from ground level.
2. Control and protection equipment for the electrical control of tap changer.
3. Terminal boards and gland plates for incoming and outgoing cables.
4. Illumination lamp and 5 A, 240 V 3 pin sockets and switch.

All cables shall enter the kiosk from the bottom and the gland plate shall be not less than 450 mm from the base of the box. The gland plate and the associated compartment shall be sealed in suitable manner to prevent the ingress of moisture, rodents, insects etc. from the cable trench. Gland plates, cable lugs, cable glands, etc. shall be furnished. The gland plate shall be made into two detachable halves, for facilitating the termination of other supplier's cables and contractor's cables separately.

The marshalling box shall be supplied with space heater with thermostat control and cubicle lighting with ON-OFF switches and associated fuses.

2.6.25. PAINTING

The internal and external surfaces including oil filled chambers and structural steel work to be painted shall be shot or sand blasted to remove all rust and scale or foreign adhering matter. All steel surfaces in contact with insulating oil shall be painted with two coats of heat resistant, oil insoluble, insulating varnish.

All steel surfaces exposed to weather shall be given a primary coat of zinc chromate, second coat of oil and weather resistant varnish of a color distinct from primary, and final two coats of glossy oil and weather resisting non-fading paint of color light Grey corresponding to shade no. 631 of IS 5. Primary paint shall be as per IS: 104 / International Standards and intermediate and final coats of paint shall be as per IS-2932 / International Standards.

All paints shall be carefully selected to withstand heat and extremes of weather. The paint shall not scale off or wrinkle or be removed by abrasion due to normal handling. The total thickness of the paint shall not be less than 50 microns.

2.6.26. CONTROL CONNECTION AND INSTRUMENT WIRING, TERMINAL BOARD

All controls, alarms, indicating and relaying devices provided with the transformer shall be wired by the supplier up to the terminal blocks inside the marshalling box. The supplier shall supply and install the required 1.1 kV grade heavy duty PVC insulated, steel wire armoured/unarmoured, PVC sheathed, multicore cables with copper conductors of at least 6 sq. mm for CT leads and not less than 2.5 sq.mm for other conforming to IS.1554 / International Standards. The cables shall be properly supported.

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.

Not more than two (2) wires shall be connected to one terminal.

Terminal block for control cable shall be of reputed make. Terminal blocks for CT secondary shall have shorting facility. At least 10% additional terminal blocks shall be provided. All cabling from the marshalling box to various equipment shall be in the scope of the Supplier.

Where apparatus is mounted on panels all metal cases shall be separately earthed by means of copper wire of suitable size.

All wiring diagram for control & relay panel shall preferably be drawn as viewed from the back & shall show the terminals boards arranged as in service. All diagrams shall show which view is employed.

Terminal board rows should be spaced adequately not less than 100 mm apart.

2.6.27. INSULATING OIL

The new insulating oil, supplied with the transformer shall conform to the requirement of IS: 335 / International Standards while tested at suppliers' premises. No inhibitors shall be used in oil. The make and quality of oil to be used shall be got approved beforehand. Sampling of oil shall be done in accordance with IS: 6855.

2.6.28. OIL PRESERVATION SYSTEM

A silica gel breather shall be provided in the airside vent line. Prior to filling the oil in the main tank suitable number of samples shall be tested for BDV, moisture content, resistivity at 90°C, tan delta at 90°C, dissolved gas analysis and interfacial tension. The oil samples taken from the transformer at site shall conform to the requirements of IS: 1866 / International Standards.

Ten percent (10%) extra oil shall be supplied for topping up, in non-returnable container suitable for outdoor storage.

2.6.29. CURRENT TRANSFORMERS

Current transformer for neutral side of Power transformer, Unit Auxiliary, Station transformer and other auxiliary transformers shall be in the scope of supply of this contract.

The neutral CTs shall comply with the requirements of IS: 2705 / IEC: 185 and shall have the following ratings:

Neutral CT:

CT Ratio	:	200 / 1A For Power Transformer
No. of cores	:	1
Purpose	:	Restricted Earth Fault Protection
Accuracy Class	:	PS
Knee point voltage	:	>=300V
Magnetization Current	:	<= 15mA at Vk/2

2.6.30. BOLTS AND NUTS

Bolts and nuts shall conform to ASTM: A193, B-7 and ASTM – A194-2H. Steel bolts and nuts exposed to atmosphere with suitable finishes like cadmium plated or zinc plated passivity shall be used for diameter above 6 mm. All bolts, nuts and washers in contact with non-ferrous parts shall, which carry current shall be of phosphor bronze, where the transfer of current is through bolts. Suitable spanners shall be provided to reach the bolts where these have been located in inaccessible position.

2.6.31. LABELS AND PLATES

Each transformer shall be provided with a rating plate of weatherproof material fitted in a visible position showing the appropriate items given below as per IS: 2026 (Part-I).

a) Type of transformer.

b) Number and year of specification.

c) Manufacturer's name.

d) Manufacturer's serial number.

e) Year of manufacture.

f) No. of phases.

g) Rated power.

h) Rated frequency.

i) Rated voltage.

j) Rated current.

k) Vector group symbol.

l) % Impedance voltage at rated current.

m) Type of cooling.

n) Connection diagram.

o) Insulation level.

p) Total weight.

q) Transportation weight.

r) Un-tanking weight & height.

s) Weight & volume of insulating oil.

A plate showing the location and function of all valves and air release cocks or plugs shall be suitably located adjoining the rating plate. This plate shall also warn operators to refer to the maintenance instructions before applying the vacuum treatment for drying.

A plate showing the tap position and the voltage ratio, along with precautions to be taken while changing the taps, shall be mounted adjoining the tap switch.

1. Labels shall be provided for all apparatus such as relays, switches, fuses etc. contained in any cubicle or marshalling kiosks.

2. Descriptive labels for mounting indoors or inside cubicles and kiosks shall be of material that will ensure permanence of numbering. A matt or satin finish shall be provided to avoid dazzle from reflected light. Labels mounted on dark background shall have white lettering. Danger notices shall have red letters on white background.

All labels shall be of noncorrosive material and shall be attached to the panels with brass screws, which have received rust preventive treatment. If required, labels can be stuck to the panels with suitable adhesive also.

2.6.32. FITTINGS AND ACCESSORIES

Each transformer shall be provided with accessories but not limited to the following:

1. Oil temperature Indicator as described in the specifications.
2. Winding temperature Indicator as described in the specifications.
3. Resistance thermometer for remote indication of oil temperature.
4. One number oil-level gauge with low level alarm contacts and a dial, showing minimum, maximum, and normal oil levels. The gauge shall be readable from the transformer base level.
5. One oil filling valve (inlet)
6. One oil drain valve (outlet). Drainpipe between transformer & soak oil pit.
7. One filter valve located at the top of the tank on HV side.
8. One filter valve located near the bottom of the tank on the LV side of the transformer (diagonally opposite to the filter valve at the top).
9. Two oil-sampling valves at top and bottom of main tank with provision for fixing PVC pipe.
10. Pressure relief device of resealing type with alarm and trip contacts to vent out pressure in case the pressure in the tank rises above pre-determined safe limit as described in the specifications.
11. A Buchholz relay mounted in between the conservator and tank as described in the specifications.
12. Conservator and breather as in the specifications.
13. Oil preserving equipment complete in all respects.
14. Dehydrating air breather with silica gel filling and oil seal.
15. Eye bolts and lugs on all parts for ease of handling as described in the specifications.
16. Two Grounding terminals.
17. Jacking pads.
18. A valve schedule plate showing the location and function of all valves and air releases, cocks or plugs. This plate shall also warn operators to refer to maintenance instructions before applying the vacuum treatment for drying.
19. One set of equipment for control, protection, indication and annunciation of each transformer, detecting elements or devices, instruments, current transformers, indicating lamps (where necessary), auxiliary relays (including those for remote annunciations and trips) etc. as detailed in the various clauses of the specification.

20. Suitable weatherproof cubicle with space heater for housing the control equipment, terminal blocks for current transformer secondary and other cables, etc.
21. A set of devices for lifting the various parts of the transformer as also the complete transformer (one set common to all the transformer).
22. Terminal connectors.
23. Off load tap changer
24. H.V., LV and neutral Bushings
25. Wiring in metallic conduit upto marshalling box with PVC copper stranded cables of 1100 volts grade.

The equipment and accessories furnished with the transformer shall be suitably mounted on the transformer for ease of operation, inspection and maintenance. The mounting details shall be subject to the approval of the Purchaser.

Indication, alarm and trip relay equipment shall have contacts suitable for operation with 220 V D.C. supply. Any other accessories or appliances recommended by the manufacturer for the satisfactory operation of the transformers together with their prices shall be given in the Bid separately.

Transformers shall be fitted with wheels for mounting on rails.

2.6.33. PACKING AND TRANSPORT

The packing may be in accordance with the Bidder's standard practice. Special arrangement shall be made to facilitate handling and to protect the projecting connections from damage in transit. The conservator, the bushings and the wheels shall be removed and packed separately with weatherproof wrapping and bags of dehydrating material for the parts which might suffer from moisture during transport. Special support of the winding shall be adopted to prevent damage during transport in hills, to be removed prior to commissioning.

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.

2.6.34. GUARANTEES

The following parameters shall be guaranteed for Generator Step Up Transformer:

a) No load losses in kilowatts at rated voltage and rated frequency.

b) Load losses (Total losses minus no load losses) in kilowatts at rated output, rated voltage and rated frequency.

The penalties shall be separately evaluated for:

a) The excess of test figures of the no load losses in kilowatts over the corresponding guaranteed figures.

b) The excess of the difference between the test values of the load losses in kilowatts over the corresponding guaranteed values.

The penalties shall be calculated at the rate of 1840 US $ per kW for the no load losses and at the rate of 750 US $ per kW for the load losses in kilowatts for Power Transformer. For fraction of a kilowatt, the penalties shall be applied pro-rata.

Bid Evaluation:

For the purpose of comparison of bids, following formula shall be used:

$C_a = C + 1840*W_i + 750*W_c$

Where,

C_a= Comparative contract price

C= Price quoted of transformers

W_i = No load losses in KW guaranteed under rated conditions.

W_c = Load losses in KW guaranteed under rated conditions

2.6.35. DRAWINGS, DATA, MANUALS AND GUARANTEED PARTICULARS

The following drawings and test reports for each item are to be supplied along with the Bid Document:

1. General outline dimensional drawings showing front and side elevation and plan of transformer and all accessories including coolers and external features, spacing of wheels in either direction of motion, quantity of insulating oil, centre of gravity. The drawing should indicate location of LV and HV terminals with respect to centre line and ground.
2. Detailed dimensioned drawing showing clearances required for the transformer, fire walls, ground clearance, clearance from overhead conductor.
3. Assembly drawings and weights of main component parts.
4. Shipping drawings showing dimensions and weights of each package.
5. Drawings giving the design loads for foundations.
6. Descriptive brochures for all auxiliary equipment.
7. A complete Bill of Material for the equipment.
8. Type tests and special test reports conducted on similar transformer.
9. Quality Assurance Programme and firefighting scheme as proposed by Bidder.

Post Bid Drawing & Documents

After award of contract, the Supplier shall supply six (6) copies of the following drawings, for approval as per agreed time schedule:

1. General outline drawing showing front and side elevation and plan of the transformer and all accessories including coolers and extreme features with details of dimensions, spacing of wheels in either direction of motions, net and shipping weights, crane lift for un-tanking, size of lifting

lugs and eyes, bushing lifting dimensions, clearance between HV and LV terminals and ground, quantity of insulating oil, etc.

2. Foundation plan showing loading on each wheel and jacking points with respect to centreline of rail track.
3. Details of each type of bushing and terminal connections.
4. Bus bar trucking details.
5. Name plate drawing with terminal marking and connection diagram.
6. Wheel locking arrangement.
7. Transportation dimension drawing.
8. Magnetizing characteristic curves of current transformers.
9. Efficiency Curve.
10. Inter connection diagram.
11. Schematic and control wiring diagram for all accessories and auxiliary equipment.
12. Over-fluxing withstand time characteristics of transformer.
13. Sectional view showing the general constructional features of the transformers, core, winding, tap changer etc.
14. Schematic diagram showing the flow of oil and water 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 transformers/heat exchanger alarm to scale.
15. Large-scale drawings of high and low tension windings of the transformers, showing the nature and arrangement of insulation and terminal connections.
16. Typical Operation and Maintenance Manual supplied of the Equipment supplied by the Supplier for a Project.
17. Operation, maintenance and erection manuals (6 copies) shall be supplied by the manufacturer one month prior to the shipment of the transformer. The manuals shall contain all the drawings and information required for erection, operation and maintenance of the transformer. Any other drawing & document which is considered necessary by the purchaser shall also be supplied by the contractor.
18. Descriptive literature and data on transformers, windings, bushings, heat exchangers, tap changing gear, temperature detector, Buchholz relay, instruments, and controls, etc. shall also be supplied by the manufacturer along with the instruction manuals.

. After approval and after work completion at site six (6) sets of as built drawings and one set of reproducible print sheets shall be supplied.

2.6.36. SPARE PARTS AND TOOLS

The spare parts mentioned hereunder are meant for use by the Employer for 5 years trouble free operation & shall not be used as erection / commissioning spares required during installation. All the spare parts shall be interchangeable & shall be of the same material and workman ship as corresponding parts of the main equipment.

If any additional spare parts, required for a 5 years trouble free operation period are recommended by contractor, these shall be listed and the unit price shall be quoted in the price schedule. The Employer reserves the right to order any or all of such spares.

All spare parts shall be protected against corrosion suitably packed and shall be marked with identification labels in the English Language. The identification shall be in accordance with the agreed Works Identification System.

All spare parts, tools and materials shall be delivered in marked boxes of sufficient sturdy construction to withstand long term storage. Material that is subjected to long term storage shall be stored in a dry, ventilated room with low humidity.

Acceptance of any spare parts will not take place before the Contractor has submitted the complete final list of all spare parts and tools. They shall be replaceable without cutting or destruction of adjacent components. Before issue of the Completion Certificate, the spare parts shall be checked at the Site by the Contractor in presence of the Engineer / Employer.

Mandatory Spare Parts for GSU

The following spare parts shall be mandatorily included in the supply. A set in the list below, shall imply quantity provided for one (1) GSU Transformer (3 phase):

Item No	Description	Qty.
Generator Step-up (GSU) Transformer		
1	HV bushing complete with gaskets etc.	1 set
2	LV terminal bushings of 11 kV or as specified in technical specifications complete with gaskets.	1 set
3	HV neutral bushing and gaskets.	1 set
4	Gaskets for all openings with tank requiring gaskets	2 set
5	Oil and winding temperature indicators	1 set
6	Silica gel drying agent / required for one filling of transformers	1 Lot
7	Diaphragm and spares for conservator tank	2 set
8	Oil level indicator	1 set
9	Buchholz relay	1 set

10	Air dryer / silica gel breather	1 set
11	Neutral C.T.	1 No
12	Safety valve / Pressure relief valve	2 set
13	Spares of off-circuit Tap Changer	1 set
14	Magnetic oil level gauge	1 set
15	Set of valves	1 set
16	Fuses, MCCB and MCB"s, Terminal Block	1 set
17	Indication Lamps	1 set
18	1 One (1) Limb of HV winding in a separate oil filled tank One (1) Limb of LV winding in a separate oil filled tank	1 Lot
19	1. Indicating Lamps with holders and Lens	1 set

Mandatory Spare Parts for Station Service transformer

Item No	Description	Qty.
	Station Service Transformer	
1	H.V bushing complete with gaskets etc.	1 set.
2	L.V terminal bushing as specified in technical specifications.	1 set.
3	Neutral bushing and gaskets.	1 No.
4	Gaskets for all openings with tank requiring gaskets	1 set
5	Silica gel drying agent / required for one filling of transformer	1 Lot

6	Diaphragm and spares for conservator tank & explosion vent and pressure relief valve	1 set
7	Buchholz relay	1 set
8	Neutral Current Transformer	1 set
9	Fuses, MCCB and MCB's, Terminal Block	1 set
10	Oil and winding temperature indicators	1 set
11	Indicating Lamps with holders and Lens	1 set
12	Magnetic oil level gauge	1 set

Special Tools and Tackles

Item No.	Description	Qty.
	Special Tools and Tackles	
1	Oil filtration system complete with hoses, accessories etc. as per technical specification	1 set
2	Jacks required for lifting of Power Transformer	1 Lot
3	Oil Sampling bottle of stainless steel having 1 litre capacity each along with impermeable oil proof, transparent plastic or rubber tube of 5 mm diameter (of sufficient length) along with suitable connectors to fit the tube on to the oil sampling valve of the transformer and the oil collecting bottles respectively. The bottles shall be capable of being sealed gas tight and shall be fitted with cocks on both ends.	2 set
4	Set of chain pulley block of suitable capacity required for handling of items in transformer vault along with required sling etc.	1 Lot
5	Winches of required capacity required for movement of GT on Track along with required accessories.	1 Lot

6	Spanners including D ring and box type of all sizes	2 set
7	Set of all types and sizes of eye bolts	1 Lot
8	Torque wrenches of each size	2 set
9	Racks for storage of Tools and Tackles	2 set
10	Rails for movement of transformers (refer layout drawing)	1 Lot

2.6.37. TESTING OF TRANSFORMER

Each transformer shall be completely assembled and tested at the factory. Tests shall be performed in the presence of Purchaser's representative. Tests shall be performed in compliance with latest edition of IS: 2026 / IEC 76. No material shall be shipped until the test reports are duly approved by the Purchaser or his representative. The following type test reports as per IS:2026 shall be submitted along with the tender documents:

Type Tests:

1. Measurement of winding resistance
2. Measurement of voltage ratio and check for voltage vector relationship.
3. Measurement of impedance voltage/short circuit impedance (principle tapping) and total loss.
4. Measurement of no-load loss and current.
5. Measurement of insulation resistance.
6. Dielectric tests.
7. Temperature – rise test (at the lowest tap).
8. Test on tap changers

Additional Type Tests:

1. Vacuum test on tank.2
2. Pressure Test on Tank.
3. Pressure Test on Relief Device:

Routine Tests:

All routine tests/additional routine test as stipulated in IS: 2026/IEC:76 shall be carried out by the supplier in presence of Purchaser's representative, at no extra cost to the purchaser.

Special Tests:

Special tests as specified in IS: 2026 (Part-I)/IEC 76 and mutually agreed shall also be carried out. The Bidder shall clearly state the testing facilities available with them for conducting short circuit, measurement of acoustic level, and other special tests as per the standards.

Tests at site:

After erection at site, the transformers shall be subjected to the following tests:

1. Windings and Insulation resistance test.
2. Ratio and polarity test.
3. Test for ascertaining the vector group.
4. Dielectric test of oil, moisture content and Dissolved Gas Analysis.
5. Zero sequence impedance test.-
6. Heat Run Test
7. Protection devices checks for
   - Buchholz relay
   - pressure relief device
8. Transformer protective relays checks
9. Bushing p.f. test
10. Other tests as per I.S. or manufacturer's recommendations.

Tests on associated equipment:

Bushings, current transformers, winding temperature indicating devices, dial thermometers, Buchholz relays, auxiliary motors and motor starting contactors, coolers, control devices, insulating oil and other associated equipment included in the scope shall be tested by the Supplier in accordance with relevant IS or IEC. If such equipment is purchased by the Supplier on a sub-contract, he shall have them tested to comply with these requirements and the test certificates shall be furnished to the Purchaser. Inspection of tests at the sub-contractor works shall be arranged by the Supplier, if required by the Purchaser.

2.6.38. TEST REPORTS:

1. After all tests have been completed, six certified copies of each test report shall be furnished. Each report shall supply the following information:

a. Complete identification data including serial number of the transformer/equipment tested. Calibrated oscillographs of impulse test shall form part of the test report.

b. Method of application, where applied, duration and interpretation of results for each test. Quantities corrected to 75°C shall be given.

c. Temperature and pressure data including ambient temperature and atmospheric pressure.

2. Routine test reports shall also furnish the following information:

a. Calculated value of regulation at unity, 0.9, 0.8 lagging and 0.95, 0.9 leading power factor.

b. Calculated values of positive, negative and zero sequence impedances of three-phase bank.

c. Calculated values of efficiency of transformer at 50, 75 and 100 percent of rated capacity with 1.0 and 0.9 power factors.

3. The Bidder shall state in his proposal the testing facilities available at his works. In case full capacity testing facilities are not available, the Bidder shall state the method proposed to be adopted so as to ascertain the transformer characteristics corresponding to full capacity testing. The Bidder shall also indicate tests recommended to be carried out at site during installation and commissioning. These tests shall be carried out by the Supplier during erection supervision.

4. The Purchaser and/or his representative including third party inspection agency appointed by the Purchaser shall have the right to witness any or all tests.

5. The Purchaser reserves the right to reject the transformer, if losses exceed the declared losses beyond tolerance limits as per IS/IEC or temperature rise in oil and of winding exceed the value specified.

2.6.39. SHOP INSPECTION

No equipment or material shall be dispatched to the site prior to its inspection at manufacturer's works by the Purchaser or his authorized representative. The Purchaser's representative shall have access and facilities for un-restricted inspection of manufacturer's works.

2.6.40. ERECTION, TESTING AND COMMISSIONING

The installation of the transformers includes but not limited to the following:

- transport and unloading of the transformers from the trailer to the respective bases of the transformers. The Purchaser shall provide the transformer foundation based on the dimensions and weight given by the Supplier.
- Welding, jointing and clamping, soldering, brazing as per drawings and as per engineering practices and Quality Assurance Plan.
- Installation of control cabinet,
- Installation of High Voltage and Low Voltage bushings,
- Installing drain oil pipe between transformer & soak oil pit,
- Filling and treatment of oil,
- Field tests comprising Commissioning, operational or other tests as per technical provisions and/or applicable standards, whether specifically mentioned or not.
- Performance/Final acceptance tests as applicable in accordance with provisions of technical specifications.
- Corrections (if any) in erection or during assembly for the transformers shall be done as per approved drawings.
- Any other activities/services not specially mentioned in technical provisions but necessary for completeness of the Equipment, its commissioning, performance testing or sustained operation/ maintenance.
- Implementation of quality assurance plan and control of quality.

The erection agency shall be responsible to arrange all the tools and tackles necessary for the erection, testing and commissioning of the transformer. The Supplier shall submit the foundation design for the same to the Purchaser for approval.

The Contractor shall maintain at his site office up-to-date copies of all drawings. He shall also maintain, continuous record of all stages of erection, test data and changes made in the drawings and supply one corrected copy to Purchaser.

2.6.41. OBLIGATIONS OF THE PURCHASER

The Purchaser shall not provide any lifting facility for the transformer. The power requirement by the Contractor for the erection works (welding etc.) shall be arranged by himself.

The Purchaser shall not provide any accommodation to the Supplier or Contractor or any of its employees. However, the Purchaser shall render full assistance to them in this regard.

The purchaser shall provide soak oil pit near to the switchyard.

2.6.42. QUALITY ASSURANCE PROGRAM

A quality assurance program detailing specific control procedure proposed to be adopted for controlling the quality characteristics relevant to each item of equipment shall be furnished. This shall include, but not be limited to the following to ensure conformance of equipment specification and relevant Codes/Standards:

1. Inspection of incoming raw materials.
2. Tests to Verify chemical and physical properties of all materials including test certificates of bought-out items like motors, contactors, circuit breakers, instruments / gauges etc. as per relevant Indian Standards.
3. Tests during manufacture / assembly of transformer, its fittings and accessories including customer hold points etc.
4. Other tests as part of manufacturer's standard quality assurance plan.

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3. MEDIUM VOLTAGE SWITCHGEAR

3.1. Scope

Scope of work under this section covers the provision of labour, tools, plants, materials and performance of work necessary for the design, manufacture, quality assurance, quality control, shop assembly, shop testing, delivery at site, site storage and preservation, installation, commissioning, performance testing, acceptance testing, training of Employer's personnel, handing over to Employer and guaranteeing for trouble free operation of 33 kV Medium Voltage Switchgear as per the specifications hereunder, complete with all auxiliaries, accessories, spare parts. All ferrous parts shall be suitably pre-treated for removal of rust, dust & grease before application of powder coating.

The scope of work shall be for a complete and comprehensive functional system covering all supply and services/works including but not limited to following:

- One (1) incoming supply feeder from 33 kV Switchyard
- One (1) outgoing feeder for Barrage area,
- One (1) outgoing feeder to Colony,
- One outgoing feeder to Station Service Transformer,
- One (1) outgoing feeder (Spare),
- Bus PT as required for Bus Section.

All the above panels shall be complete with free standing cubicles, protection, metering, busbar system, cabling, wiring and other accessories, each comprising of following major equipment. The quantities shall be finalised during detailed engineering.

- 33 kV Vacuum circuit breaker (alternatively SF6 circuit breaker is also acceptable).
- Required no. of current transformers,
- Required no. of potential transformers for incoming panels only,
- Required no. of ampere meters with selector switches,
- Required no. of voltmeters with selector switches for incoming panels only,
- Required no. of energy meters,
- Potential transformer, voltmeters with selector switches for each section of bus,
- All necessary AC bus bars,
- All necessary auxiliaries for control and supervisory circuits, local control switch and other relays as required,
- All secondary wiring, terminal blocks, labelling and nameplates, sockets etc,
- Indicators / Annunciators as required,
- Cubicle lighting including lighting fixtures and power sockets,
- Earthing trucks or interlocked earth switches,
- Space heaters,
- All protection relays and systems,

- Coordination and provision of necessary contacts and / or ports for integration with plant SCADA system.

Any other item(s) not mentioned specifically but necessary for the satisfactory completion of scope of work defined above, as per accepted standard(s) / best national / international practices.

3.2. Standards

Standard	Particular
IS: 1248 (Part-1 to 9)	Direct acting indicating analogue electrical measuring instruments and their accessories.
IS: 2705 (Part -1 to 4)	Current Transformers
IS: 3427	AC Metal Enclosed Switchboard & Controlgear above 1 kV & upto & including 52 kV
IS: 3156 (Part-1 to 4)	Voltage Transformers
IS: 3231(Part 0 - 3)	Electrical relays for power system protection
IS: 7118	Recommendations for direction of movement for control devices operating electrical apparatus
IS: 8828	Electrical accessories: circuit breakers for over current protection for household and similar installations
IS: 10118 (Part-1 to 4)	Code of practice for selection, installation and maintenance of Switchboard and control gear
IS: 11353	Guide for uniform system of marking and identification of conductors and apparatus terminals
IS: 11138 & IEC-56	Specification for HV alternating circuit breakers
IEC 60044	Instrument transformers
IEC 62271-100	High-voltage Switchboard and control gear - Part 100: High voltage alternating-current circuit-breakers
IEC 62271-200	High-voltage Switchboard and control gear - Part 200: A.C. metal-enclosed Switchboard and control gear for rated voltages above 1 kV and up to and including 52 kV.
IEC 60694	Common specifications for high-voltage Switchboard and control gear standards.

3.3. Specific Parameters and Layout Conditions

3.3.1. Layout and General Arrangement

One (1) no. 33 kV breaker shall be used for 33 kV incoming supply from 33 kV Switchyard and four (4) nos. 33 kV CBs for outgoing feeders and bus PT for bus.

The 33 kV Switchgear shall be suitable for indoor installation with all necessary interlocks. The installation of the switchgear is proposed inside the powerhouse.

The system offered for the 33 kV MVS scheme shall be as per Single Line Diagram enclosed with the specification. All incoming and outgoing feeder s of 33 kV Switchgear shall be protected for instantaneous and time delay over current and earth fault (50 / 51) protection

The system shall be compatible with station DAS / SCADA, regarding input and output needed for operation, control and monitoring of 33 kV switchgear from DAS / SCADA.

3.4. Rating and Functional Characteristics

3.4.1. Rating

System Description

Location & Type	Indoor, Metal clad
No. of bus bar	1
Type of earthing	Solidly earthed
System Requirement	
Rated system voltage, kV, r.m.s	33 ±10%
Highest Design voltage, kV, r.m.s	12
Rated frequency, Hz	50 ± 5%
Rated withstand Voltage to earth - Power Frequency Lightning Impulse (peak value)	 28 kV 75 kV

Rated short time withstand current (rms) for 1 Sec	25 kA
Rated Peak withstand current	62.5 kA
Rated normal current	630 A
Control voltage DC	220 V ± 10 %
Auxiliary AC supply, 3 phase	415 V ± 10 %
Circuit Breaker	
Type of interrupting Medium	Vacuum or SF_6
Description	Three phase equipped with group control mechanism
No. of interrupter unit per pole	1
First-pole-to clear factor	1.5
Rated short circuit breaking capacity, kA (rms)	25 kA
Rated short circuit making capacity, kA -(peak)	62.5 kA
Rated cable charging breaking current, kA (rms)	25 kA
Rated operating sequence	O-3 min-CO-3 min-CO
Normal voltage for operating mechanism i.e charging motor (DC) Trip coil Voltage Closing coil Voltage	220 V + 10 % / - 10 % 220 V DC +10%, -20% 220 V DC, ± 10 %
Current Transformer	
Current Ratio	
Incoming feeders	100 / 5 A
Outgoing feeders	100 / 5 A
Accuracy class	
REF Protection	PS
E / F and O / C protection	20 VA, 5P20
Metering	0.5
Potential Transformer	
Transformation Ratio	33 kV / V3 / 110V / V3 /110V / V3

Accuracy class	
Relaying	3P
Metering	0.5
Rated Voltage	1.2 times continuous

3.4.2. Current ratings and short circuit capabilities

The complete 33 kV Switchgear shall be designed to be capable of withstanding without damage all stresses due to maximum symmetrical short circuit (peak) currents in the bus bar and in the incoming and outgoing bays.

The complete design and layout shall be subject to approval by the Employer.

3.5. Performance Guarantee

The 33 KV Switchgear along with all auxiliaries and accessories shall be capable of performing intended duties under specified conditions. The Contractor shall guarantee the reliability and performance of the individual equipment as well as of the complete system.

3.6. Design and Construction

The 33 kV Indoor Switchgear shall be of the steel enclosed type vermin proof, dust proof and shall comply with the requirements of latest edition of IEC / IS. The switchgear should be internal arc-tested. The switchgear shall be complete with Vacuum circuit breakers/SF6 circuit breakers, dry type resin cast instrument transformers, insulators, bus bars, earthing arrangements, instruments and protective relays, labels, cable termination boxes, glands, all necessary wiring and auxiliary devices required to perform its functions.

The switchgear shall be metal clad, compartmentalized, free standing, dead front type. There shall be separate chambers for Busbars, CTs / cable termination, Instrument / Control equipment, CB chamber. The Circuit Breaker (CB) shall be trolley mounted, horizontal drawout type. The finger contacts of CB shall pass through sprouts for making contact with Bus bars / cable connections. The sprouts shall be protected with independently operated automatic shutters to avoid accidental contact with live parts.

Contractor shall ensure availability of spare parts and maintenance support services for offered equipment for a minimum period of 15 years from date of supply. Contractor shall also give at least one year notice to end user before phasing out products / spares to enable end user for placement of order for spares and services.

The cold rolled sheet of the panel shall not be less than 2.5 mm thick. The end section of panel shall be provided with blank plates with provisions to facilitate

further bus bar extension on either side. To represent the single line diagram, a mimic diagram shall also be made available on the panel. The circuit breaker cubicle shall be provided with space heater and door operated illumination lamp.

3.6.1. Bus Bars

All the bus bars within the switchgear assembly shall be air insulated, compartmentalized and shall have rated current capacity of minimum 630 A. Bus bars shall have mechanical and thermal capacity of not less than that represented by the short time current rating of circuit breakers. The bus bars shall be of Copper conductors (Preferable) conforming to IEC / IS.

3.6.2. Circuit breaker

The 33 kV circuit breakers shall be vertically trolley mounted, horizontal draw out & isolating type of latest generation of Vacuum breaker/SF6 breaker, electrically trip free, with anti pumping device and operated by means of motor charged, stored energy type spring mechanism.

Motor operating mechanism shall have provision for closing / opening of breaker manually and an interlock shall be provided between electrical and manually operating modes for either electrical or manual operation. Circuit breaker shall be according to IEC / IS and shall be complete with the proper interlocking. Circuit breaker should not be able to close in service position with door open. The CB shall have distinct position in cubicle viz service, test and Isolated Position with panel door closed.

3.6.3. Current transformer

The current transformer shall be of inductive type. It shall be mounted within the cubicles and shall comply with the requirements of relevant IEC / IS. It shall be used for protection and metering as per Single

3.6.4. Potential transformer

The potential transformer shall be of inductive type. It shall be mounted within the cubicles and shall comply with the requirements of relevant IEC / IS.

The potential transformers shall be of two cores used for metering and protection.

Minimum VA shall be 100 VA for metering & 50 VA for protection core.

3.6.5. Earthing Trucks

For earthing of bus & cable side earthing truck shall be provided. Alternatively, suitably interlocked earth switches may be offered. In case of earth truck suitable alarm warning system be provided if the terminals being earthed are live.

3.6.6. Control description

3.6.6.1. GENERAL

Each Vacuum circuit breaker shall be equipped with facilities for remote operation. Each Vacuum circuit breaker unit shall be equipped with a manual / auto selection switch, local start-stop push button and an indicator showing the position of the breaker in the control room. The Vacuum circuit breaker shall be operable with the breaker in test position. Auxiliary contactors with an alarm contact for remote indication of tripped condition shall be provided for protection of control circuits. All circuit breakers shall be equipped with trip circuit supervision device.

Auxiliary contacts for at least the following remote indications of the circuit breakers shall be wired to terminal blocks:

- Main contact position,
- Test and connected / service position,
- Trip condition,
- Protection relay contacts,
- Trip circuit supervision relays.

Metering and protection

Incoming revenue metering shall be provided as well as individual metering on each feeder circuit breaker.

Incoming feeder containing current transformers and voltage transformers shall have power meter capable to display kWh, current, voltage. Also, ammeters and ammeter selector switches, voltmeters and voltmeter selector switches located in the respective feeder compartment doors.

Revenue meters shall be Schneider Power Measurement ION 7700, or equivalent. Feeder meters shall be similar to the Schneider Power Measurement ION 7700 or equivalent (Satec PM130E).

All metering circuit shall be terminated in terminal blocks for remote metering purposes.

3.7. Testing

All the equipment covered under this section shall comply with the requirements of type tests prescribed in the relevant IEC / IS Standards. It shall be certified by the contractor that type test in accordance with the relevant standards have been successfully carried out for all type of equipment being supplied by him.

The 33 KV Switchgear shall be assembled fully at the manufacturer's works with all the instruments, meters etc. connected.

The panel comprising of circuit breaker, current transformer, voltage transformer, etc. shall be subjected to the following routine tests in accordance with the details specified in the relevant IEC / IS as amended from time to time.

1. Circuit Breaker:

- Measurement of resistance of the main circuits (Between Bus and Cable termination,
- Operating mechanism test,
- One-minute power frequency voltage dry withstand test on the main circuit,
- Voltage withstand test on control and auxiliary circuits,
- IR measurement of complete board.

2. Voltage Transformer:
   - Verification of terminal markings and polarity,
   - Power frequency test on primary and secondary winding separately, measurement of partial discharges,
   - Determination of error according to the requirements of the appropriate accuracy class,
   - Over voltage inter turn tests,
   - IR measurement of windings.
3. Current Transformer:
   - Verification of terminal marking and polarity,
   - High voltage power frequency test on primary and secondary,
   - Determination of error according to the requirement of the appropriate accuracy class,
   - IR measurement.

All type tests and routine tests reports shall be submitted and got approved from the Employer before despatch of the equipment.

3.8. Installation and Commissioning

The contractor shall furnish all labour, supervision, tools, supplies, shims, supports and all other provisions or materials necessary to assemble, erect, install, testing and commissioning of the equipment in a thorough workman like manner following the best modern practices. The equipment and its components shall be placed with great care and accuracy and shall be aligned correctly to provide an installation consistent with the close tolerances used in the erection of modern equipment. The proper elevations and centrelines to which equipment is to be set shall be established by the contractor.

The contractor shall furnish a complete outline of the proposed methods and procedures to be followed for the site testing including a list of equipment and instruments to be used to the Employer for review at least 60 days before the schedule testing.

3.9. Field Tests

After installation, the switchgear system shall be field tested as per relevant IEC standards, including operational tests and megger value of insulation. The contractor shall prepare and hand over to Employer, details of all test results in a report in a mutually agreed format.

3.10. Drawings and Design Calculations

Contractor shall provide its drawings in conjunction with its calculations as well as references, showing the detailed design of 33 kV Switchgear as required by Engineer for its review / approval.

Contractor shall furnish six (6) sets of all the 33 kV Switchgear drawings for approval. After approval and after work completion at site six (6) sets of as built drawings and one set of reproducible print sheets shall be supplied.

3.10.1. Drawings

The Contractor shall submit all the drawings and documents as required by Engineer. These drawings and documents should include at least the following:

- General arrangement, outline and foundation drawings,
- Detailed information and descriptive literature, explaining various safety, protective and regulation features of equipment / components,
- Drawings, showing general arrangement, sections of all major assemblies, subassemblies and major components,
- Drawing showing mechanical interlocking scheme,
- Control schematic drawings,
- Structure drawings for 33 kV switchgear along with the bill of Material,
- Foundation Drawings,
- Fixing details of structure 33 kV Switchgear,
- Electrical drawings,
- Erection, commissioning, operation and maintenance instructions for 33 kV switchgear and other accessories, etc.

3.10.2. Design memorandum.

The contractor shall prepare and submit to the Employer a “Design Memorandum” of the proposed equipment / system fulfilling the contract specification / requirement given in the section for approval prior to submission of any drawings and documents. The memorandum shall include the design philosophy, methodology, system description, input parameters for design, standard and codes, design and selection criteria, equipment data, material specification, major technical features, basic arrangement / layout etc.

3.11. Spare Parts & Special Tools

Contractor shall separately indicate the price of spare parts and special recommended tools. Each item shall be clearly described.

The Contractor shall supply all necessary tools, devices, testing instruments / equipment etc. required for installation, testing, repair and maintenance at site. These shall remain the property of the contractor unless otherwise agreed to be taken over by Employer any / all of these at mutually agreed conditions

All spare parts shall be identical electrically and mechanically to corresponding parts of the equipment supplied and shall be suitably packed and clearly marked, ready for long term indoor storage.

If dismantling of certain parts requires the use of special tools, Contractor shall propose the list of special tools including their make and detailed specification as recommended by manufacturer(s), (to be accepted by the Employer) for operation and maintenance at site.

Purchaser reserves the right to purchase or not the spare parts and special tools covered in this chapter.

3.11.1. Mandatory Spares Part

Specified spare parts to be supplied under this section are as follows:

S.No.	Description	Quantity
1.	33 kV circuit breaker	1 No.
2.	Circuit breaker trip and closing coils.	3 Nos. each
3.	Fixed and moving finger contacts of type used for each set comprises 6 fixed and 6 moving contacts)	1 set
4.	Bus insulator	6 nos.
5.	Indicating meter of each type used	1 no. of each used type
6.	Over current relays	1 no.
7.	Over current and earth fault relay	1 no.
8.	Indicating lamps with assembly of each type used	10 nos. of each used type

If any additional spare-parts (required for trouble free operation) are recommended by bidder, these shall be listed and the unit price shall be quoted in the price schedule. The Employer reserves the right to order any or all such spares.

3.11.2. Tools and Instruments

The Supplier shall supply all necessary tools, devices, testing Instruments / equipment etc. for installation, repair, and maintenance at site. These shall remain the property of the Supplier unless otherwise agreed to be taken over by Employer any / all of these at mutually agreed conditions.

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4. 415V LOW VOLTAGE SWITCHGEAR

4.1. SCOPE

This specification covers the design, manufacturing, testing at manufacturer's works, ex-works supply, loading at manufacturer's works, insurance, transportation, and destination store delivery one number of station service board and three nos Unit Auxiliary Boards and three numbers ACDBs along with their accessories. In addition, 50 nos 63A three phase power sockets and four numbers 125A three phase power sockets are also included in the scope. All the required accessories, documents & equipment whether specified herein or required to complete the equipment shall be in the scope of the bidder.

The scope shall also include supply of special tools & plants required for the erection, testing and commissioning of LT Switchgear/Distribution Boards and also supply of mandatory spares required for maintenance of LT Switchgear/Distribution Board for five years trouble free operation. The scope of this specification also covers the unloading, storage, insurance, handling, transportation from stores to site, erection, testing & commissioning of the equipment & its accessories. The manufacturer shall also recommend the additional spares required for efficient and trouble free operation of LT Switchgear/Distribution Board.

Bidders shall also quote for the type tests, which may be performed at the discretion of the purchaser.

4.2. STANDARDS

Except where otherwise specified or implied, the design and manufacturing of LT switchgear/distribution boards and their accessories shall conform to the provisions of the latest IS/IEC mentioned below.

4.2.1. List Of Standards:

S.No	Code	Particular
1.	IS: 5	Color for ready mixed paint and enamels
2.	IS: 375	Marking and arrangements of bus bars
3.	IS: 722	AC electricity meters
4.	IS: 802, Part – 1, Sec-1	Use of structural steel in overhead transmission line towers: material, load and permissible stresses

5.	IS: 1248 (Part-1 to 8)	Direct acting indicating analogue electrical measuring instruments and their accessories.
6.	IS: 1356 (Part-1)	Electrical equipment of machines for general use
7.	IS: 1885 (Part-17)	Electro-technical vocabulary for switchgear and control gear
8.	IS: 2086	Carriers and bases used in rewirable type electric fuses upto 650 V.
9.	IS: 2147	Degree of protection provided by enclosure for low voltage switchgear & control gear
10.	IS: 2633	Methods of testing uniformity of coating of uniformity of zinc coated articles
11.	IS: 2705 (Part -1)	Current Transformers: general requirements
12.	IS: 2705 (Part - 2	Current Transformers: measuring current transformers
13.	IS: 2705 (Part- 3)	Current Transformers: protective current transformers
14.	IS: 2705 (Part - 4)	Current Transformers: protective current transformers for special purpose
15.	IS: 3156 (Part-1)	Voltage Transformers: general requirement
16.	IS: 3156(Part-2)	Voltage Transformers: measuring voltage transformer
17.	IS: 3156(Part-3)	Voltage Transformers: protective voltage transformers
18.	IS: 3156(Part-4)	Voltage Transformers: capacitor voltage transformers
19.	IS: 3231	Electrical relays for power system protection
20.	IS: 5082	Wrought Aluminum & Aluminum alloy bars, rods, tubes and sections for electrical purposes
21.	IS: 6005	Code of practice for phosphating of iron & steel
22.	IS: 6875 (Part-1)	Control Switches for voltages upto and including 1000V AC and 1200V DC (General requirements)
23.	IS: 6875 (Part-2)	Control Switches for voltages upto and including 1000V AC and 1200V DC (Push

		buttons and related control switches)
24.	IS: 6875 (Part-3)	Control Switches for voltages upto and including 1000 V AC and 1200V DC (Rotary control switches)
25.	IS: 7118	Recommendations for direction of movement for control devices operating electrical apparatus
26.	IS: 8623 (Part-1)	Specification for factory built assemblies of switchgear and control gear for voltage not exceeding 1000V (General requirements).
28.	IS: 8623 (Part-2)	Specification for factory built assemblies of switchgear and control gear for voltage not exceeding 1000V (Particular requirements for busbar trunking system).
29.	IS: 8828	Electrical accessories: circuit breakers for over current protection for household and similar installations
30.	IS: 13703(Part-1)	Low voltage fuses: General requirements
31.	IS: 13703(Part-2/sec-I)	Low voltage fuses: Supplementary requirements for fuses with high breaking capacity for industrial application
32.	IS: 13703(Part-4)	Low voltage fuses: Supplementary requirements for fuse link for protection of semiconductor devices.
33.	IS: 10118(Part-1)	Code of practice for selection, installation and maintenance of switchgear and control gear: general
34.	IS: 10118(Part-2)	Code of practice for selection, installation and maintenance of switchgear and control gear: selection
35.	IS: 10118(Part-3)	Code of practice for selection, installation and maintenance of switchgear and control gear: Installation
36.	IS: 10118(Part-4)	Code of practice for selection, installation and maintenance of switchgear and control gear: Maintenance
37.	IS: 13947 (Part-1)	Specification for low voltage switchgear & control gear: general rules
38.	IS: 13947 (Part-2)	Specification for low voltage switchgear &

		control gear: circuit breakers
39.	IS: 13947 (Part-3)	Specification for low voltage switchgear & control gear: switches, disconnectors, switch disconnector and fuse combination units
40.	IS: 13947 (Part-4/sec-1)	Specification for low voltage switchgear & control gear: contactors and motor starter
41.	IS: 13947 (Part-5/sec-2)	Specification for low voltage switchgear & control gear: control circuit devices and switching elements
42	IEC: 947	Specification for low voltage switchgear & control gear

4.3. PARTICULARS OF 415 VOLT AC SYSTEM

The 415V switchgear panel board shall be metal enclosed indoor cubicles free floor standing type.

The Station Service Board will receive power from 500 KVA emergency DG set and one number 800 KVA SST. Incoming breakers from Station Service Transformer side and from DG set shall be electrically interlocked, so that at a time only one supply is available to the Station service Board.

The Unit Auxiliary Boards will receive power from 250 KVA Unit Auxiliary Transf ormers and are interconnected as per Single Line Diagram

ACDBs shall be with incomer MCCBs and outgoing MCBs.

The number of outgoing feeders shall be as per system requirements and shall be approved by the Owner during detailed engineering stage. At least 20% spare feeders shall be provided in each Switchgear.

4.4. CONSTRUCTIONAL DETAILS OF DISTRIBUTION BOARDS:

1. 415V LT AC distribution boards shall be provided with rubber gasket packing on the doors and shall be IP: 54 protection class and shall be suitable for indoor mounting.

2. The AC distribution boards shall be of metal enclosed, free standing type. The distribution board should be of dust tight and vermin proof and have locking arrangements. The switchboards shall be modular in construction and shall have a frame made from steel angles of suitable sizes to accommodate the required equipment. Portions of the frame accommodating the live parts such as bus bars, breakers etc., shall be covered with sheet steel fabrications in a good manner taking into account the minimum clearances and creepage distances. Each cubicle shall be provided with a panel heater of suitable capacity, thermostatically controlled to counter humidity.
3. Each cubicle of the distribution board shall be divided into compartments or modules, housing the incoming air circuit breaker units and outgoing feeder with moulded case circuit breaker units. Each ACB unit shall be draw out type and shall be mounted on carriage assembly, constructed so that the unit can be removed and replaced while the buses are energized. The carriage shall have self engaging definite position stops for disconnected, test and connected positions. All necessary means shall be provided for easy removal and handling of unit.
4. All the steel cubicles of distribution board shall conform to IS: 4237 and IS: 2675 and shall be fabricated from heavy gauge steel sheets. Front, rear, top & bottom sides shall be not less than 2.5 mm thick steel sheets. Stiffeners shall be provided wherever necessary.
5. The panel edges and cover/door edges shall be reinforced against distortion by rolling, bending or by the addition of welded reinforcement member.
6. The complete structure shall be rigid, self supporting, free from flaws, twists and bends. All cutouts shall be true in shape and devoid of sharp edges.
7. Provision shall be made in all compartments for providing IP: 54 degree of protection, when circuit breaker of module trolley has been removed. All cutouts shall be provided with neoprene/synthetic rubber gaskets.
8. All switches, indicating instruments, breakers etc shall be mounted on front side of the boards. Entry of cables shall be from the bottom of the panel. The overall design and construction of the board shall be good in appearance and provided with pedestals so that these boards can be free standing and suitable for floor mounting which shall be suitable for mounting directly on the concrete foundations. Anchor fasteners to the channel with floor shall be included in the scope of supply. The complete details, along with relevant drawing shall be submitted along with the tender.
9. Distribution board shall be provided with base frame made of structural steel sections along with all necessary mountings and hardware required for levelling the frame, attaching it to the concrete floor, and grouting under it.
10. The bus bars shall be made of Aluminium insulated with PVC sleeving and shall be rated for 1250A for Station Service Board and 400A for Unit Auxiliary Board at 415 volts, 50Hz, 3 phase, 4 wire system. The bus bars should be able to withstand a short circuit current of 40kA. The bus bars shall be located preferably on the topside of each board and shall be so designed and mounted that the expansion or contraction does not subject either the bus bars or the insulating supports to any undue stress.
11. The distribution board shall be complete with small wiring, terminal blocks, earthing conductors, identification tags, ferruling of all internal wiring etc. All secondary and control wiring shall be done with stranded copper wires, of size 2.5mm2, with voltage rating 1.1 kV with 4 mm2 for VT circuits and 6 mm2 for CT circuits.

12. Terminal blocks suitable for terminating all outgoing cables shall be provided at the bottom of each cubicle of the switchboard The spacing between the adjacent blocks shall not be less than 100 mm and the space between the bottom blocks and cable gland plate shall not be less than 200 mm
13. All components like meters, relays etc, shall be grounded using green coloured stranded Cu wire of 2.5 Sq. mm. properly terminated to the ground bus provided at the bottom of each cubicle. The ground bus shall be interconnected through the complete switchboard and two terminals at the ends of each board shall be provided for connection to the station ground.
14. The minimum clearance in air between phase to earth for the entire run of horizontal and vertical busbars shall be at least 25mm. For all other compartments distance between “two live parts”, a live part and an earth part and isolating distance shall be at least 10mm throughout.
15. All single front boards shall be provided with removable bolted covers at the rear. The covers shall be provided with danger labels.
16. All identical circuit breakers and module chassis of same size shall be fully interchangeable without being modified. All Air Circuit Breakers shall be fully draw out circuit breakers, which can be drawn out without having to unscrew any connections. The circuit breakers shall be mounted on rollers or guides for smooth movement between SERVICE, TEST & ISOLATED positions and withdrawal from the switchboard. Testing of the breaker shall be possible in TEST position. A trolley for ease of removing the ACB shall form a part of the equipment.
17. The connection from busbars to the MCCBs shall be fully insulated/shrouded, and securely bolted. The partition between the feeder compartment and cable alley may be non-metallic and shall be of such construction as to allow cable cores with lugs to be easily inserted in the feeder compartment for termination.
18. All equipment and components shall be neatly arranged and shall be easily accessible for operation and maintenance. The internal layout of all the modules shall be subject to purchaser’s approval. Bidder shall submit dimensional drawings showing complete internal details of tapping from busbars, tapping to module components, for each type and rating for approval.
19. All sheet work shall be pretreated in tanks, in accordance with IS: 6005. Degreasing shall be done by alkaline cleaning. Rust and scale shall be removed by pickling with acid. After acid pickling parts shall be washed in running water. Then these shall be rinsed in slightly alkaline hot water and dried. The phosphate coating shall be class-C as specified in IS: 6005. The phosphated surface shall be rinsed and passivated prior to application of stoved lead oxide primer coating. After primer application two coats of finishing synthetic enamel paint on panel shall be applied. Electrostatic painting shall also be acceptable. Finishing paints on panels shall be of shade 631 of IS: 5 unless required otherwise by the purchaser. The paint thickness shall be coated by peel able compound by spraying method to protect the finished surfaces from scratches, grease, dirt and oily spots during testing, transportation, handling and erection.
20. Space heater shall be provided in the distribution boards wherever the manufacturer considers them necessary and recommend their provision for preventing harmful moisture condensation. The space heaters shall be suitable for continuous operation on 240V AC, 50 Hz single phase supply and shall be automatically controlled by thermostats. Necessary isolating switches and fuses shall also be provided.

4.5. NAME PLATES AND LABELS

1. The AC distribution board shall be provided with prominent, engraved identification plates. The module identification plate shall clearly give the feeder number and feeder designation. For single front switchboards, similar panel and board identification labels shall be provided at the rear also.
2. All name plates shall be of non rusting metal or three (3) ply laminated with white engraved lettering on black back ground, inscription and lettering sizes shall be subjected to purchaser's approval.
3. Suitable tally plates shall be provided for easy identification of all equipment, located inside the panel/module. These labels shall be positioned so as to be visible and shall give the device number, as mentioned in the module wiring diagrams.

4.6. POWER BUSBARS AND INSULATORS

1. The AC distribution panel shall be provided with three phase Aluminium busbar and one neutral busbar.
2. All busbars and jumper connections shall be of high conductivity aluminium of adequate size. The busbar shall be rated in accordance with specified continuous and short time current rating specified in Technical Parameters of this specification.
3. The cross section of the busbars shall be uniform throughout the length of switchgear and shall be adequately supported and braced to withstand the stresses due to specified short circuit currents.
4. All busbars shall be adequately supported by non-hygroscopic, non-combustible, track resistant and high strength type polyester fibreglass moulded insulators. Separate support shall be provided for each phase and neutral busbars.
5. All busbar joints shall be provided with high tensile steel bolts, spring washers and nuts to ensure good contacts at the joints. Non-silver-plated busbars joints shall be thoroughly cleaned at the joint locations and suitable contact grease shall be applied just before making a joint.
6. All busbars shall be colour coded as per IS: 375.
7. The bidder shall furnish calculations along with the bid, establishing the adequacy of busbar size for specified current ratings based on short circuit current and temperature rise considerations at specified ambient temperature.

4.7. EARTH BUS

1. A galvanized steel earthing bus shall be provided at the bottom of each panel and shall extend throughout the length of each distribution board. It shall be welded/bolted to the framework of each panel and breaker earthing contact bar.
2. The earth bus shall have sufficient cross section to carry the momentary short circuit and short time fault currents to earth as specified in specifications, without exceeding the allowable temperature rise.

3. All non - current carrying metal work of the distribution board shall be effectively bonded to the earth bus. Electrical conductivity of the whole switchgear enclosures framework and the truck shall be maintained even after painting.
4. All metallic cases of relays, instruments and other panel mounted equipment shall be connected to earth bus by independent stranded copper wires of size not less than 4 mm2. Insulation colour code of earthing wires shall be green. Earthing wires shall be connected to terminals with suitable clamps and connectors. Looping of earth connection that would result in loss of earth connection to other devices when a device is removed is not acceptable. However, looping of earth connections between equipment to provide alternative paths or earth bus is acceptable.
5. V.T. and C.T. secondary neutral point earthing shall be at one place only on the terminal block. Such earthing shall be made through links so that earthing of one secondary circuit can be removed without disturbing the earthing of other circuit.
6. All hinged doors shall be earthed through flexible earthing braid.

4.8. CIRCUIT BREAKERS

4.8.1. Air Circuit Breakers

1. The Air Circuit Breakers shall be triple pole, horizontal draw out type and shall have inherent fault current breaking and making capacity as specified in Technical Parameters of this specification.
2. Air Circuit Breakers shall be mounted along with its operating mechanism on telescopic rails. The cradle should be so designed and constructed as to permit the smooth withdrawal and insertion of the breaker into it. The movement should be free of jerks and shall preferably be on rollers and not on the flat surface. Suitable guides shall be provided to prevent misalignment of the breaker.
3. There shall be “Service”, “Test”, and “Fully withdrawn” positions for the breakers. In “Test” position circuit breaker shall be capable of being tested for operation without energizing the power circuit i. e. power contacts shall be disconnected while the control circuits remain undisturbed. Locking facilities shall be provided so as to prevent movement of the circuit breaker from the “service”, “Test” or “Fully withdrawn “position. It shall be possible to close the door in “Test” position.
4. All circuit breakers shall have short circuit releases and shunt trip coil.
5. All circuit breakers shall be provided with required number of NO/NC potential free contacts with at least 2NO and 2NC spare potential free auxiliary contacts. These contacts shall be in addition to those required for internal mechanism of the breaker. Separate limit switches having required number of contacts shall be provided in both “Service” and “Test’ position of breaker. All contacts shall be rated for making, continuously carrying and breaking 10 Amp at 240V AC and at 220V DC respectively.
6. Suitable mechanical indications shall be provided on all circuit breakers to show “Open, “Close”, “Service”, “Test”, and “Spring charged” positions.
7. Main poles of the circuit breakers shall operate simultaneously in such a way that the maximum difference between the instants of contacts touching during closing shall not exceed half cycle of rated frequency.

8. All Air Circuit Breakers shall have following interlocks:

    a) Movement of circuit breaker between “Service” and “Test” position shall not be possible unless it is in open position. Attempted withdrawl of a closed circuit breaker shall not trip the circuit breaker. The breakers shall have door interlocking facility so that the cubicle door cannot be opened with the breaker closed in ‘Test’ or ‘in service’ position.
    b) Closing of circuit breakers shall not be possible unless it is in “Service” position, “Test” position or in “Fully withdrawn” position. An adjustable time delay be provided in ACB closing mechanism.
    c) A breaker of particular rating shall be prevented from insertion in a cubicle of different rating.
    d) Circuit breakers shall be provided with safety shutters operated automatically by movement of circuit breaker carriage, to cover the stationary isolated contacts when the breaker is withdrawn. It shall however be possible to open the shutters intentionally, against spring pressure for testing purpose.
    e) Interlocking shall be provided to prevent a close circuit breaker being inserted into the panel.

9. Circuit breakers shall be provided with electrical anti pumping and trip free feature, even if mechanical anti pumping feature is provided.
10. Mechanical tripping shall be possible by means of front mounted Red Trip push button. In case of electrically operated breakers these push buttons shall be shrouded to prevent accidental operation.
11. Means shall be provided to slowly close the circuit breaker in “Withdrawn” position, if required for inspection and setting of contacts. In “Service” position slow closing shall not be possible.

Operating Mechanism

Power Operated Mechanism

a. Circuit breaker shall be provided with motor operated spring charged mechanism. The motor shall be a universal motor suitable for operating from 220V DC/240V AC control supply with voltage variation from 85% to 110%. Motor insulation shall be class “E” or better.
b. The charging time for closing springs shall not be more than 30 seconds.
c. Once the closing springs are discharged, after one closing operation of circuit breaker, it shall automatically start recharging of the spring.
d. The mechanism shall be such that as long as power is available to the motor, a continuous sequence of closing and opening operations shall be possible. After failure of power supply at least one open-close-open operation shall be possible.

e. Provision shall be made for emergency manual charging and as soon as this manual charging handle is coupled, the motor shall automatically get decoupled.
f. Circuit breakers shall be provided with closing and tripping coils. The closing coil shall operate correctly for voltage variation between 85% to 110% of rated control voltage. The trip coil shall operate correctly for voltage variation between 70% to 110% of rated control voltage.
g. Mechanical tripping shall be possible by means of front mounted red coloured trip push button. These push buttons shall be shrouded to prevent accidental operation.
h. Provision for mechanical closing of the breaker only in "Test" and "Withdrawn" positions shall be made. This mechanical closing facility shall be shrouded to prevent accidental operation

Manual Operated Mechanism

a) Manually operated mechanism shall be of manual spring charging, stored energy type.
b) The circuit breaker shall have a spring charging handle and push button for closing the breaker mechanically after the spring has been charged. However, closing by spring charging handle after the spring has been fully charged shall also be acceptable, provided the movement of contacts does not take place with the movement of handle and the contacts operate only when the spring stored energy is released. Overcharging of spring shall not be allowed.
c) The closing action of the circuit breaker shall charge the tripping spring thus making it ready to trip.
d) Interlocks shall be provided such that breaker shall not close unless the spring is fully charged.

4.8.2. Moulded Case Circuit Breaker

1. The MCCBs shall be designed in accordance with the IEC Publications 947.1 and 947.2. All MCCBs shall be manually/electrically operated and shunt trip type.
2. All MCCBs shall be draw out type, housed in individual metal- enclosed compartments. Each MCCB shall be mounted on a carriage assembly with wheels running on the tracks secured to the inside of the compartment. The carriage shall have self-engaging definite position stops for disconnected and connected position. Means shall be provided for easy removal and handling of the units.
3. A mechanical interlock shall prevent moving of the MCCB from connected position, while the breaker is closed, and also prevent the access door being opened unless the breaker is in withdrawn position.
4. MCCBs are used as outgoing circuit breaker of switchgear. All MCCBs shall be provided with motor wound spring mechanism and shunt trip. The normal current rating of all MCCBs shall be as per load requirements as shown in the single line diagrams attached with this specification.

5. It should be possible to adjust the thermal release setting at site over a wide range with the help of setting plugs, the details of which shall be furnished in the tender. MCCBs shall be flush mounted type so that these could be maintained with least disturbance to the associated circuits. These should be quick make, quick break, independent manual and current breaking type with shunt trip features and should be provided with ambient temp. compensated thermal overload with adjustable settings and magnetic short circuit releases. The position of the operating knob should clearly indicate ON/OFF and trip conditions. It should have over current and short circuit release as well as provision for tripping automatically when there is a single phasing in the circuit.
6. All MCCBs on the switchgear shall be provided with ON/OFF indicating lamps. Requisite number of normally open and normally closed auxiliary contacts shall be provided for satisfactory operation of the scheme and indication required. Neutral isolation shall be provided on all TPN circuits. The knob of isolators/disconnecting links shall be accessible through cutouts made in front door. Overload release setting shall be got approved from the Owner during detailed design stage.
7. All MCCBs provided on the switchboard shall be of same make complying with the above requirement.
8. MCCB contacts shall be of self-cleaning type, made from an approved arc resisting material. All contacts shall be self-aligning and shall be readily replaceable. Main and secondary disconnecting contacts shall be silver plated with spring, which will ensure high-pressure contact. Secondary contacts shall be engaged both in connected and test position.

4.9. RELAYS & TIMERS:

1. All relays shall be provided as shown in the drawing and any other relays required for operation of the complete system shall be included and shall conform to the requirements of IS: 3231 and shall be suitable for operation under climatic conditions specified. All relays and instruments shall be provided on the front side of the panel.
2. The over current and earth fault relays shall be of three pole, static type with inverse and definite minimum characteristics, and instantaneous element with adjustable settings suitable for O/C & E/F protection of the respective circuits.
3. Provision shall exist for testing each relay, in place, by injecting current and voltages from external sources.
4. All relays and timers in protective circuits shall be flush mounted on panel front with connections from the inside. They shall have transparent dust tight covered removable from the front. They shall either have built in test facilities or shall be provided with necessary test blocks and test switches located immediately below each relay. Auxiliary relays and timers may be furnished in non-draw-out cases.
5. All AC relays shall be suitable for operation with 110V VT secondary and 1 Amp CT secondary. The manufacturer shall provide control transformers in the panel.

6. All protective relays and timers shall have at least two potential free output contacts. Relays shall have contacts as required for protection schemes/control requirements. Contacts of relays and timers shall be silver faced and shall have a spring action. Adequate number of terminals shall be available on the relay cases for applicable relaying/ control schemes.
7. All protective relays, auxiliary relays and timers shall be provided with hand reset operation indicators for analyzing the cause of operation.
8. All AC relays shall withstand a test voltage of 2 kVrms for one (1) minute.

4.10. INSTRUMENT TRANSFORMERS

1. All current and voltage transformers shall be completely encapsulated cast resin insulated type suitable for continuous operation at the temperature prevailing inside the switchgear enclosure, when the distribution board is operating at its rated condition and the outside max. ambient temperature is 50 degreeC.
2. All instrument transformers shall be able to withstand the thermal and mechanical stresses resulting from the maximum short circuit and momentary current ratings of the associated switchgear.
3. All instrument transformers shall have clear indelible polarity markings. All secondary terminals shall be wired to a separate terminal on an accessible terminal block where star point formation and earthing shall be done.
4. All PTs shall have readily accessible HRC fuses on both primary as well as secondary sides.

4.11. INDICATING INSTRUMENTS

1. The incomer shall have the following provisions of indicating instruments on the panel:
    a) Ammeter with selector switches
    b) Voltmeter with inbuilt selector switch
    c) KW meter
    d) KWH meter
2. All indicating and integrating meters shall be flush mounted on panel front. The instruments shall be of at least 48mm square size with 90-degree scales and shall have an accuracy class of 1.5%. The covers and cases of instruments and meters shall provide a dust and vermin proof construction.
3. All instruments shall be compensated for temperature errors and factory calibrated to directly read the primary quantities. Means shall be provided for zero adjustment without removing or dismantling the instruments.
4. All instruments shall have white dials with black numerals and lettering. Black knife-edge pointer with parallax free dials shall be preferred.
5. Watt-hour meters shall be of three phase, three element type.

4.12. CONTROL & SELECTOR SWITCHES

1. Control and selector switches shall be of rotary type with escutcheon plates clearly marked to show the functions and positions. The switches shall be of sturdy construction suitable for mounting on panel front. Switches with shrouding of live parts and sealing of contacts against dust ingress shall be preferred.
2. Circuit breaker control switches shall have three positions and shall be spring return to 'Neutral' from 'Close' and 'Trip' positions and shall have pistol grip handles. They shall have at least two (2) contacts closing in close position, and two contacts closing in trip positions unless specified otherwise.
3. Ammeter selector switches shall have four stay put positions with adequate number of contacts for three phase four wire systems. These shall have oval handles. Ammeter selector switches shall have make before break type contacts to prevent open circuiting of CT secondary. Contacts of the switches shall be spring assisted and shall be of suitable material to give a long trouble free service.

4.13. ALARMS

Provisions shall exist on the annunciator panel (common for the entire station) for the following tripping:

1. O/C & E/F tripping of ACB.
2. Under voltage tripping of ACB.
3. Tripping of each of the outgoing feeders

4.14. INDICATING LAMPS

1. Indicating Lamps shall be of the panel mounting filament type and low watt consumption. Lamps shall be provided with series resistors, preferably built in the lamps assembly. The lamps shall have escutcheon plates marked with its functions, wherever necessary.

2. Lamps shall have translucent lamp covers of the following colours, as warranted by the application.

Colour	Indication
Red	Breaker CLOSED
Green	Breaker OPEN
Amber	For all healthy conditions. (Control supply and also for spring charged
Blue	For all alarm conditions (e.g overload)

3. Bulbs and lamps cover shall be easily replaceable from the front of panel.

4. Indication lamps should be located just above the associated push buttons/ control switches. Red lamps shall invariably be located to the right of lamps along the centre line of control switch/push button pair. Blue and Amber lamps should normally above the red and green lamps.

4.15. FUSES

1. Fuses shall be of HRC cartridge fuse link type. Screw type fuses shall not be accepted. Fuses for AC circuits shall be of class 2 type, kArms breaking current capacity at 415V AC and for DC circuits class 1 type, 20 kA breaking current.
2. Fuses shall have visible operation indicators.
3. Fuses shall be mounted on fuse carriers, which are mounted on fuse bases. Wherever it is not possible to mount fuses on carriers, fuses shall be directly mounted on plug in type of bases. In such cases one set of insulated fuse pulling handle shall be supplied with each switchgear.
4. Fuse rating shall be chosen by the Bidder depending upon the circuit requirements and these are subject to approval of purchaser.

4.16. TEST BLOCKS

Test blocks shall be provided on the switchgear for instrument transformers. The test blocks shall be of the back-connected type, semi flush mounted, switchboard type with removable covers.

All test blocks shah be provided with suitable circuit identification. The test blocks and plugs shall be arranged so that the current transformer secondary circuits cannot be open circuited in any position, while the test plugs or cover plugs are in place, being inserted or being removed.

4.17. PROTECTION CO-ORDINATION

It shall be the responsibility of the Contractor to ensure complete co-ordination between upstream and downstream circuit breakers so that during faulty condition circuit breaker nearest to the fault shall operate. Therefore, ACBs and MCCBs of the same manufacturer shall be preferred.

4.18. TESTS & REPORTS

1. Type test reports of Circuit Breakers, Busbars and panels, Contactor and Relays and all-important components like instrument transformers, meters, isolating switches and fuses etc shall be furnished by the successful Bidder before fabrication of switchgear is started. The reports shall cover all applicable type tests listed in relevant Indian Standards for all components for each type and rating being supplied.
2. However, at the discretion of the purchaser the supplier shall conduct any or all type tests. Charges for conducting these type tests shall be indicated separately for each equipment of each type and rating in the bid.
3. Routine tests shall be carried on all boards and associated equipment, as per relevant standards at Contractor's/supplier's cost. Three copies of all routine and type tests result shall be submitted for approval before dispatch of the switchboards and other accessories.
4. Purchaser reserves the right to witness any or all the type tests/ routine tests for which at least 20 days advance notice shall be given by the contractor.
5. The Bidder shall include in his price schedule (indicating it separately), the cost of carrying out the following type tests.
    a. Switchgear panels and circuit breaker of each rating with circuit breaker mounted inside the switchgear panel except duty cycle test of breaker which shall be conducted on each rating of breaker outside the panel, if the panel supplier is not the manufacturer of the circuit breaker.
        i. Short time withstand test
        ii. Temperature rise test
        iii. Test for degree of protection

    b. Following type tests shall be carried out on circuit breaker of each rating:
        i. Duty cycle test
        ii. Electrical endurance test
        iii. Mechanical endurance test

    c. Degree of protection test on local push buttons

    d. LT bus bar of each rating shall be type tested for:
        i. Short time withstand test
        ii. Temperature rise test
        iii. Air and water tightness test

6. All procedures for type tests shall be approved by the Purchaser before commencement of type tests.
7. Following routine tests as per IS: 8623 shall be performed on LT Switchgear/ Distribution Boards:

a. Inspection of switchgear/distribution boards including inspection of wiring and electrical operation test including the interlock test on LT board offered.
b. Dielectric Test.
c. Checking of protective measures and of the electrical continuity of the protective circuit

4.18.1. commissioning Checks

The Contractor shall carry out the following commissioning checks, in addition to the other checks and tests recommended by the manufacturers.

4.18.2. General

1. Check name plate details according to the specification.
2. Check for tightness of all nuts, bolts, and joints, connecting terminals.
3. All moving parts, where required, are properly lubricated.
4. Check earth connection.
5. Check cleanliness of insulators and bushings.
6. Check for physical damage.
7. Check for any tools or loose material left in and around the switchgear.

4.18.3. Circuit Breakers

1. Check alignment of breaker truck for free movement.
2. Check correct operation of shutters.
3. Check Control winding for correctness of connections, continuity and IR value.
4. Check Manual operation of breaker completely assembled.
5. Power closing/opening operation, manually and electrically
6. Breaker closing and tripping time
7. Trip free and anti pumping operation
8. IR value, minimum pick up voltage and resistance of coils
9. Contact resistance
10. Simultaneous closing of all the three phases
11. Check mechanical and electrical interlocks provided
12. Check on spring charging motor, correct operation of limit switches and time of charging
13. All functional checks including interlock checks

4.18.4. Current Transformers

1. Megger between winding and winding terminals to body.
2. Polarity test.
3. Ratio identification checking of all ratios on all cores by primary injection of current.
4. Spare CT cores, if any, to be shorted and earthed.

4.18.5. Voltage Transformer

1. Insulation resistance test
2. Ratio test on all cores
3. Polarity test
4. Line connections as per connection diagram

4.18.6. Cubical Wiring

1. Check all switch developments
2. Each wire shall be traced by continuity test and it should be made sure that the wiring is as per relevant drawing. All interconnections between panels/equipment shall be similarly checked.
3. All the wires shall be meggered to earth.
4. Functional checking of all the control circuit i.e. closing, tripping control, interlock, supervision and alarm circuit including the cubicle heater check.

4.18.7. Relays

1. Check connections and wiring
   a) Megger all terminals to body
   b) Megger AC to DC terminals
2. Check operating characteristic by secondary injection
3. Check minimum pick up voltage of DC coils
4. Relay settings
5. Check CT and VT connections with particular reference to their polarities for directional relays, if required.

4.18.8. Meters

1. Check calibration by comparing it with a sub-standard.
2. Megger all insulated portions.
3. Check CT and VT connections with particular reference to their polarities for power type meters.

4.19. DRAWINGS/ LITERATURE ETC.

1. The Bidder shall submit with the tender, 2 copies of drawings of general arrangement drawings showing front view, rear view, cable entry arrangement, foundation details etc.
2. Six prints of each of the following drawings shall be submitted within 90 days of the award of contract for the review and comment of the Purchaser.
   a. General Arrangement Drawings.
   b. Foundation plan
   c. Single line Diagram
   d. Schematic Drawings

e. Interlocking scheme for operation of incoming breakers to SSB
f. Equipment & component layout drawings (external as well as internal)
g. Bill of material (indicating manufacturer type, rating, make, quantity, reference drawing & item no. etc. of all components)
h. Wiring diagram

After the final approval of the drawings 6 prints of the approved drawings shall be submitted to the purchaser, before the dispatch of the equipment.

3. The tenderer shall supply complete technical details for each component like ACB, MCCB, CT, PT, relays, annunciation, instruments etc. to enable proper understanding of the offered equipment.
4. Six -sets of instruction manuals covering instructions for installation, operation and maintenance shall be supplied by the contractor before dispatch of the equipment.
5. All switchgear components shall be of reputed make.

4.20. TECHNICAL PARAMETERS

S.No	Parameter	Value
	A. AC System	
1	Voltage	415V+/- 10%
2	Frequency	50Hz +/- 3%
3	Fault Level	40 kA (rms)
	B. DC System	
1	System Voltage	220V DC, variation ±10 %
2	Fault Level	20 kA
	C. Control Supply Voltage	
1	Trip & closing coils	220V DC
2	Spring charging motors (Universal)	240V AC/220 V DC
	D. AC Distribution Panel	
1	Bus bar rating Station service board / UAB	1250 A / 400A

2	Short time (1 sec) current	40 kA
3	Panel Colour Finish 1. Interior 2. Exterior	 Glossy White Shade No. 631 of IS: 5
	E. One Minute Power Frequency Withstand	
1	Power Circuits	2.5 kV (rms)
2	Control Circuits	2.5 kV (rms)
	F. Air Circuit Breaker	
1	No. of Poles	3
2	Rated frequency	50 cycles
3	Rated current - Station Aux. Board	1250A / 400A
4	Rated short time Withstand current	40KA for 1 sec.
5	Rated short circuit making capacity	105 KArms
6	Short circuit performance category	P-2 with rated operating sequence for short circuit making and breaking capacity tests as O-t-CO-t-CO where t= -3 min. interval or resetting time of the circuit breaker whichever is lesser.
	G. Moulded Case Circuit Breaker	
1	Voltage	AC, 3Phase, 415 ± 10%
2	Frequency	50Hz
3	Short circuit breaking current	40 kAp
4	Operating Mechanism	Manual Trip Free
5	Temperature Rise	As per IS: 13947
6	Mechanical Rise	As per IS: 13947
7	Auxiliary Contacts	10 NO & 10NC
	H. Meters	

1	Accuracy Class	0.5
2	One minute power frequency withstand voltage (kV rms)	2
	I. Current Transformers	
1	Type	Cast resin, primary bar type
2	Application	Metering/ Protection
3	Secondary Current	1 Amp.
4	Voltage class & Frequency	1100V, 50Hz
5	Class of insulation	E or better
6	Accuracy class & burden i) Accuracy class for Metering CT ii) Rated Burden (metering CT) iii) Accuracy class for Protection iv) Rated Burden for Protection CT	 i) Class 0.5 ii) Adequate for application but not less than 15 VA iii) 5P20 iv) 30VA
	J. Potential Transformer	
1	Type	Cast Resin
2	Rated primary voltage	415/√3V
3	Rated Secondary Voltage	110/√3V
4	Frequency	50Hz
5	Class of insulation	E or better
6	Accuracy class for metering	0.5
7	Method of connection i) Primary ii) Secondary	 Star Star

4.21. SPARE PARTS AND SPECIAL TOOLS

The spare parts mentioned hereunder are meant for use by the Employer for 5 years trouble free operation & shall not be used as erection / commissioning spares required during installation. All the spare parts shall be interchangeable & shall be of the same material and workman ship as corresponding parts of the main equipment.

If any additional spare parts, required for 5 years trouble free operation period, are recommended by contractor, these shall be listed and the unit prices shall be quoted in the price schedule. The Employer reserves the right to order any or all of such spares.

All spare parts shall be protected against corrosion suitably packed and shall be marked with identification labels in the English Language. The identification shall be in accordance with the agreed Works Identification System.

All spare parts, tools and materials shall be delivered in marked boxes of sufficient sturdy construction to withstand long term storage. Material that is subjected to long term storage shall be stored in a dry, ventilated room with low humidity.

Acceptance of any spare parts will not take place before the Contractor has submitted the complete final list of all spare parts and tools. They shall be replaceable without cutting or destruction of adjacent components. Before issue of the Completion Certificate, the spare parts shall be checked at the Site by the Contractor in presence of the Engineer / Employer.

Mandatory Spares Parts

The following spare-parts shall be mandatorily included in the supply. One set shall imply the quantity provided / used for one unit.

S. No.	Description	Quantity
AC Auxiliary System		
	Air Circuit Breaker	
1	Spring charging universal motor (operable on 240 V AC) for draw-out circuit breakers	1 nos. of each type;
2	Closing Coils for circuit breakers	2 nos of each type
3	Tripping Coils for circuit breakers	2 nos of each type;
4	Main contacts for circuit breakers:	1 Set provided for one ACB
5	Secondary contacts for circuit breakers;	2 sets
6	Breaker control switch	1no of each type;

7	Solid-state overcurrent trip devices without ground fault element;	1 no for each type of CB used;
8	Solid-state overcurrent trip devices with ground fault element;	1 no for each type of CB used;
9	CT & PT	1 No. of each type
10	Indicating Lamps	1 No. of Each type
11	Push button	1 No. of each type
12	MCBs / HRC Fuses	1 No. of each type
13	Under voltage relay (27).	1 set
	MCCB	
14	MCCB	1 no. of each rating
15	Auxiliary switch / contact	LS
16	Operating knob handle	1 no of each type

If any additional spare-parts required for trouble free operation are recommended by bidder, these shall be listed and the unit price shall be quoted in the price schedule. The Employer reserves the right to order any or all of such spares.

Tools and Instruments

The Supplier shall supply all necessary tools, devices, testing Instruments / equipment etc. for installation, repair and maintenance at site. These shall remain the property of the Supplier unless otherwise agreed to be taken over by Employer any / all of these at mutually agreed conditions. The following tools shall be mandatorily included in the supply:

- Additionally racking handles for trolley and handles for manual charging of spring motors shall be supplied one for each cubicle.
- One lifting and transfer truck for draw-out circuit breakers,
- One portable test set for test purposes and calibration of the circuit breaker overcurrent tripping devices,
- One device for slow closing,
- One set of templates,
- One set of gauges,
- One set of special keys for contact adjustment,
- Any additional tools / special devices required for assembly/erection, dismantling and maintenance shall be tested and included in the offer by the Contractor.

Additionally, the Contractor shall furnish the unit price for above special tools for any addition/deletion of items by the Employer.

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5. CONTROL AND PROTECTION SYSTEM

5.1. SCOPE

The scope of this specification covers the design, manufacturing, supply, assembly, perform the factory and commissioning tests, install and connect the control and monitoring including, alarm display covering the entire station, printers, protection and instrumentation system including protective relaying, metering and control equipment for the safe operation of the Turbines, Generators, Generator Transformer, Station Service Transformer, 33 kV switchyard, 33 kV Line feeders and all auxiliary equipment. All the required accessories, documents & equipment whether specified herein or not shall be in the scope of the bidder. The scope shall also include central protection monitoring system, note book computer, corresponding software for processing of results of disturbance recorder etc.

The scope of supply shall also include necessary special tools required for erection, testing, commissioning, and maintenance. Mandatory spares/Recommended spares required for normal operation and maintenance for 5 years shall also be quoted separately

It is not the intent to specify completely all details of design and construction of the equipment. However, the equipment shall conform, in all respects, to high standards of design, engineering & workmanship and be capable of performance as envisaged in this specification or as per the latest and modern practices. The bidder shall supply the protection system of best quality maintaining quality control and assurance during manufacturing of equipment as per the approved quality assurance plan which he has to submit to the owner for his approval before the start of manufacturing. The Owner or Engineer-in-charge will interpret the meaning of drawings and specifications and shall have power to reject any work of materials which in his judgment are not in full accordance therewith. The bidder is required to submit the calculations for selecting the time setting for control/ protection relays etc. of generating units, its auxiliaries, switching equipment and 33KV feeder for approval.

5.2. TECHNICAL REQUIREMENTS

The control, protection and metering equipment covered under the scope of supply shall be able to sustain a reasonable amount of mechanical vibrations as may be encountered on electrical power plants as well as seismic vibrations/ accelerations without malfunctioning or damage.

All equipment shall operate satisfactorily in ambient temperature up to 50°C without any air-conditioning and down to -10°C.

All protective relays shall be microprocessor based numerical relays. Relays shall be suitable for local reset. They shall have self monitoring (diagnostics/ test) facility and LED status display

Each protection and control relay shall have complete insulation between AC voltage and 220 V DC voltage Coils and contacts. The insulation level between relay coil and contacts shall not be less than 1500 V.

All protection and control circuits shall operate satisfactorily on nominal 220 V DC with a variation of ±10%V.

The contractor shall supply complete schematic and wiring diagrams for the equipment including metering, control and protective devices. The bid should contain the complete details of hardware/ software covered in the offer, keeping in mind that shortfalls in the quantities shall be made good without additional cost.

All contacts shall have a minimum rating of 10A over a range of 6 to 600 V AC. Pilot devices such as selector switches, push button stations, thermostats, shall be of heavy-duty type.

415 V AC circuit terminals shall be segregated from other terminals and shall be equipped with non-inflammable, transparent cover to prevent contact with live parts. Warning labels with red lettering shall be mounted thereon in a conspicuous position.

Sensitive control circuits shall be effectively shielded against extraneous signals and interference.

All instruments, control knobs 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 panel. All CT and PT connections inside the panel shall be with shielded wires.

No equipment shall be installed on rear access doors.

All relays shall be provided with 15% spare output contacts.

Modern station protection monitoring system shall be based on the principle of distributed intelligence. The unit protection as well as 33KV Switchyard equipment protection system and 33 KV switchgear protection system shall communicate via interference immune optical fibre cables. Provision shall be made for extension communication with other numerical protection devices: 33KV overhead lines protection devices. The system shall provide for local as well as remote monitoring of protection system from any location. The functionality of the required system may be summarized as follows:

- Testing and simple function check of the relay circuits and tripping logic,
- Provision for central analysis of relays and disturbance recorder,
- Provision for changing device setting from a control central.
- The system shall continuously log all events and warn the user should an abnormal operating situation arise.

- The user interface shall be equipped with graphical displays and take full advantage of modern multiple windows technology. It shall provide the user with an overview of the status of the station and facilitate coordination of protection functions.

5.3. CODES AND STANDARDS

The equipment shall conform to the following standards in particular:

Code/Standard	Description
IS: 3231	Electrical relays for power system protection.
IS: 2705	Auxiliary current transformers.
IS: 3156	Auxiliary potential transformers.
IS: 1248	Direct acting electrical indicating instruments.
IS: 722	Energy meters.
IS: 90	Recorders.
IS: 2208	HRC cartridge fuse links up to 650 V.
IS: 3202	Code of Practice for climate proofing of electrical equipment.
IS: 375	Marking & arrangement of switchgear, busbars, main connection and auxiliary wiring.

5.4. UNIT CONTROL

5.4.1. Unit Control Board (UCB)

Each turbine generator shall be provided with a complete set of instruments, gauges, control and safety devices on unit control board, provided for monitoring the conditions of the unit during normal operation and emergencies. The instruments and gauges for the unit include pressure gauges, level indicators, temperature and flow indicators, position indicator, indicating lamps for status indication etc along with suitable transducers for various control functions stipulated. These shall be mounted/ placed in the unit control board or the auxiliaries in the machine hall. The safety devices shall comprise equipment and devices for sensing abnormal operating conditions, for giving visual and audible annunciation and shut down of the unit when required. The items, quantities and location of the instruments are to suit the requirements for safe and satisfactory operation of the generating units and the auxiliary systems. Generating units and auxiliaries shall be started manually from this board.

Unit operation

Unit control board shall be local control centre for overall sequence of operation. It shall check for presence of all required criteria before it issues a particular command. The control system shall have the following features incorporated:

- Checking of start criteria
- Automatic/ Manual synchronizing
- Electrical isolation of the unit
- Quick complete automatic shut down of the unit
- Emergency shut down of the unit
- Manual Control and Interruption of Control at any stage

5.4.2. Alarms And Trips

The provision of alarms indicated may change during detailed designing. The protective gear shall include the following minimum alarms and shall be provided on the Unit Control Board.

1. OPU	-	Low oil pressure
2. Governor system	-	Low oil pressure
3. Governor oil pump	-	Failure
4. Turbine bearings	-	High temperature
5. Generator bearings	-	High temperature
6. Governor oil pumps	-	Intermittent failure
7. Governor sump tank	-	High and Low oil level
8. Guide vane opening	-	Malfunction.
9. Station supply failure	-	Tripping
10.Control supply failure	-	Failure
The following minimum tripping with alarm shall be provided for the turbine:		
1. Hydraulic Gates (upstream)	-	Emergency closure
2. Turbine bearing	-	Very high temperature
3. Turbine over speed	-	115 percent (in manual mode)
4. Governor oil pump	-	Failed
5. Turbine over speed	-	120 percent (in auto mode)
The following minimum alarm & trip contact shall be provided for the generator:		

1. Generator bearing	-	High temperature (Alarm & Trip)
2. Fire detection	-	Operation (Alarm)
3. Exciter faults	-	Operation (Alarm & Trip)
4. DC control supply failure	-	Alarm & Trip
5. Generator over speed	-	Alarm & Trip
6. Generator winding	-	High temperature (Alarm & Trip)

5.5. PROTECTIONS

The following numerical protections shall be provided for Generator, Generator Transformer, & 33 kV Line Feeders and shall be accommodated in panels to be located in the Control Room/Switchgear room.

5.5.1. Generator & Generator Transformer Protection

Following protections shall be provided on each of the generators:

- Reverse Power (32G)
- Loss of Excitation (40G)
- Negative Phase sequence (46G)
- Voltage restrained over current relay (51VR)
- Generator over voltage relay (59)
- Generator voltage balance protection (60 P)
- 95% Stator Earth Fault Relay (64GS)
- Generator differential relay (87G)
- Main Transformer REF Protection (64 GT)
- Main Transformer Differential Protection (87 GT)
- Station Service Transformer O/C & E/F protection (50/51)
- Station Service Transformer REF Protection (64)
- Unit Auxiliary Transformer O/C & E/F protection (50/51)
- Unit Auxiliary Transformer REF Protection (64)
- 33 kV Bus Protection

All the protective relays shall be of microprocessor based numerical type with high reliability with inbuilt test/ diagnostic facilities. The protective devices indicated above are only indicative. Any other protection recommended by the Supplier may be given. The Supplier may suggest suitable scheme required for the generator protection keeping modern trends in view. The final scheme will be decided by the Purchaser/Consultant in consultation with the Supplier during final design. Sufficient number of potential free contact shall be available for control and monitoring functions, leaving at least 15% as spare.

5.5.2. 33kV Line Protection

Following relay for protection of 33 kV transmission line shall be mounted in one of the panels:

67P Directional - Over current protection.

67G Directional - Earth fault protection.

86 High speed tripping relay

The protection system shall be designed and used for a fast and selective protection of generators, generator transformers and outgoing feeder with a quick separation of faulty part.

Differential protections shall be designed to have high stability for external faults and C.T. Saturation.

Generator negative phase sequence shall give an alarm followed by tripping in case of unbalanced current. Negative phase sequence function shall have inverse characteristics to suit to I2 2t value which can be tolerated by Machine.

The generator, generator transformer and switchyard protections shall be designed in a way that all protections available are in two independent sub systems. Some of the important and most vulnerable protections shall be duplicated to ensure reliability and security of generators.

Two independent sub systems necessarily be powered by two independent DC sub systems which shall be powered by DC battery bank in the station.

Tripping matrix shall be provided for each protection group to enable the programs of the tripping logic including the fully automatic supervision of the matrix programming diodes and the tripping multiple contactors. Necessary coordination with the turbine, generator and associated auxiliary equipment suppliers for the purpose of alarm, tripping, annunciation shall be the responsibility of the bidder. The software tripping matrix shall be continuously supervised.

5.6. METERING AND PROTECTION PANELS

Metering panels shall conform to international standards. Protective relays, control switches, indicators and monitoring devices shall be mounted on the front. The relays, terminals, and control circuit breakers shall be inside the panel. The completed panel shall be factory inspected and tested and a standard simulation test shall be performed on the system before shipment in the presence of purchaser's representative.

These panels shall be located in the control room. The indicators and monitoring devices such as PF (power factor), kW, kVAR, KWH, Voltage, Current, control and selector switches etc. shall be located in front of the panels.

5.7. SETTING CALCULATIONS

The contractor shall calculate during the detailed designs the setting values of all protection relays covered under this section and submit them to purchaser for approval. During erection and commissioning, the contractor shall set all relays in accordance with approved settings.

5.8. INSTRUMENTS

5.8.1. General

All instruments shall be of the switchboard type, back connected, flush mounted, dust tight and tropicalized. They shall be of square pattern and comply with IS: 1248 and shall be of accuracy class 1. These instruments/ energy meters/ indicating lamps/ control switches shall be mounted on the UCB to be located in the machine hall.

Zero adjustment for pointers shall be accessible from the front of the instruments. All auxiliary equipment such as shunts, transducers, interposing C.T./P.T., etc. that are required shall be included in the scope of supply.

All instruments shall be subjected to an applied potential test of 2 kV for one minute. Wherever specified digital meters shall be provided to indicate frequency and power factor parameters.

5.8.2. Frequency Meters

These shall be long range, calibrated for 45-50-55 Hz. These shall be of the digital type.

5.8.3. Ammeters, Voltmeters, Kw Meters

These shall be of taut band type. The kW meter shall be suitable for measuring unbalanced loads on a 3 phase, 3 wire system. The kW meter and voltmeter shall operate on potential transformer secondary voltage of 110V (phase-to-phase).

5.8.4. Power Factor Meters

The range of P.F. meters shall be 0.5 – 1 – 0.5. These shall operate on 110 V potential transformer secondary (phase-to-phase).

5.8.5. Energy Meters

Digital energy meters of reputed make shall be provided. Main recording of energy for the energy sold to the PDD/PDC shall be at the point of interconnection The panel mounted energy meters on generator, feeder and station transformer are required for the purpose of record of units generated and utilized in the station as well as the estimation of line losses These energy meters should therefore be of same class as the main/ check meters to be installed at the point of interconnection.

5.8.6. Indicating Lamps

These shall be switchboard type of low power consumption. Lamps shall be supplied complete with necessary resistors. Lamps shall be provided with screwed translucent covers to diffuse light. The lamp covers shall preferably be unbreakable, moulded, heat resistant material and shall be tropicalized.

5.8.7. Control Switches

All control switches shall be rotary. Back connected contacts shall be used on switches.

The handle of control switches used for circuit breaker operation shall turn clockwise for closing and anti-clockwise for tripping and shall spring return to neutral from close/trip with lost motion device.

Ammeter selector switches shall be with make before break feature and shall have three positions to read the three phase currents. Voltmeter selector switches shall also have three positions, suitable to read phase-to-phase voltages.

5.9. SYNCHRONISING EQUIPMENT

One auto synchronizer is to be supplied and located inside each unit control board. One manual synchronizing trolley shall be supplied loose with connections available on the generator relay panels located in the control room, to be used as and when manual synchronization is being attempted. The voltage transformer secondary connections shall be linked with the unit auto synchronizer located in the related unit control board. The contractor shall make all necessary arrangements to ensure that proper synchronizing takes place.

5.10. SPARE PARTS

Contractor shall separately indicate the price of spare parts and special recommended tools. Each item shall be clearly described.

All spare parts shall be identical electrically and mechanically to the corresponding parts of the equipment supplied and shall be suitably packed and clearly marked, ready for long term indoor storage.

If dismantling of certain parts requires the use of special tools, Contractor shall supply them with the equipment. Each tool shall be described, and its unit price indicated in the Tender.

Mandatory Spares

Bidder shall quote for the following mandatory spares as a minimum.

S.No.	Item	Qty.
1	50/51 relays	2 sets of each type used
2	Single phase metrosil (if used)	3 Nos.
3	Three phase metrosil (if used)	1 set
4	Test block	2 Nos.
5	Tripping relay of type used	2 sets of each type used
6	Trip circuit supervision of type used	2sets of each type used
7	Auxiliary relays of type used	5 sets of each type used
8	Auxiliary relays socket of type used	5 sets of each type used
9	Fuse blocks & Fuses, Heavy Duty terminal blocks, internal tined copper wires.	15% of each type
10	Protection Relays of each type	1 no

If any additional spare parts required for trouble free operation are recommended by bidder, these shall be listed and the unit price shall be quoted in the price schedule. The Employer reserves the right to order any or all of such spares.

Tools and Instruments

The Supplier shall supply all necessary tools, devices, testing Instruments / equipment etc. for installation, repair and maintenance at site. These shall remain the property of the Supplier unless otherwise agreed to be taken over by Employer any / all of these at mutually agreed conditions.

5.11. TESTS

The tenderer shall submit with his proposal copies of the type test reports of the equipment, relays & panels included in the offer. All equipment shall be subjected to routine and functional tests in accordance with the relevant standards.

5.12. DRAWINGS

The contractor shall submit 2 copies of the following drawings along with the bid for equipment suitability assessment.

1. General arrangement drawing of machine hall showing layout arrangement of various panels.
2. Principal layout drawings for the unit control Boards, unit control panels and relay boards showing the layout of equipment on and inside each panel.
3. Complete list of hardware/ software and other details proposed alongwith full specifications.
4. Literature & illustrative material for the type of relay & equipment included in the offer.

Within 90 days after the award of work, the Manufacturer shall submit to Purchaser, for review and comment, 6 copies of the following drawings:

1. Principal layout drawings for the unit control Boards, unit protection panels and relay boards showing the layout of equipment on and inside each panel.
2. Control & schematic drawings for control & protection circuits. The transducers required for electrical and physical quantities such as pressure, flow, temperatures etc. shall be decided at the time of detail engineering.
3. Internal wiring diagrams of all panels and boards giving internal connections for all the equipment.
4. Detailed scheme of automatic control with configuration of each equipment.
5. Setting calculation of Relays.
6. Item wise bill of materials listing all devices alongwith make and specifications, Board/ Panel wise.
7. Foundation drawings
8. Complete literature & illustrative material for each type of relay & control/ monitoring equipment.

After the final approval of the drawings 6 prints of the approved drawings shall be submitted to the purchaser, before the dispatch of the equipment.

5.13. INSTALLATION

Contractor shall install the control, protection, and metering system in accordance with the requirements of this Specification.

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6. CONTROL AND MONITORING SYSTEM, AUTOMATION, SCADA

6.1. General

The Scope covers the detailed requirements for the design, manufacture, factory testing, transportation and delivery at site, site storage and preservation, installation, site testing and commissioning of the Unit Control, SCADA and Automation (hot redundant) systems including all associated equipment and cabling including integration of the equipment under the electrical EBOP and in mechanical MBOP for their monitoring and control from the main SCADA in the powerhouse control room. Scope also includes the integration of monitoring of the equipment at remote site (Intake) as well as monitoring and control of switchyard equipment i.e. SAS (Station Automation system) in the control room SCADA. The supply shall include all software, parts, devices, accessories and special tools, which though not individually specified, but are necessary to construct, operate and maintain the complete Unit Control, SCADA, automation and communication systems as described hereafter. All hardware and Software shall be 100% compliant to OPC Specifications and shall be OPC Certified.

a) The Unit Control, SCADA and PLC Automation systems shall be referred in this specification as the Plant Control System (PCS). The PCS shall conform to the General SCADA Architecture- as per details given below.
b) This section specifies the general requirements for the design, manufacture, integration and factory testing of the PCS system as shown in SCADA Architecture drawing comprising of Unit Control Boards, Station Service Board, Switchyard control Board, Intake Control Board etc. SCADA Work Stations and the Optic Fibre Network to be supplied under this contract complete with all the appurtenances, spare parts, and shop drawings.

1. The Contractor shall include all the software, data bases, computers, screens, interfaces and hardware necessary for the control and monitoring of the entire plant and facilities from any of the Human Machine Interfaces (HMI), Operator Work Stations or Engineering Work Stations as specified.
2. The Contractor shall integrate all the equipment with SCADA system furnished under this Contract.

3. All control and monitoring signals for the equipment and systems provided under this contract shall be wired to Input & Output Modules and/or Programmable Logic Controllers (PLC) identical or compatible to the redundant master PLC controllers supplied within each Control Board. Interposing control relays shall be supplied as required to interface with external control systems. For Electrical Protection interfaces, heavy duty high speed lockout, tripping and control relays shall be provided. The preferred interfaces, with the master PLC of systems supplied by others shall be done via a fibre optic links through the SCADA Communication Network. The Contractor shall be responsible for interfacing requirements of the systems, and for the creation, integration and testing of the data base, HMI screens, reports, alarms, diagnostics and other features required to ensure the same overall functionality of the Master PLC. The Contractor shall review and ensure full compatibility of hardware and communication interfaces of systems and devices being supplied under other packages with the SCADA and LAN network included in this package. Any interfacing equipment not specifically included but required during execution for smooth functioning of the SCADA system, shall be deemed to be included in this package.

4. The interfaces with the SCADA Communication Network shall include:
    - The fibre optic communication system to remote site through ADSS cable,
    - The vibration monitoring system,
    - The Electrical Protection System,
    - The Dispatch System (through OPGW),
    - The Energy Monitoring system (EMS),
    - The Voice over IP system (VoIP). The VoIP system shall include a Server and VoIP routers. These routers shall be installed in separate panels (800X800X2300 mm). The system shall establish telephone communications throughout the Power Plant and Remote Sites, Switchyard and to the Utility Dispatch via the OPGW system,
    - The Closed Circuit TV system (CCTV). The system shall send video pictures from the Remote Sites and Power House to the Control Room.

5. The design and assembly of the Unit Control, SCADA and Automation systems shall follow the following rules:
    - The Unit Control, SCADA and Automation systems shall be fully hot redundant. Systems A and B shall be provided throughout,
    - In each Control Board, Master PLC-A and Master PLC-B shall be fully synchronized and shall operate simultaneously without interference,
    - In each Control Board, Master PLC-A shall be interfaced with System-A of other redundant systems including DC and UPS supplies. Master PLC-B in turn shall be interfaced with System-B of other redundant systems including AC, DC and UPS supplies,
    - Master PLC A and B shall be totally isolated from one-another and shall preferably be installed in separate panels,

- System-A interface relays and System-B interface relays shall be isolated from one another and be located in the rear panel section of the relative Master PLC,
- The HMI shall be installed in a separate panel along with the Energy Meter. Common I/O modules shall be installed in the HMI panel. Common interface relays shall be installed in the rear panel section,
- No common I/O modules or interface relays shall be installed in the Master PLC-A and Master PLC-B sections,
- The Unit Control Boards (UCB) shall include a section that shall house the Automatic synchronizer as well as the manual synchronization controls and meters,
- The Unit Control Boards shall include the signals from redundant AVR panels and the redundant Governor Control panels.
- The Fibre Optic Network will be designed so that Circuit A and B shall be interfaced to both LAN-1 and LAN-2.

6.2. Scope

The main components comprising the Unit Control, SCADA and PLC Automation systems shall include but not limited to the following. The Contractor shall supply all components required to satisfy the requirements for the control and SCADA system of the overall complete project as per the present specifications. All components shall be OPC certified.

1. Unit Control Boards (UCB-1, UCB-2, UCB-3)
    - Panel-1 to include Master PLC-A and, I/O modules and interface relays relative to Systems-A,
    - Panel-2 to include Master PLC-B and, I/O modules and interface relays relative to Systems-B,
    - Panel-3 to include the Human Machine Interface (HMI), a GPS slave clock, a VoIP telephone, Channel-A and B Ethernet Switches, the Energy Meter and I/O modules and interface relays common to Systems-A and B,
    - Panel-4 to include the Automatic Synchronizer, the Synchro-check relay and the
    - controls and meters for manual synchronization,
    - Panel-5 to include the System-A Governor Controls and interface relays,
    - Panel-6 to include the System-B Governor Controls and interface relays,
    - Panel-7 to include the System-A Automatic Voltage Regulator (AVR),
    - Panel-8 to include the System-B Automatic Voltage Regulator (AVR),
    - The Fibre Optic cable and Patch Cords to connect all SCADA Element.

2. Station Service Board (SSB)

- Panel-1 to include Master PLC-A and, I/O modules and interface relays relative to Systems-A. List of I/O modules required is to be defined by Contractor as required for the monitoring of the SSB components,
- Panel-2 to include Master PLC-B and, I/O modules and interface relays relative to Systems-B. List of I/O modules required is to be defined by Contractor as required for the monitoring of the SSB components,
- Panel-3 to include the Human Machine Interface (HMI), a VoIP telephone, Channel-A and B Ethernet Switches, and I/O modules and interface relays common to Systems-A and B,
- Panel-4 to include the additional I/O modules and interface relays common to Systems-A and B.
- The Fibre Optic cable and Patch Cords to connect all SCADA Element.

3. Generator Floor Patch Panels
    - Channel-A and Channel-B Patch Panels. One pair located on the Generator floor between Unit 1 and the service bay and a second pair located between Units 2 and 3. Patch Panels shall house Converters, Routers, Ethernet Switches, etc. within 2-rack mount type panels of 800 mm by 800 mm by 2300 mm;
    - Patch Panels to serve UABs, SSB, UCBs as well as Unit Protection Boards,

4. Intake Control Board (ICB)
    - Panel-1 to include Master PLC-A and I/O modules. Space shall be provided for any interface relays required in the future relative to Systems-A. List of I/O modules required is to be defined by Contractor,
    - Panel-2 to include Master PLC-B and I/O modules. Space shall be provided for any interface relays required in the future relative to Systems-B. List of I/O modules required is to be defined by Contractor,
    - Panel-3 to include the Human Machine Interface (HMI), a VoIP telephone and I/O modules and interface relays common to Systems-A and B. This panel shall be provided with 4 communication ports, I/O modules for digital I/O and analog I/O and additional space to double the number of I/O,
    - Channel-A and Channel-B Patch Panels to house Channel-A Ethernet Switches,
    - Channel-B Routers, etc. within 2-rack mount type panels of 800 mm by 800 mm by 2300 mm,
    - The Fibre Optic cable and Patch Cords to connect all SCADA Element.

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5. Main Control Room
    - Two (2) Operator Work Stations c/w Desktop Computers, Keyboard, mouse and two (2) no 22 inch LED Screen;

- Four (4) Large Video Screens (LVS) 55 inch LED Screens including video Matrix Switcher to Control the LVS Screens arranged to form a matrix with narrow bezels c/w hardware for wall mount assembly and the necessary high quality enclosure to hide supports and cables;
- One (1) Engineering Work Station c/w Desktop Computers, Keyboard, Mouse and one (1) 22 inch LED Screen;
- One (1) Portable Engineering Work Station c/w Laptop Computer complete with separate lockable Docking Station, 22 inch Screen, Keyboard and Mouse;
- One (1) Historian Work Station c/w redundant Raid Servers, Keyboard, Mouse and one (1) 22 inch LED screen;
- One (1) CCTV Station c/w Servers, Keyboard, Mouse and one (1) 22 inch LED screen;
- One (1) EMS Station c/w Servers, Keyboard, Mouse and one (1) 22 inch LED screen;
- One (1) Operator Work Station for protection system c/w Desktop Computers, Keyboard, mouse and 22 inch LED Screens;
- One (1) Engineering Work Station for protection system c/w Desktop Computers, Keyboard, Mouse and one (1) 22 inch LED Screen;
- One (1) Portable Engineering Work Station for protection system c/w Laptop Computer complete with separate lockable Docking Station, 22 inch Screen, Keyboard and Mouse;
- One (1) DWS Work Station for Dispatch system c/w Desktop Computers, Keyboard, Mouse and one (1) 22 inch LED Screen;
- One (1) multi functional B/W Laser Printer/Copier/Scanner/Fax suitable for A3 and A4 formats,
- One (1) desktop Colour Laser Printer suitable for A3 and A4 formats,

  One (1) desktop Dot Matrix Printer,

  One (1) Printer Router/Server,

  One (1) no. VOIP System for powerhouse & remote

- Channel-A and Channel-B Ethernets Switches as required to serve the Work Stations and Servers within the Control Room;
- Channel-A and Channel-B Patch Panels housing Convertors, Routers, Ethernet Switches, etc. within 2-rack mount type panels of 800 mm by 800 mm by 2300 mm;
- The GPS Clock, Antennas and IRIG-B distribution coax cabling,
- Control Room top quality heavy duty furniture including desks, tables, stands, cabinetry and chairs. The furniture shall include accommodation for above mentioned Work Stations and equipment provided herein;
- The Fibre Optic cable and Patch Cords to connect all SCADA Element.

6. The Optic Fibre cable Network for the complete system including all provisions for interfacing equipment and systems. The Optic Fibre cables shall be installed in rigid steel conduit throughout. Optic Fibre extension and Patch Cords to interface Control Boards, Protection Boards, Work Stations, Automatic energy metering system, RTU, etc. shall be provided and laid in dedicated cable trays or conduits.

7. Automatic Energy metering System shall comprise of the following:
    - Panel of automatic billing system floor mounted with glass door with swivel frame for installation of the central microprocessor unit, distribution panels for data collection from the meters with pulse output, PC computer, monitor and UPS unit. The panel shall be installed in the control room.
    - Panel of automatic energy metering system floor mounted with swivel frame. The panel shall be installed in Switchyard.
    - Shielded cables for connection of meters to distribution panel,
    - Link between the meter optical port and serial computer port.

6.3. Copyrights and Software Licenses

1. The Employer shall own the copyrights for all documentation and software developed for the project.
2. All software licenses and vendor support agreements shall be in the name of the Employer.
3. The programming software, instruction manuals, application software and data files shall become the property of the Employer at completion of the project.
4. All program documentation shall be reviewed and approved by the Employer prior to implementation. Refer to submittal requirements specified herein.
5. The Contractor shall submit a full copy of the application software updates once a month until the warranty period expires to the Employer and/or its designee to be kept in case of force major events or bankruptcy of the Contractor.

6.4. Abbreviations

The following are common abbreviations used in this Section:

1. PCS: Plant Control System
2. DCS: Distributed Control System
3. MMI: Man Machine Interface (includes HMI and OWS)
4. HMI: Human Machine Interface (in Control Boards)
5. OWS: Operator Work Station (in Control Rooms)
6. EWS: Engineer Work Station
7. VWS: VoIP Work Station
8. DWS: Dispatch Work Station
9. HWS: Historian Work Station

10. EMS: Energy Management Work Station
11. CCTV: Closed Circuit TV
12. ZCS: Zoom Processor Analysis Work Station
13. LVS: Large Video Screen
14. LSB: Less Significant Bit
15. MFM: Multifunction Meter. Also referred as Energy Meters or Power Measurement Device
16. NTP
    (1) Network Time Protocol (Time Synchronization)
    (2) Notice to Proceed (Submittals)
17. OPC
    (1) Open Protocol Compliance (open connectivity, open standards)
    (2) Object-Linking and Embedding (OLE) for Process Control
18. OPGW: Optical Ground Wire
19. PC: Personal Computer (Desktop Computer)
20. PLC: Programmable Logic Controller
21. RTU: Remote Terminal Unit
22. PMD: Power Measurement Device. Also referred as Multifunction Meter
23. SCADA: Supervisory Control and Data Acquisition
24. SNTP: Simple Network Time Protocol
25. UTC: Coordinated Universal Time
26. VESA: Video Electronics Standards Association
27. UCB: Unit Control Board
28. SSB: Station Service Board
29. ICB: Intake Control Board
30. UPB: Unit Protection Board
31. PLCC: Power Line Carrier Communication
32. VLAN: Virtual Local Area Network
33. VoIP: Voice over IP
34. ODBC: Open Data Base Connectivity
35. IRIG: Inter-Range Instrumentation Group
36. LAN: Local Area Network
37. IGMP: Internet Group Management Protocol
38. RSTP: Rapid Spanning Tree Protocol
39. HDM: Historical Data Management

6.5. Standards And Codes

The equipment covered under these specifications shall conform to the latest edition of the following standards:

Code	**Specification**
IEC 61850-3	Communication networks and systems in substations - Part 3: General requirements
IEC 61850-4	Communication networks and systems in substations - Part 4:

	System and project management
IEC 61850-5	Communication networks and systems in substations - Part 5: Communication requirements for functions and device models
IEC 61850-6	Communication networks and systems for power utility automation - Part 6: Configuration description language for communication in electrical substations related to IEDs
IEC 61850-7-410	Communication networks and systems for power utility automation - Part 7-410: Hydroelectric power plants - Communication for monitoring and control
IEC 61850-7-1	Communication networks and systems in substations - Part 7-1: Basic communication structure for substation and feeder equipment
IEC 61850-7-2	Communication networks and systems for power utility automation - Part 7-2: Basic information and communication structure - Abstract communication service interface (ACSI)
IEC 61850-7-3	Communication networks and systems for power utility automation - Part 7-3: Basic communication structure - Common data classes
IEC 61850-7-4	Communication networks and systems for power utility automation - Part 7-4: Basic communication structure - Compatible logical node classes and data object classes
IEC 61850-10	Communication networks and systems in substations - Part 10: Conformance testing
IEC 61131-1	Programmable controllers - Part 1: General information
IEC 61131-2	Programmable controllers - Part 2: Equipment requirements and tests
IEC 61131-3	Programmable controllers - Part 3: Programming languages
IEC 61131-5	Programmable controllers - Part 5: Communications

IEC 61131-7	Programmable controllers - Part 7: Fuzzy control programming
IEC 60870-1 series	Telecontrol equipment and systems. Part considerations. Section One: General principles
IEC 60870-2 series	Telecontrol equipment and systems - Part 2: Operating conditions
IEC 60870-3	Telecontrol equipment and systems. Part 3: Interfaces (electrical characteristics)
IEC 60870-4	Telecontrol equipment and systems. Part 4: Performance requirements
IEC 60870-5 series	Telecontrol equipment and systems. Part 5: Transmission protocols
IEC 60870-6 series	Telecontrol equipment and systems - Part 6: Telecontrol protocols compatible with ISO standards and ITU-T recommendations
IEC 60338	Telemetering for consumption and demand
IEC 60381-1	Analogue signals for process control systems. Part 1: Direct current signals
IEC 60381-2	Analogue signals for process control systems. Part 2: Direct voltage signals
IEC 61000	Electromagnetic compatibility (EMC)
IEC 60255-5	Electrical Relays - Part 5: Insulation coordination for measuring relays and protection equipment - Requirements and tests
IEC 60255-22-1	Measuring relays and protection equipment - Part 22-1: Electrical disturbance tests - 1 MHz burst immunity tests
IEEE 488.1	Standard Digital Interface for Programmable Instrumentation
IEEE 488.2	Standard Codes, Formats, Protocols, and Common Commands for Use with IEEE Std. 488.1-1987, IEEE Standard Digital Interface for Programmable Instrumentation
IEEE 762	Standard Definitions for Use in Reporting Electric Generating Unit Reliability, Availability, and Productivity
IEEE 1010	Guide for Control of Hydroelectric Power Plants

IEEE 1046	Application Guide for Distributed Digital Control and Monitoring for Power Plants
IEEE 1050	Guide for Instrumentation and Control Grounding in Generating Stations
IEEE 1059	Recommended Practice for Monitoring Electric Power Quality
IEEE 1174	Standard Serial Interface for Programmable Instrumentation
IEEE 1222	IEEE standard for All-Dielectric self-supporting Fibre Optic Cable
IEEE 1249	Guide for Computer-Based Control for Hydroelectric Power Plant Automation
IEEE 1344	Standard for Synchro phasors for Power Systems
IEEE 1346	Recommended Practice for Evaluating Electric Power System Compatibility with Electronic Process Equipment
IEEE 1451.1	Standard for a Smart Transducer Interface for Sensors and Actuators--Network Capable Application Process (NCAP) Information Model
IEEE 1451.2	Standard for a Smart Transducer Interface for Sensors and Actuators - Transducer to Microprocessor Communication Protocols and Transducer Electronic Data Sheet (TEDS) Formats
IEEE1588	Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems
IEEE 1590	Recommended Practice for the Electrical Protection of Optical Fibre Communication Facilities Serving, or Connected to,

	Electrical Supply Locations
ANSI C57.13.3	Guide for the Grounding of Instrument Transformer Secondary Circuits and Cases
OPC UA- Parts 1 to 11	Unified Architecture Products Specifications
OPC TEST LAB Parts 1 to 11	OPC Lab Certified Products
BS EN 55011	Limits and methods of measurement of radio disturbance characteristics of industrial, scientific, and medical (ISM) radiofrequency equipment

6.6. Design Requirements

1. The Plant Control System (PCS) shall monitor and control independently and redundantly each of the three generating units of the Plant and associated facilities. The PCS shall include all necessary hardware and software for measurement indication, recording and automatic & manual control of the plant equipment and auxiliary systems.

2. The Man Machine Interface (MMI) refers to the Control Room Operators Work Stations (OWS) and to the Control Board Human Machine Interfaces (HMI). All MMI shall operate independently and have full Unit Control and Monitoring capability. The Control Board HMIs shall have priority over the Control Room OWS. A local / remote switch shall be provided at the local HMI's.

3. The PCS shall provide local and centralized control and monitoring of the power plant & associated facilities from the MMI located in the plant control room. The PCS shall provide capabilities for full remote control of the generating units, kW and MVAR set point control, switchyard operation, the Intake, Spillway and Desilting gate operation and instrumentation (ICB), and Surge Shaft instrumentation.

4. The PCS shall be configured to provide the following control functions:

a. Local Control: In this mode of operation, the equipment and systems are locally and manually operated at each device. This control mode does not have automatic sequences; the operators shall follow the manual operation procedure to place the unit in the desired mode.
b. UCB Control: In this position the Unit can operated in manual and automatic with all start permissive and interlocks functional. The UCB Control position shall override the Central Control position and shall remain fully functional if the Central Control crashes.

c. Central Control: Central Control from the Control Room is the normal position.
   This mode offers the same operation facilities as UCB mode.
d. When in the UCB Control or Central Control positions, the following modes shall be available:
   - Manual/Discrete Operation: This mode provides individual control over each individual system and/or devices utilizing the MMI screens. The operator shall follow manual operation procedure to place the unit or auxiliaries in the desired mode. Important safety interlocks and permissive shall be active in this mode with option of overriding them from the HMI screens,
   - Automatic Step-By-Step Sequence: In this mode the unit starting and stopping sequences are executed step by step. All prerequisites and conditions shall be displayed on the screen and when all of them are met, the operator can initiate the next step,
   - Automatic Continuous Sequence: In this mode, the units start and stop sequences are initiated by the operator, but no additional operator intervention shall be required. The operator shall be able to monitor all conditions and actions on the operator's screens.

5. The PCS shall be PLC and Personal Computer PC based, completely integrated industry standard state-of-the-art system. The system shall have an "open architecture" which shall permit reconfiguration, expansion, interface with third party equipment and future upgrades.

6. Design and Performance Criteria

a. Availability
   - The PCS shall be designed to minimize the consequences of failures by providing sufficient failure detection, and recovery procedures, such that no single device failure shall result in the loss or degradation of any other station in the system,
   - The PCS shall be designed to minimize the duration of failures by the ability to diagnose and resolve problems quickly and to replace any failed part easily,
   - The Average System Availability for two consecutive 500-hour periods shall be 99.98% or better.

b. Maintainability

The hardware and software elements of the PCS shall be easy to maintain by Employer using the maintenance facilities, hardware and software tools, and recommended spare parts provided by the Contractor.

c. Expandability
   - The PCS shall be capable of being expanded by adding more stations, controllers, functions, input-output modules, or intelligent devices such as metering modules, etc. The expansion of the data base and components shall not degrade the performance of the specified system,
   - For ease and flexibility in expanding the PCS, the Contractor shall conform to the industry standard open architecture concept as described herein.
   - Space is to be provided in all boards for expansion of I/O modules by 50% minimum or as indicated in the scope.

d. Quality and Technology
   - The hardware and software products shall be of high quality in design, fabrication, and performance,
   - The standard hardware equipment (such as PLC, HMI, computers, screens, printers, etc) and devices of the PCS shall be brand-new and shall be the latest design technology. In order to meet this requirement, the Contractor shall defer the procurement of all standard hardware until one month prior to system integration. The Contractor shall not use project laptops and workstation as development tools during the design and applications engineering phase of project,
   - The Contractor shall use and provide the latest versions of all the standard software, e.g., the operating system, utilities, language compilers, graphics software, picture editor, networking software, database management system, which are available at the time of system integration, as long as there is full upward compatibility with the PCS software,
   - All software shall be standard. Therefore, Contractor's code modification on standard software packages shall not be permitted,
   - At the end of the project, the Contractor shall upgrade all firmware and software to latest editions. Controller flash memories shall also be updated if required.

7. Testing Requirements

a. The Contractor shall meet the system functional and performance requirements as given in these Documents. The verification of compliance with the requirements shall be done through a series of tests focused primarily on functionality, response, CPU utilization, and system availability.

b. The testing sequence of the complete system shall consist of the following:
   - Pre-Factory Acceptance Test (Pre-FAT),
   - Factory Acceptance Test (FAT),
   - Site Acceptance Test (SAT),
   - Availability Demonstration (AD),
   - Network efficiency Test (NET),
   - All system testing shall be made with all the control nodes and stations and the ultimate number of points simulated.

8. Software: All software including operating licenses, manuals, documentation, and electronic files used for developing and implementing the automation system Controllers and MMI stations shall be furnished to and become the property of the Employer.

9. Training and Support

a. Training shall include sessions and courses in the theory, detailed operation, testing, and maintenance and troubleshooting of the automation system and as a minimum shall include the following hardware and software training modules: System Overview, System User, Basic System Maintenance, Advance System Maintenance, Engineering Tools, System Configuration, Historian and Specific Applications.

b. The Contractor shall submit a training plan, instructor's background and qualifications, course outline, course material and subject matter. Training course material shall include the use of site-specific Operations and Maintenance Manuals, to the maximum extent possible.
c. The Contractor shall provide off-site and on-site training for the Employer's staff including, but not limited to:
    - On-site training for a minimum of 6 operators,
    - System overview and hardware maintenance and troubleshooting for maintenance personnel,
    - System overview, application software development, modifications, troubleshooting for engineering personnel,
    - On-the-Job-Training (OJT) for engineering and maintenance personnel.
d. Continuous on site support shall be provided for the first four weeks after the first unit is in commercial operation, and for two additional non-sequential one week periods selected by the Employer during the duration of the warranty period.

6.7. Product Description

1. Controller Stations (CS) Hardware

General Requirements

- The CS shall be redundant; PLC and PC based and shall include a local panel mounted HMI and software and hardware interfaces with multifunction meters, excitation system, governor system, auto and manual synchronization, protective relays.

- Each CS shall be a designed to be standalone system to operate independently from other components in the PCS. Therefore, all functions shall be available in each CS at any time whether the Process Control Network is in service or not.

- The Contractor shall provide hot redundant CPUs, power supplies and communication processors. Redundant I/O modules are required for interfacing the redundant Interfaces including the AVR, the Governor Control, the Electrical Protection and the Mechanical Protection. No redundancy is required for other input-output modules.

- The Programmable Logics Controllers (PLC) of the Control Boards shall be in redundant configurarion. The CPU of system-A shall be synchronized the CPU of system-B to allow seamless and bumpless switchover between the active and the standby CPU. The standby CPU shall allow replacement under power conditions without shutting down the station and without affecting the performance of the CS. Both CPU shall include the following features:
    - The same hardware and accessories
    - The same application firmware and software,

- The same data blocks,
- The same image content,
- The same program and the same memory program,
- Data updating is event driven and done simultaneously and in synchronism.

- All CPU's and modules shall be provided with flash memory cards to hold the upto-date application programming without any need for a module battery backup.

- The CS shall communicate with input-output modules, intelligent electronic devices, multifunction meter modules, multifunction relays, digital exciter, digital governor and other PLC-based controllers independently using industry-standard field bus protocols. All components shall be seamlessly integrated in the PCS.

- The CS shall communicate with other nodes and systems over the Process Control Networks using industry-standard communication protocol.

- All CS functions shall be programmed in IEC 61131 compliant language.

- The CS shall have on-line, self-checking diagnostic routines periodically checking each component in the architecture. Error conditions shall identify the area where the malfunction is located and the specific problem shall be reported to the operator on a dedicated screen.

- The CS shall have the capability of automatic start-up and initialization following restoration of power after an outage without manual intervention. All restarts shall be reported to the operator.

- Software maintenance activities at a CS shall not affect other CS in the PCS. All compilers, utilities, management software, and storage media required for software maintenance shall be provided.

- The CS shall have the necessary processing power, memory, and peripheral facilities to accommodate the software tools and application software as described in this section. The final application software shall not occupy more than 30% of the PLC and PC memory taking into account the expansion provisions.

- The CS shall periodically synchronize their clock time using the standard time signal transmitted by the GPS Synchronized System. The plant wide time synchronization error shall not exceed ±100 nanoseconds.

2. Large Video Screens (LVS)

High Resolution Color, flat large scale Video Monitors shall be furnished. The monitors shall be mounted on the wall in a 2x2 matrix. Supports and hardware required to mount them along with the enclosure furniture shall supplied by the Contractor. The monitors shall be the latest available Heavy Duty commercial grade and have, as a minimum, the following characteristics:

- LED backlit,
- 55 inch screen;
- Resolution : 1920 x 1080;
- Contrast ratio: 3000:1,
- Brightness: 500 cd/m²,
- Image Aspect Ratio: 16:9,
- Thin 19mm or less Bezel.
- Burn-in resistant technology.
- 24/7 Rated Display.
- Viewing angle of ±80° vertical and horizontal.
- Anti-Glare, Anti-Reflective Screen Treatment.
- Standard VESA mounting; DVI input.

Manufacturer: The approved manufacturers shall be Sony, Samsung, NEC or equivalent.

3. Video Matrix Switcher

A 4x4 DVI Video matrix shall be furnished, and shall have, as minimum the following characteristics:

- 4 DVI female output,
- 1920x1200 resolution or higher,
- Capable of switching any of the 4 inputs on any of the 4 outputs,
- Must be easily controllable from front-panel pushbuttons and IR remote control.

4. Operator Workstations (OWS)

Industrials Desktop PC Computers with Windows XP™ Professional or newer operating system and the latest Microsoft Office Basic Edition shall be furnished and shall have, as minimum the following characteristics:

- Intel® Xeon® Dual-Core Processor (2.40 GHz, 4 MB cache, 1066 MHz memory) or better,
- 4GB DDR3 SDRAM at 1333MHz,
  - 500 GB (7200rpm or faster) SATA hard disk,
  - One (1) DVD+/-RW with Double Layer optical drive,
  - Gigabit Ethernet port,
  - Four (4) USB ports,
  - One (1) IEEE1394 port,
  - One (1) serial port,
- Dedicated 1024MB Video Card with two (2) HDMI and one (1) DVI ports to support 1920x1200 resolution,
- All necessary adapters and software required to connect Control, Metering and Monitoring functions of the local HMI of the Control Boards as well as selected function from systems provided by others and integrated into the SCADA.

- The two (2) HDMI ports on the video card shall be used for dual monitor setup and the DVI port for the Large Monitor (2x2 video matrix).

Manufacturer: The approved manufacturers shall be Hewlett Packard, Dell or equivalent.

5. Engineering Work Stations (EWS)

Industrials Desktop PC Computers with Windows XP™ Professional or newer operating system and the latest Microsoft Office Basic Edition shall be furnished and shall have, as minimum the following characteristics:

- Intel® Xeon® Dual-Core Processor (2.40 GHz, 4 MB cache, 1066 MHz memory) or better,
- 4GB DDR3 SDRAM at 1333MHz,
- 1000 GB (7200rpm or faster) SATA hard disk,
- One (1) DVD+/-RW with Double Layer optical drive,
- Gigabit Ethernet port,
- Four (4) USB ports,
- One (1) IEEE1394 port,
- One (1) serial port,
- Dedicated 1024MB Video Card with HDMI port to support 1920x1200 resolution,
- All necessary adapters and software required to display Control, Metering and Monitoring functions of the local HMI of the Control Boards as well as selected function from systems provided by others and integrated into the SCADA. Access to PLC program functions shall be available from these stations to do maintenance or update of software through a high level password.

Manufacturer: The approved manufacturers shall be Hewlett Packard, Dell or equivalent.

6. Laptop Engineering Work Station (EWS)

A Professional grade Heavy Duty Mobile Workstation Laptop Computer with Windows

XP™ Professional or newer operating system and the latest Microsoft Office Basic Edition shall be furnished and shall have, as a minimum, the following characteristics:

- Intel® Core i7 processor, with a minimum of 4 MB L2 cache 800 MHz front side bus or better,
- 4 GB DDR3 SDRAM 1333MHz or faster memory,
- TB (7200rpm or faster) SATA hard disk,
- One (1) DVD+/-RW with Double Layer optical drive,
- Gigabit Ethernet port,
- Intel Centrino 802.11a/b/g/n wireless adapter,
- 17 inches widescreen (1920x1200) LED (LED backlit) display,
- Four (4) USB ports,
- One (1) IEEE1394 port,
- One (1) serial port (internal or external),

- Dedicated 1024MB Video Card with DVI port to support 1920x1200 resolution,
- Integral Bluetooth 2.0 or newer adapter,
- Spill Proof Keyboard,
- Multi-button wireless Bluetooth compatible laser mouse,
- External lockable Docking Station,
- All necessary adapters and software required to display Control, Metering and Monitoring functions of the local HMI of the Control Boards as well as selected function from systems provided by others and integrated into the SCADA. Access to PLC program functions shall be available from these stations to do maintenance or update of software through a high level password.

Manufacturer: The approved manufacturers shall be Hewlett Packard, Dell or equivalent.

7. Historian Work Station (HWS)

a. Redundant network storage station shall be provided to be used for configuration back-up and storage of historical data.
b. The storage stations shall be sized to provide storage for 100 revisions of all configuration and programming files for the PCS plus storage capacity for the historian server as specified herein in the Historian Data Management software section plus storage capacity to backup 100 data files for the Protection Server and 100 data files for the Machine Conditioning Server. The storage capacity shall not be less than 1TB (mirror) and shall be hot-swappable hard disk in Raid configuration.
c. Communication with the multipurpose servers shall be done thru a 10 Gbps redundant network.
d. An Industrial Desktop PC Computer Server with Windows Server 2003™ or newer operating system, a redundant 2 hard disks RAID 1 setup and the latest Microsoft Office Basic Edition shall be furnished, and shall have, as minimum the following characteristics:
    - Intel® Xeon® Dual-Core Processor (3.5 GHz, 4 MB cache, 1066 MHz memory) or better,
    - 4GB DDR3 SDRAM at 1333MHz,
    - One (1) 250 GB (7200rpm or faster) SATA hard disk,
    - Two (2) 1.0 TB (7200rpm or faster) SATA hard disk,
    - One (1) SATA RAID Controller,
    - One (1) DVD+/-RW with Double Layer optical drive,
    - Gigabit Ethernet port,
    - Four (4) USB ports,
    - One (1) IEEE1394 port,
    - One (1) serial port,
    - Dedicated 1024MB Video Card with HDMI port to support 1920x1200 resolution,
    - All necessary adapters and software required to register Control, Metering and Monitoring events of the local HMI of the Control Boards as well as all functions from systems provided by others and integrated into the SCADA.
    - The two 500 GB hard disks shall be setup as RAID 1 with the SATA RAID controller.

Manufacturer: The approved manufacturers shall be Hewlett Packard, Dell or equal.

8. PC Screens

Workstation Monitors as shown on the SCADA SYSTEM ARCHITECTURE drawings shall be furnished, as a minimum, the following characteristics:

- Active matrix –LED, 22-inch screen,
- Minimum pixel pitch of 0.264 mm, and resolution of 1920x1200 at 60 Hz,
- Viewing angle of +/-80° vertical and horizontal, Antiglare with hard-coating 3H faceplate coating; HDMI input.
- One external screen shall be provided for the Laptop Engineering Work Station.

Manufacturer: The approved manufacturers shall be HP, Dell, Samsung or equivalent.

9. Mice

One (1) multi-button UCB Laser Mouse per desktop computer shall be furnished with software for interfacing with the operating system for each Server/Workstation. The mouse shall be ergonomically designed for either left or right hand operation. The mouse shall provide up/down and left/right scrolling.

One extra mouse shall be provided for the Laptop Engineering Work Station.

The mouse shall be Microsoft, Logitech or approved equal.

10. Keyboards

An ergonomically designed Spill Proof Keyboard per computer shall be furnished for interfacing with the operating system for each Server/Workstation. The keyboard shall be split and sloped to encourage natural hand positioning.

One extra keyboard shall be provided for the Laptop Engineering Work Station.

The keyboard shall be Microsoft, Logitech or approved equal.

11. Printers

a. Multifunctional Black and White Laser Printer/Copier/Scanner/Fax shall be furnished for the main control room. The printers shall be used for printing reports, screens, trend data, etc. The printers shall be high volume rated. The printer shall have, as a minimum, the following features:

- Media size up to A3,
- Print Speed- 35 pages per minute/copy per minute or higher,
- 1200x1200 dpi or higher print/copy,
- 600 dpi optical scan resolution or higher,
- 100 or more-sheet multipurpose tray, 2 x 250 or more-sheet input trays, 500 or more-sheet input tray with cabinet, 50 or more-sheet auto document feeder; 250 or more-sheet output bin,
- Connectivity: 10/100/1000 Base-T Ethernet print server; 1 Hi-Speed USB 2.0,

- Fax features include 300 dpi, 33.6 kbps, auto fax reduction,
- Memory 256 MB minimum,
- 40 GB Hard disk,
- Media size up to 11.7in x 17.7in,
- Compatible with Windows XP or newer operating system.
- Manufacturer: HP, Canon, Xerox or equal.

b. A3 Color Laser Printer shall be furnished and shall have, as a minimum, the following features:

- Colour: up to 26 ppm or more,
- Black: up to 31 ppm or more,
- Memory: 256MB or more,
- Connectivity: 10/100/1000 Base-T Ethernet print server; 1 Hi-Speed USB 2.0,
- Media size up to A3,
- 500 or more sheet input tray,
- Up to 600 x 600 x 4 dpi resolution or more,
- Compatible with Windows XP or newer operating system.
- Manufacturer: HP, Canon, Samsung or equal.

c. Dot Matrix Printer shall be furnished for the main control room. The printer shall have, as a minimum, the following features:

- Print speeds up to 475 cps or more,
- 128KB receive buffer/memory or more,
- Up to 360 x 360 dpi graphics resolution or higher,
- Connectivity: 10/100/1000 Base-T Ethernet print server; 1 Hi-Speed USB 2.0,
- Rated at 20000-hours MTBF or more,
- 400 million character printhead life or more;
- 7.5 million character ribbon life or more;
- Compatible with Windows XP or newer operating system.
- Manufacturer: Epson, Okidata or equal.

d. A4 Black and White Laser Printer shall be furnished as shown on the SCADA SYSTEM ARCHITECTURE drawings for the control room. The printer shall have, as a minimum, the following features:

- Print speed: up to 35 ppm,
- Print resolution: up to 600 x 600 dpi,
- Memory: 128MB,
- 100 sheet multipurpose input tray 1, 500 sheet input tray 2,
- 250-sheet output bin,
- Media size A4,
- Connectivity: 10/100/1000 Base-T Ethernet print server; 1 Hi-Speed USB 2.0; Compatible with Windows XP or newer operating system.
- Manufacturer: HP, Canon, Samsung or equal.

12. Routers

Router shall be furnished and shall have, as a minimum, the following features:

- 8 Fast Gigabit ports (10/100/1000 Base-T Ethernet),
- 1 Hi-Speed USB 2.0; DHCP server.
- Heavy Duty Industrial Grade.
- A minimum of two (2) spare RJ45 port shall be provided for each router.
- Manufacturer: Rugged Com, Cisco Linksys or equal.

Computer, Server and Controller Requirements:

Each personal computer and controller shall be dual ported to its redundant LAN.

Computers connected to more than one LAN shall be dual ported to all networks.

13. Managed Industrial Ethernet Switches

- The managed industrial Ethernet switches shall support, store and forward switching mode, 100Mbit/s as a minimum and 1,000Mbit/s or 10,000Mbit/s as required,
- The managed switches shall support Bootstrap Protocol (Boot P),
- The managed switches shall support Simple Network Management Protocol (SNMP) Versions 1 through 3 or latest and Remote Monitoring (RMON),
- The switch shall be manageable by the use of a standard Internet browser. If other management software is required, the software shall be supplied at no additional cost,
- SNMP OPC server shall be provided and the data from the switches shall be integrated in the PLC system,
- The managed switches shall support Internet Group Management Protocol
- (IGMP) snooping and multicast filtering,
- The managed switches shall support Virtual LAN (VLAN) network topology,
- The managed switches shall support Rapid Spanning Tree Protocol 802.1w
- (RSTP),
- The managed switches shall support industrial ring topology,
- The managed switches shall be provided with auto negotiation and auto crossing RJ45 ports and ST style fiber optic ports as required,
- The switches shall be provided with power indicators and link and activity indicators for each port,
- Spare ports shall be provided for each switch. The number of spare ports shall be 25% of the used ports as minimum and not less than 4 ports,
- The nominal supply voltage shall be 220 VDC. The power supply shall be a Universal range of 48-300VDC,
- Fiber Optic Ethernet Switches shall be Heavy Duty Industrial Grade have enough ports to connect all devices requiring a Fiber Optic connection,
- Spare ports shall be provided for each Ethernet switch. The spare ports shall be
- 25% minimum and not less than 4 ports,
- Manufacturer: Rugged Com Belden® Hirschmann - Or equivalent.

14. Managed Storage Area Network Switches

- The managed Storage Area Network switches shall support the communications for the network storage equipment and multipurpose servers,
- The management protocols and integration requirements are equal to the Managed Industrial Ethernet Switches specified above,
- The switches shall be provided with power indicators and link and activity indicators for each port,
- Spare ports shall be provided for each Network switch. The spare ports shall be 25% minimum and not less than 4 ports,
- The nominal supply voltage shall be 220 /48V DC. The power supply shall be a Universal range of 48-300VDC,
- Manufacturers: The manufacturer and model of the switches shall be part of the approved list of SAN switches from the network storage equipment manufacturer.

15. Ethernet Copper to Fibre Optic Media Converters

- The Ethernet converters shall only be used when it is not possible or practical to use devices or switches with fibre optic ports,
- The function of this module is to convert twisted pair Ethernet to and from a fibre optic segment. The physical and logical interface shall be fully compatible with IEEE 802.3. No additional adapters or transceivers shall be allowed,
- The fibre optic ports (transceivers) shall be matched with the type of the fibre optic cable,
- The Ethernet converters shall be provided with the following indicators: power; electrical link; electrical data; fibre link; fibre data,
- The fibre optic connectors shall be MT-RJ type (or ST or SC);
- The nominal supply voltage shall be 220 /48V DC. The power supply shall be a Universal range of 48-300VDC;
- Manufacturers: Moxa; Rugged Com; Phoenix Contacts, or approved equal.

16. RS232/RS422/RS485 to Fibre Optic Media Converters

- The function of this module is to convert the RS232/RS422/RS485 communication signal over copper cables to and from a fibre optic segment. The physical and logical interface shall be fully compatible with EIA 232 and EIA 422/485. No additional adapters or transceivers shall be allowed,
- The fibre optic ports (transceivers) shall be matched with the type of the fibre optic cable,
- The converters shall be provided with the following indicators: power; transmit electrical; receive electrical; transmit fibre; receive fibre; The fibre optic connectors shall be MT-RJ type (or ST or SC),
- The nominal supply voltage shall be 220 DC. The power supply shall be a Universal range of 48-300VDC,
- Manufacturers: Rugged Com; Phoenix Contacts, Moxa, Or approved equal.

17. Control Boards, Patch Panels and RTU Panels

All Panels shall be multiples of 800x800x2300 mm. They can be wider if needed. They shall be rack mount type with outer glass door complete with lockable hardware. The glass shall be tempered and door shall be easily removable during commissioning. Inner rack frame shall be constructed so as to leave no opening with the back. The rear door shall be provided full height complete with lockable hardware. All doors shall be provided a heavy-duty 3-point lock system. Protection class shall be IP52.

Manufacturer: The approved manufacturers shall be Rittal or equivalent.

18. Programmable Logic Controllers (PLCs)

Synchronized redundant PLCs shall be responsible for the control monitoring and metering functions of the units and auxiliary systems and shall interface with the HMI. They shall be a rugged industrial design and shall have, as a minimum, the following features:

- Two (2) High-performance 2MHz or higher CPUs in redundant configuration; Minimum 32MB. However, the same shall be selected based on application requirement,
- Minimum 4096 bytes free mix combination of various I/O types,
- Less than 0.15 ms / kb Scan Time,
- Less than 1 sec response time to operator commands,
- Hot backup redundancy capabilities,
- Two (2) Power Supply Cards,
- Two (2) Synchronizing Modules,
- Optical Fibre Cable for Synchronization,
- Fast Ethernet Ports,
- Field bus (Mod bus/ Profibus) External interface compatibility.
- Compliant to IEC 61131 and OPC Lab certified
- Manufacturer: SIEMENS SIMATIC, SCHNEIDER MODICON PREMIUM, GE FANUC, ABB AC800M or equal.

19. HMIs – Human-Machine Interfaces (HMIs)

HMIs shall be supplied in each Control Board and shall have, as minimum the following characteristics:

- All HMIs shall be OPC compliant,
- Display: 15 inch TFT display, 64K colors,
- Resolution: 1024 x 768 pixels,
- Control elements: Touchscreen resistive analog,
- User memory: 12 MB, additional 12 MB for options,
- 256 KB non-volatile memory for Software PLC data,
- Interfaces: 1 x RS485, 1 x RS422, 2 x USB, 2 x RJ 45 Ethernet, 1 x combined SD/Multi Media Card Slot, 1 x CF card slot; Degree of protection: IP 65, NEMA 4X front, IP 20 rear; Configuration software: WinCC flexible Standard.
- Manufacturer: SIEMENS Simatic, SCHNEIDER Magelis, GE Fanuc, ABB CP400 or equal.

20. Input/ Output (I/O) Modules

a. General

- Each CS shall be provided with a system of input-output modules (local or remote), instrumentation bus, and power supplies,
- All input-output modules shall be of “hot-swappable” type, to allow for replacement under power, while the CS is running. The replacement of a module shall not cause downtime for the CPU and the other modules; The input-output modules and power supplies shall meet the Surge Withstand Capability standards as defined by IEC and ANSI/IEEE;
- The input-output modules shall be provided with redundant power supplies. Each power supply shall be fed from a different 220 V DC power supply circuit. The loss of a single power supply shall not cause the loss of any input-output module, and shall alarm the operator,
- In the case of the UCB, the Contractor shall provide a minimum of 30% spare capacity of I/O modules for each type used, installed, and wired to be verified when the equipment is approved for shipping after the Factory Acceptance Test. Furthermore 50 % space shall be provided above the provided I/O modules for future addition in the UCB.
- In the case of SSB, ICB the Contractor shall provide the number of I/O modules indicated below with 100% space for future expansion.

b. Digital Input Modules

- The digital input modules shall accept normally open or normally closed dry contacts for status and sequence-of-events inputs. All digital inputs shall include optical isolators and filtering to eliminate contact bounce,
- The digital input module shall accept bi-stable and momentary-change inputs. Circuit breaker status and switch positions are bi-stable inputs. Equipment alarms and protective relay operations are momentary-change inputs;
- Protective relay operations, including electrical and mechanical protective devices, shall be processed as momentary-change inputs.

c. Analog Input Modules

- The analog input modules shall accept and process transducer voltage signals in the range of ± 10V DC or current signals in the range of ±20 mA DC. All inputs shall be galvanically isolated,
- The analog input processing shall include filtering, scaling, and A/D conversion with a 12-bit 2's complement resolution,
- Accuracy shall be at least ±1% and linearity ±1/2 LSB over the full input range and temperature range.

d. Resistance Temperature Detector (RTD) Input Modules

- The RTD input modules shall have the capability of interfacing with Platinum or Copper RTDs,
- The RTD input shall have a minimum resolution of 14 bits plus sign.

e. Control Output Modules

- The control output modules shall support both maintained and pulse (momentary) outputs,
- All outputs shall use heavy duty interposing relays with three Form-C gold plated contacts.

f. Instrumentation Bus
The Instrumentation Bus shall be designed in accordance with industry-standards such as Field bus, MODBUS, Inter-bus or Profibus.

g. Communications Media

- The communications media for all external (outside of any cabinet) communication links shall be fibre optics,
- The communications media for internal (inside CS cabinet) communication links may be copper.

h. Physical Requirements:
The CS shall be housed in a standard electronic equipment cabinet with a window door, as specified herein.

i. Power Requirements:
The CS shall be suitable for operation from a 220 V DC.

21. Synchronizer, Synchrocheck and Manual Controls and Meters

The synchronizing device shall be housed in a dedicated panel as part of the UCB. An Automatic Synchronization and Paralleling with Power Lines System per unit shall be supplied.

Manual synchronization controls and meters shall be provided for manual synchronization such as the ABB model Synchrotact or equivalent CSS assembly. Manual synchronization controls and meters shall have the following features:

- Double Frequency meter (Generator and Power Line side),
- Double Voltmeter (Generator and Power Line side),
- Synchroscope,
- Speed control (UP/DOWN),
- Voltage control (UP/DOWN),
- Local/Remote switch,
- AUTO/MAN/TEST selector,
- Circuit breaker Control Switch (OPEN/CLOSE),
- Circuit breaker OPEN/CLOSE pilot lamp,
- Mimic of complete power and control single line diagram.

22. Protection, Auxiliary and Interposing Relays

High speed protection relays shall be provided for the opening, closing and tripping of the HV Circuit Breakers. Auxiliary relays shall be provided for Electrical, Protection, for Mechanical Protection and for all 220 V DC circuits. Interposing relays shall be provided for all output signals of the I/O modules controlling external devices including motor starters, coils etc. carrying a thermal load.

The relays shall be Heavy Duty Industrial Grade have a rating compatible with the load. All relays shall be provided with gold plated contacts. Relays shall be mounted in dust tight housing and shall be the plug-in type. The relays must be provided with set screws to secure them to their base. Clips shall not be accepted for Protection and Auxiliary relays under any circumstances. Clips are accepted for interposing relays.

Protection Relays shall be High Speed and specifically designed for tripping of circuit breaker coil. Relay coils shall be supervised using an external Supervisory Relay. They are designated as IEEE function number 86 and 94. Lockout relays shall be of the latching type resettable with an external pushbutton. Remote resetting is not permitted. Relays shall be rated rated 10 A continuous, 30 A make 5 s at 220 V DC suitable for 100,000 electrical and 1 million mechanical operations. A minimum of 10 convertible form A and B contacts shall be provided. A minimum of 3 spare contacts shall be provided for future use.

Auxiliary and Supervisory Relays shall be Heavy Duty with contacts rated 5 A continuous, 30 A make at 220 V DC suitable for 100,000 electrical and 1 million mechanical operations. A minimum of 4 convertible form A and B contacts shall be provided. A minimum of 2 spare contacts shall be provided for future use.

The Interposing relay contacts shall be rated 10 A continuous 20 A make at 240 V AC and 48V DC suitable for 100,000 electrical and 1 million mechanical operations. All relays shall be provided with three form C contacts and LED operation indication.

Relays shall be mounted in the rear section of the I/O module panel and shall be isolated from one another. No mixing of control Voltage is allowed. Metal barriers shall be used to separate Voltage classes. System A, B and Common shall be located in different panels.

Manufacturers accepted:

- Protection Relays: ABB Combiflex RXME, RXMS & RXMV or Alstom MVAJ,
- Auxiliary Relays: ABB Combiflex, Alstom PRIMA or equal; Interposing.
- Relays: Tyco O/E/N type 51D-3 gold or equal.

23. Time Standard System

a. The PCS and the Electrical Protective System shall be provided with an accurate external time standard. A GPS satellite synchronized clock shall maintain the time reference for all time synchronized devices and systems.
b. The clock shall receive and decode time information transmitted by the GPS with an accuracy of ±100 nanoseconds or better.
c. The GPS receiver shall be provided with the antenna, interconnection terminations, cables, and mounting hardware.
d. The standard time in day of year, hours, minutes and seconds shall be displayed continuously at the device.

e. A separate time slave clock shall be provided. In Control Room the clock shall be mounted above the LVS screen. The clocks shall display the date, weekday, year, hours, minutes, and seconds. The time display shall be displayed in characters 80 mm high minimum. Date, weekday and year shall be displayed in characters 40 mm high minimum. Display shall be LED.
f. The time standard shall also display the system frequency, the frequency deviation from standard frequency, and the time deviation between system time and standard time.
g. The time standard shall be provided with direct interfaces to the Plant and Unit Control Networks independently.
h. Inter-Range Instrumentation Group (IRIG) time synchronization connections to the unit and plant protective relays shall be provided.
i. NTP Client/Server hierarchical time distribution is allowed, however no Simple Network Time Protocol (SNTP) clients are acceptable for time synchronization for controllers, HMIs, Workstations, Servers or any other device that provide control, protection, historian or network management functions in the system. NTP Client shall make a transaction with its server over its polling interval. The polling interval shall be dynamically adjusted between 64 to 1024 seconds.
j. Clock synchronization shall not have an error greater than 1/10 of the timestamp resolution.
k. No domain time synchronization shall be used for the Windows computers as a primary time synch method.
l. The GPS system shall be provided with a master clock and three slave clocks. GPS main and slave clocks shall be provided complete with PPS and IRIG-B configurable output, GPS antenna and surge protection kit or approved equivalent.
m. Manufacturer: Arbiter 1088B or equivalent Symmetricom (True Time) or approved equal.

24. Miscellaneous Power Supplies

a. General Requirements:

The Contractor shall provide all necessary power supplies required to achieve the system's required functionality. The selection of the power supply shall be done considering the modularity/interchangeability criteria for the entire system. The output voltage shall not vary more than 5% with voltage input variation between 20% to +10%, and output current variation from 0% to 100%.

b. Power Supplies: Type: 220V DC to 48V DC
- Protection: input and output side protected against overload, short circuits, and reverse voltage,
- Nominal output current: minimum 20% greater than the maximum current to be supplied,
- Operating and status indication,
- The residual ripple shall be lower than the maximum required by the connected equipment,
- Primary Switched and electrically isolated between input and output side,
- Modular design,

- Mounting type: standard rail mounting or as required.
- Type: 240V AC to 48V DC
- Input: 240V AC 50 Hz, fused, with harmonic filter (power to be provided by UPS),
- Output: 48V DC,
- Nominal output current: minimum 20% greater than the maximum current to be supplied,
- The residual ripple shall be lower than the maximum required by the connected equipment, but never greater than 100mVpp,
- Operating and status indication,
- Type: Primary switched-mode power supply,
- Electrically isolated between input and output side,
- The power supply shall be protected against excessive current and reverse voltage,
- Modular design,
- Mounting type: standard rail mounting or as required.
- Type: 48V DC to 48V DC
- Input: 48V DC fused,
- Output: 48V DC +/-1%,
- Protection: input and output side protected against overload, short circuits, and reverse voltage,
- Nominal output current: minimum 20% greater than the maximum current to be supplied,
- Operating and status indication,
- The residual ripple shall be lower than the maximum required by the connected equipment,
- Primary Switched and electrically isolated between input and output side,
- Modular design,
- Mounting type: standard rail mounting or as required.
- Type: 240V AC to 220V DC
- Input: 240V AC 50 Hz, fused, with harmonic filter (power to be provided by UPS);
- Output: 220V DC +/-1%,
- Protection: input and output side protected against overload, short circuits, and reverse voltage,
- Nominal output current: minimum 20% greater than the maximum current to be supplied,
- Operating and status indication,
- The residual ripple shall be lower than the maximum required by the connected equipment,
- Primary Switched and electrically isolated between input and output side,
- Modular design,
- Mounting type: standard rail mounting or as required.

25. Multifunction Meter

a. The digital multifunction meters shall be of micro processor based power and energy meter type.

b. The meter shall include onboard non-volatile memory. The amount of memory shall be enough to register a minimum of 16 freely selectable parameters, every 15 minutes for 45 days. The minimum memory shall be 5MB.
c. The meter shall be programmable and shall include logical and mathematical functions to perform calculations over any measured parameter.
d. The meter shall be fully configurable using the local display and/or via a software application.
e. The device shall comply with the following measurement standards:
   - IEC 62053-22 Class 0.2S,
   - ANSI C12.20 0.2 Class 10 & 20,
   - ANSI C37.90.

f. The device shall comply with following power quality and quality of supply standards and network connection requirements:
   - EN 50160,
   - IEC 61000-4-30 Class A,
   - IEC 61000-4-7 harmonics & inter-harmonics,
   - IEC 61000-4-15 flicker,
   - IEEE 1159.

g. The device shall be capable to be connected to 4 wire Wye, 3 wire Wye, 3 wire delta, direct delta and single phase systems.
h. The device shall be able to be powered from AC (90-240V) &/or DC (220 /48V).
i. The device shall be able to operate in sub tropical environment with a temperature of 20 to 70ºC, and humidity of 5-95% non-condensing.
j. The device shall be able to synchronize automatically with the GPS clock directly or through one of the communication ports.
k. The device shall be capable to timestamp the historical data.
l. The device shall have a backlight LED screen with the following minimum characteristics:
   - High visibility, 320x240 pixels, 3.5" x 4.5", LED backlit with adjustable contrast screen,
   - Capability to display numerical and up to four graphical data simultaneously; the numerical data can include real time, historical time stamped and name plate data. The graphical data can include frequency spectrum and trends logs,
   - Multiple programmable screens: The multifunction meter shall be provided complete, including all the necessary connections, protections (fuses, etc.), software applications, and communications and mounting accessories.

j. Voltage Inputs
   - The device shall include four (4) voltage inputs rated to 240 V Line-Neutral / 415 V Line-Line V AC rms,
   - The inputs shall be able to accept an overload of 1500V AC rms continuous,
   - The inputs shall be able to withstand a 2500VAC rms 50 Hz for 1 minute;
   - The minimum impedance shall be 5MΩ per phase.

m. Current Inputs
   - The device shall include five (5) current inputs rated to 5A, with a maximum voltage of 600V,
   - The current inputs shall have a starting current of 0.005A rms,
   - The current inputs shall be able to accept an overload of 500A rms for 1 second, non-recurring,
   - The current inputs shall be able to withstand a 2500 V AC rms 50 Hz for 1 minute,
   - The burden shall be 0.05 VA @ 5A, and the impedance 0.002W/phase, or less.

n. Analog Inputs
   - The device shall include four (4) analog DC current inputs, with a selectable range of 0-1mA, 0-20mA and 4-20mA,
   - The input impedance shall be 24 Ω @ 20mA,
   - The accuracy shall be +/- 0.3% at full scale,
   - The isolation to ground shall be at least of 750V,
   - The channel to channel common mode isolation shall be at least of 400 kΩ.

o. Digital Outputs
   - The device shall include two electromechanical relays form C (NO, Common, NC terminals) rated 250VAC/3A,
   - The device shall include two solid state outputs rated 30VDC/50mA for SCADA supervision.

p. Communication Ports
   - RS-232 Port
     - The device shall include a serial RS-232 port for configuration/maintenance purpose,
     - The port shall be able to connect to 300-115000bps baud rates,
     - The connector shall be standard male DB9,
     - The port shall be fully isolated (optical preferable) from the other connections in the device.
   - RS-485 Port
     - The device shall include a RS-485 port for parameters reading. The Contractor shall select this port or the Ethernet port to provide connectivity to the PLC,
     - The port shall be able to connect to 300-57600bps baud rates,
     - The connector shall be captured wire type,
     - The port shall be fully isolated (optical preferred) from the other connections in the device.
   - Ethernet Port
     - The device shall include an IEEE 802.3 Ethernet port for parameters reading. The Contractor shall select this port or the RS-485 port to provide connectivity to the PLC,
     - The port shall be able to connect to 10Mbps or better,
     - The connector shall be RJ45 type,
     - The port shall be fully isolated (optical preferable) from the other connections in the device.
   - Communication Protocols:

The device shall be able to communicate using the following protocols in all the ports:

- Modbus RTU,
- DNP 3.0,
- Modbus TCP (Ethernet Port),
- Telnet (Ethernet port),
- Profibus,
- Other protocols compatible with the PLC.

- Parameters
  The device shall be able to measure the following parameters per phase and three phase average:
  - Frequency,
  - Power Factor,
  - Current rms (A),
  - Voltage rms (kV),
  - Apparent Power rms (MVA),
  - Active Power rms (MW),
  - Reactive Power rms (MVAR),
  - Apparent Energy bidirectional (MVA); - Active (Real) Energy bidirectional (MWh); - Reactive four-quadrant energy (MVARh).
- At a minimum, the following calculations shall be implemented:
  - Current: demand, minimum and maximum,
  - Voltage: demand, minimum and maximum,
  - Apparent Power: demand, minimum and maximum,
  - Active Power: demand, minimum and maximum,
  - Reactive Power: demand, minimum and maximum.
- Manufacturers/Models
  - Schneider Power Measurement: Model No. ION 7550 for Units; - Satec Model PM130 Plus.

26. Optic Fiber network
    a. The scope if the present specification includes the provision of all multimode Fibre Optic cables and patch cord within the powerhouse. The Mono mode / multimode cable running from the Powerhouse to the Intake shall also be supplied and laid under this package. The present Contractor shall be responsible for supplying all termination material including converters and routers and for the connection, testing and commissioning of cable runs.

    b. The Optic Fibre network shall be comprised of multimode fibre optic cables and patch cords and shall be provided complete with terminal, patch panels and accessories.

    c. Patch Cord shall be factory terminated and their length shall be adjusted to the required length. Any extra length shall be looped and tie-wrapped. Patch cord going from one panel to the other shall be encased in orange coloured flexible flexible conduit and laid into the Control Cable Trays in a dedicated compartment. Additional cable Tray shall be supplied where necessary to reach isolated components.

d. Fibre Optic Cables shall be loose tube construction type suitable for indoor or outdoor, corrugated steel tape armoured for ruggedness and crush resistance. The Fibre Optic cables shall be run in orange PVC flexible conduit and laid in the Control Cable Trays in a dedicated compartment.

e. Cable Construction: Optical fibres shall be placed inside loose buffer tube of nominal diameter 3mm. The buffer tube will be suitable to carry 24 fibres. Buffer tube shall be fitted with a non-hygroscopic, non-nutritive to fungus, electrically non-conductive, homogeneous gel. The gel shall be readily removable with conventional nontoxic solvents. The gel shall be free from dirt and foreign matter. Each fibre shall be distinguishable by means of colour coding in accordance with TIA/EIA 598-B, Optical Fibre cable colour coding. The fibres shall be coloured with ultraviolet curable links. In buffer tubes containing multiple fibres colours shall be stable across the specified storage and operating temperature ranges and not subject to fading or smearing into each other or into the gel filling material. Colour shall not cause fibres to stick together.

   Buffer tubes containing fibres shall be colour coded with distinct and recognizable colours in accordance with TIA/EIA-598-B, "Optical Fibre Cable Colour Coding."

   A filler may be included in the cable core to lend symmetry to the cable cross section where needed. The fillers shall be nominally 3.0 mm in outer diameter.

   The central member shall consist of a dielectric, glass reinforced plastic (GRP) rod to provide tensile strength and prevent buckling. The central member shall be overcoated with a thermoplastic when required to achieve dimensional sizing to accommodate buffer tubes/filters.

   Water blocking performance using swellable polymer technology shall be used. The buffer tubes shall be stranded together with the dielectric central member and a water blocking yarn using the reverse oscillation, or "S-Z," stranding process.

   Tensile strength shall be provided by the central member, and dielectric yarn.

Dielectric strength yarns shall be applied around the outside of the cable core. Cables shall contain at least one ripcord under the outer sheath to facilitate its removal. The armour layer shall be applied directly (no inner jacket) over the dielectric strength members. The armour shall be corrugated steel tape, plastic-coated on both sides for corrosion resistance. The outer jacket shall be applied over the corrugated steel tape armour. The outer jacket shall be a MDPE with a minimum nominal jacket thickness of 1.3 mm. The polyethylene shall contain carbon black to provide ultraviolet light protection and shall not promote growth of fungus. The MPDE jacket material shall be defined by ASTM D1248, Type II, Class C and graded J4, E7 and E8. Cable jackets shall be continuous, free from pinholes, splits, blisters and other imperfections. They shall have a consistent, uniform thickness. Jackets extruded under high pressure are not acceptable. The jacket shall be smooth as is consistent with the best commercial practice. Jacket shall provide the cable with a tough, flexible, protective coating, able to withstand the stresses expected during normal installation and service. Cable jackets shall be marked with the manufacturer's name, month and year of manufacture, sequential meter or foot markings, a telecommunication handset symbol as required by Section 350G of the National Electrical Safety Code*1 (NESC®), fibre count, and fibre type. The actual length of the cable shall be within -0/+1% of the length markings. The print colour shall be white with the exception that cable jackets containing one or more coextruded white stripes shall be printed in light blue. The height of the marking shall be approximately 2.5 mm. If the initial marking fails to meet the specified requirements (i.e., improper text statement, colour, legibility, or print interval), the cable may be remarked using a contrasting alternate colour. The numbering sequence shall differ from the previous numbering sequence, and a tag shall be attached to both the outside end of the cable and to the reel to indicate the sequence of remarking. The preferred remarking colour shall be yellow, with the secondary choice being blue.

The maximum pulling tension shall be 2700 N (600 lbf) during installation (short term) and 890 N (200 lbf) long term installed. The storage temperature range for the cable on the original shipping reel shall be -40 °C to +70 °C. The installation temperature range for the cable shall be -30 °C to +70 °C. The operating temperature range for the cable shall be -40 °C to +70 °C. Life of cable - The minimum expected life of the cables shall not be less than 25 years.

f. Quality Insurance Provisions,
All cabled optical fibres > 1000 meters in length shall be 100% attenuation tested. The attenuation of each fibre shall be provided with each cable reel.
The cable manufacturer shall be TL 9000 registered.

g. Optical Cable Specification:
Fibre type: Multimode mode

- Total Fibre count: 24
- Small diameter single tube construction
- Core/Cladding: Silica

- Moisture proof
- Rodent & Termite attack protection & Prevention
- Nominal weight: 152 Kg./Km - Outside diameter: 13.1 mm.
- Minimum Bend Radius loaded: 177 mm
- Minimum Bend Radius installed: 118 mm
- Fibre type: Mono mode (Intake Remote Sites Cable for termination)
  - Total Fibre count: 24
  - Small diameter single tube construction
  - Core/Cladding: Silica
  - Moisture proof
  - Rodent & Termite attack protection & Prevention
  - Nominal weight: 152 Kg./Km - Outside diameter: 13.1 mm.
  - Minimum Bend Radius loaded: 177 mm
  - Minimum Bend Radius installed: 118 mm
  - Manufacturer: Corning or equal

27. Control Room Furniture

a. The Contractor shall supply and install modular desks, tables, cabinets and chairs for the Control Room.
b. The Control Room furniture shall include accommodation for Work Stations and equipment provided herein.
c. The desks shall be sized to comfortably accommodate the Work Station Monitors, keyboards, and mouses. Especially design compartment shall be designed to house the tower Servers and PC beneath the working surface. Space shall also be included for telephones, note taking and log book entries. Furnish storage for miscellaneous office supplies such as pencils, scissors, tape, paper clips, etc.
d. Tables shall be sized to accommodate the printers and others table top devices.
e. Shelving shall be provided below to store paper and ink cartridges.
f. Cabinetry shall be provided as shown on the drawings. The cabinetry shall be a combination of floor standing cabinets 750 mm high, 600 mm deep and wall mounted cupboard 750 mm high, 300 mm deep. Cabinetry shall be provided with shelving and doors.
g. Cabinetry shall also include the required cabinet to house the Large Video Screens array. The cabinetry shall neatly recess and support the screen using factory purchased steel hardware. Generous ventilation slots shall be provided to insure natural cooling. The cabinet shall be free standing but secured to the backwall. The cabinet shall be 450 mm deep and have full height. Shelving and doors shall be provided in lower part and all cables shall be hidden.

h. The desks, tables and cabinetry shall be constructed of Medium Density Fibre board (MDF) with Plastic Laminate Sheet surfaces and metal framing. The Plastic Laminate Sheets shall be High-pressure decorative laminate complying with NEMA LD 3, grade HGS and designated as through-colour plastic laminate. Laminate shall be provided complete with grade BKL backer sheet. Laminate will cover all visible surfaces. Side and rear panel can be made of steel resistant to denting and warping. Metal surfaces shall be cleaned, primed and painted using epoxy powder process. The furniture shall be provided with built-in receptacles to plug all the equipment and designed to hide all wiring.
i. The chairs shall be ergonomic orthopaedic, high grade upholstery fabric, steel framing and 5 wheel roller base. The chairs shall be provided with adjustable armrests, adjustable back rake, adjustable seating angle and adjustable height seat.
j. The Contractor shall design the arrangement of the Control Room furniture to optimise working surfaces and storage area while maintaining clearances for sitting and circulation.
k. Control Room furniture submittal shall be provided for review and approval by the Employer and Engineer In-charge.
l. Approved Manufacturers
    - Evans Consoles,
    - Or approved equal.

28. Man-Machine Interface (MMI) Software System

a. General Requirement

- MMI includes the HMIs in the control boards and OWS in the control rooms. Those two different types of hardware shall be completely independent (master/slave is not allowed),
- The MMI shall consist of an integrated SCADA PC-based graphic display system to support an interactive dialogue between the operator and the power plant equipment,
- All Software System shall be OPC compliant,
- The operating system for the PC-based MMI shall be Microsoft Windows XP Professional or newer.
- All required service packs, updates and patches for the operating system, MMI software and other applications shall be installed and kept up-to-date throughout the duration of the project and throughout the warranty period;
- The MMI package shall include alarming, reporting, event logging and trending capabilities,
- The software shall provide user-friendly development environment that allows for simple interactive graphics building and application software development. The software shall provide Wizards, Experts, and other productivity tools to support development without having to learn a proprietary language. Advanced development tools such as Visual Basic and scripting shall also be available,
- Real time process monitoring and historical trending shall be included,
- The MMI system shall be capable of seamlessly integrating third party software such as Microsoft's Office products, including Word, Excel, and Access,

- The MMI system shall be designed to allow for future upgrades of the software package without the necessity to reprogram the existing system,
- The database shall be designed to support the following point types:
  - Analog Inputs - Read an analog value either directly from an A/D converter or from a register within an I/O device or intelligent device and automatically convert the raw value to engineering units or use PLC scaled value,
  - Analog Alarms - Alarm capabilities for alarm suspension and remote acknowledge,
  - Analog Outputs - Write an analog value either directly to a D/A converter or to a register within an I/O device, capable of automatically converting the engineering units to raw values,
  - Calculations - Perform arithmetic and logic calculations based on other database points and store them in internal MMI registers,
  - Digital Inputs - Sense logical state of a switch or relay directly from the input module or from a bit in memory of an I/O device including intelligent devices with time tagging,
  - Digital Alarm - Alarm capabilities for alarm suspension and remote acknowledge,
  - Digital Output - Set a logical on/off state in an output relay either directly in the output module or in a bit within the memory of an I/O device.
- Each database point shall include an instrument tag name, hardware device name, address, specific parameters, signal conditioning requirements and point description,
- The database shall be stored as a standard Windows file,
- The database maintenance facilities shall be totally integrated with the graphic display system,
- The database shall make use a high-level data manipulation language, Structured Query Language (SQL),
- The database shall support import and export of individual points, groups and complete database in Comma Separated Value (CSV) file format,
- The MMI system configuration, screen development, and database deletions, additions and changes shall be able to be done offline or online. Online modifications, deletions and additions shall not interrupt the data acquisition.

b. Security Management

- The MMI software shall provide a user-based security system. The security system shall allow for the creation of users with certain rights and/or privileges. These rights must include the ability to run any combination or all of the applications in the data acquisition system,
- The ability to allow or disallow user's access to change values, such as setpoints and machine-setups, on an individual tag basis shall be supported.

c. Man-Machine Interface (MMI) Application Software

- MMI includes the HMIs in the control boards and OWS in the control rooms. Those two different types of hardware shall be completely independent (master/slave is not allowed),
- All displays (formats and design) shall be subject to review and approval by the Engineer in charge. The Employer and/or Engineer in-charge reserves the right to participate in the design of the screens as needed,
- A minimum of two MMI software workshops shall be held to coordinate the MMI development,
- The MMI system shall be designed to provide rapid and reliable information to project events and to provide the operator with the ability to monitor and control the plant without objectionable delays in system processing times. The MMI stations shall be able to be configured to perform all or a selected subset of the system functions. Control and programming functions shall be password protected,
- The Dot-Matrix printer shall be configurable for automatic alarm and operator action logging,
- The MMI station operator shall be able to use either the keyboard, or mouse to implement monitoring and control commands.

29. Displays

As a minimum, the Contractor shall be responsible for creating and integrating the following plant common MMI screens:

- Plant Navigation,
- Plant Overview,
- Plant Main One Line,
- Intake, Spillway and Desilting gate control monitoring and instrumentation indications,

Surge Shaft level indication and Penstock flow meter indication,

- Tailrace level indication, Draft tube level indication, Tail race gate control/Monitoring.
- Single Line Diagrams, including status, measurements and control for breakers, transformers, etc.
- Alarm Lists: The alarm lists shall have configurable filters to filter out the alarms not applicable to the particular unit or system. The entries in the alarm lists shall be arranged in chronological order,
- System events summary (one world map): A chronological listing of all system events, i.e.: alarms, status changes and operator-initiated actions,
- Sequence of events list (one list),
- Balance of Plant Navigation,
- Balance of Plant Individual Screens: Arrangement and dynamic information shall be displayed for each BOP system,
- System configuration screens as required
- Generator and turbine capability curves with real time operating point shown,
- Intelligent devices: All intelligent devices shall be provided with a template display. This display shall include all the signals and tuning parameters provided by the manufacturer. This applies to all the interfaces with intelligent devices,

- Auxiliary Equipment Monitor: The auxiliary equipment monitor function shall monitor the running hours including the lead-lag status of the auxiliary equipment such as governor pressure oil pumps, air compressors, main water supply pumps, etc. When the total running hours exceeds the pre-set value, and alarm shall be initiated,
- Hydraulic Conditions: One screen showing by means of a graphic colour display, unit flow rates, head and tail-water levels, trash racks differential, silt level in desilting bays, etc.
- Alarm messages with detailed descriptions shall be displayed automatically for:
  - All devices connected to the Plant or Unit Network,
  - PCS components,
  - Time counts exceeding preset value,
  - Incomplete sequences.
- Generation and Hydraulic daily and monthly reports, Help screens,
- Operational guidance and help screens for:
  - Navigation and operation,
  - Fault restoring operating procedure,
  - Links to drawings, Acrobat and MS Office documents.
- Status and analog signals from all devices connected to the Plant or Unit network,
- Status of Unit and Plant Network Systems and components including connected fibre-optic lines,
- Status of Controller Stations, Remote I/O's, PLC's, etc
- Status of HMI, PC and Servers, Display of monitoring signal of systems and integrated into the SCADA
- Additional displays shall be as required by other functions included in this Contract.

The Contractor shall be responsible for integrating as a minimum the following displays for each unit and for common systems:

- Unit Screen Navigation Page,
- Unit Control Status,
- Unit Sequence Overview,
- Sequence Monitors:

Each sequence monitor function shall monitor and display the sequential operation of the unit for each step by checking the processing time for each step of the normal start and stop sequences. All permissive, interlock and status shall also be displayed. In the event of a sequence interruption in any sequential step, the step and equipment or device shall be listed on the sequence monitor.

- Equipment Lock Out/Tag Out,
- High Pressure Lube Oil System,
- Upper Guide Bearing Lube Oil System,
- Governor,
- Governor Hydraulic Systems,
- Generator Brakes,
- Cooling Water System – Turbine Bay,
- Automatic Voltage Regulator (AVR)
- Excitation,

- Winding Temperatures,
- Bearings Temperatures,
- Generator Temperatures,
- Vibration,
- Single Line Protection and Monitoring,
- Auxiliary AC System,
- Auxiliary DC System,
- UPS system,
- DG sets,
- Fire Fighting systems,
- HVAC system,
- Auxiliary Mechanical System

All units' related screens shall have a clear identification of which unit the screen is related to, and this identification should be presented in the same location for all the screens.

a. All analog and digital signals, including signals provided by intelligent devices shall be displayed on a screen graphically. The screen design shall be representative of the process.
b. The Contractor shall make provisions to design and integrate up to 75 MMI screens before the start of the warranty period. The Contractor shall also make provisions to update and adapt to field changes and modifications the MMI screens and data bases before the start of the warranty period.
c. Faceplates: Standard faceplates shall be provided and shall not be counted as separate screens. The faceplates shall be linked with the software module for the particular piece of equipment or device.
   Breaker Faceplates:
   - In addition to the opened/tripped status for each breaker, the following information shall also be provided: local/remote status; racked-in status; test position status; racked-out status,
   - Breaker disagreement alarm shall be provided. The disagreement alarm shall be active when the actual status differs from the last command sent to the breaker. This alarm shall also activate the alarm horn.

d. Lock-out/Tag-out
   - In addition to the Unit and Plant Lock-out/Tag-out screens, each device/equipment faceplate shall have a drop down menu for selection of Lock-out/Tag-out action;
   - The Lock-out/Tag-out status shall be shown on each screen or faceplate that the device/equipment appears on,
   - The Contractor shall submit the standard lock-out/tag-out system for review and approval by the Employer/ Engineer In-charge.

e. Intelligent Devices
   - The Contractor shall provide standard templates to display the process information provided by intelligent devices such as protective relays & multifunction metres,
   - The Contractor shall submit the standard templates for review and approval by the Employer.

f. Alarm System; Alarm and Event Logs and Sequence of Events
   - The Historian Work Station shall be dedicated to data logging of alarms and events on the servers drives. Alarms and events shall nevertheless be displayed at the MMI.
   - A comprehensive alarm system shall be provided. The alarms shall be prioritized and grouped to provide user-friendly operator interface,
   - The alarm system shall comprise of process, PCS, network and communication alarms. The alarm system design shall be reviewed and approved by the Employer,
   - Alarm and event log shall be provided. The log shall include: all process alarms and events; all operator action events; all PCS alarms and events; all network and communication alarms and events of the plants including the systems provided that are integrated into the SCADA with no exception. Each alarm or event shall be logged together with its time stamp. Alarms shall include events generated by the intelligent devices,
   - Sequence of Events shall be included for discrete inputs and events generated by the intelligent devices to provide troubleshooting tools for the engineering personnel.

g. Colour Standards:
   - The colour standards mentioned in the following tables are recommended values. The final colour scheme shall be coordinated with the Employer during MMI development, and submitted for approval.

h. Equipment or Device Status:

Gate, Damper	**Circuit Breaker, Switch**	**Motor, Pump, Generator, Fan, etc.**	**Graphic Colour**
Opened	Closed	Running	Red
In Transition	N/A	In Transition (when applicable)	Flashing Red when Opening/Starting and Flashing Green when Closing/Stopping
Closed	Opened	Stopped/Off	Green
Tagged Out	Tagged Out	Tagged Out	Yellow
Fault	Fault	Fault	Magenta
In Automatic Indication	In Automatic Indication	In Automatic Indication	Amber
In Local or Manual	In Local or Manual	In Local or Manual	Blue

Indication	Indication	Indication	
In Alarm Indication	In Alarm Indication	In Alarm Indication	Unacknowledged – Cyan Acknowledged - White

i. Electrical Bus Colours by Voltage

Voltage	**Colour**	**RGB Hex Code**
132 kV	Safety Yellow	FDD31D
33 kV	Light Green	C4DA99
11 kV	Dark Blue	023457
415 VAC	White	EDF2F8
220 V DC	Red	CC0000

30. Controller Stations (CS) Software

a. Maintenance Facilities
- Each CS shall be provided with maintenance facilities to allow the users to configure the database and program any functions using a portable personal Computer or the Engineering Workstation (EWS) connected through:
  - Network,
  - Serial port,
  - Remotely via modem.
- The maintenance facilities shall be password protected and shall contain the option for a dial back security when in dial-up mode.

b. Configuration System
- The CS shall be provided with a Windows-based configuration system, which shall include all the necessary software to configure and program any function in the CS,
- The configuration system shall be installed on the portable laptop PEWS and the EWS (Multipurpose Servers),
- The configuration system shall allow downloading and uploading of configuration data files,
- The configuration system shall program, download, store programmable algorithms.

c. Programming Package
- The programming package shall be an industry standard package, IEC 61131 compliant and shall be totally integrated with the PCS software,

- No special database shall be required for the implementation of control programs. The control programs shall use ladder diagrams; function block diagrams, sequential function charts, structured text, instruction lists, process control language and C++ based routines.
- The programming package shall support on-line and off-line development, off-line simulation, documentation and reporting capabilities.

d. Naming Conventions
   - All input, output and soft points shall be named consistently in accordance with an approved naming convention,
   - The point tag shall include as a minimum: plant; location; system; subsystem; IEEE/ISA component ID (i.e PT, 52, etc.); point type (analog, discrete, etc.); connection type (software, hardwired, etc.), etc;
   - The naming convention shall be approved by the Employer and Engineer In charge.

e. Functions
   - The algorithms and functions shall reside in the PLC or controllers associated with the equipment or system as indicated in the table that follows.

Function	Location							
	Main SCADA	Unit Control Board UCB	Intake Control Board ICB	Station Service Board SSB	Unit Protection SCADA	Unit Mech Prot & MIV PLC	Unit Exc. & AVR	Unit Gov. Control PLC
Data Acquisition	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Discrete Raise/Lower and Set-point Control of MVAR & kV	Yes	Yes	No	No	No	No	Yes	No
Discrete Raise/Lower and Set-point Control of MW & Hz	Yes	Yes	No	No	No	No	No	Yes
Unit Automatic Start/ Stop Control Sequence	Yes	Yes	No	No	No	No	No	No

Synchronizer Control&	Yes	Yes	No	No	No	No	No	No
Function								
	Main SCADA	Unit Control Board UCB	Intake Control Board ICB	Station Service Board SSB	Unit Protection SCADA	Unit Mech Prot & MIV PLC	Unit Exc. & AVR	Unit Gov. Control PLC
Monitoring								
Unit Metering Display	Yes	Yes	No	No	No	No	No	No
Switchyard Metering Display	Yes	No	No	No	Yes	No	No	No
Auxiliary Metering Display	Yes	No	No	Yes	Yes	No	No	No
Governor Control & Monitoring	Yes	Yes	No	No	No	No	No	Yes
Excitation & AVR Control & Monitoring	Yes	Yes	No	No	No	No	Yes	No
Mechanical Protection Monitoring	Yes	Yes	No	No	No	Yes	No	Partial
Elec. Protection Monitoring	Yes	Yes	No	No	Yes	No	No	No
Unit Single Line Display	Yes	Yes	No	No	Yes	No	No	No
Single Line Display	Yes	No	No	No	Yes	No	No	No

Generator CB Open, Close Control and Monitoring	Yes	Yes	No	No	Yes	No	No	No
Line CB Open, Close Control	No	No	No	No	Yes	No	No	No
Line CB Open, Close Monitoring	Yes	No	No	No	Yes	No	No	No

Function	Main SCADA	Unit Control Board UCB	Intake Control Board ICB	Station Service Board SSB	Unit Protection SCADA	Unit Mech Prot & MIV PLC	Unit Exc. & AVR	Unit Gov. Control PLC
Interlocks & Trips	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
MIV Control & Monitoring	Yes	Yes	No	No	No	Yes	No	No
Intake and Spillway Gates Control & Monitoring	Yes	Yes	Yes	No	No	No	No	No
Desilting Gates Control & Monitoring	Yes	Yes	Yes	No	No	No	No	No
Dispatch Signals	Yes	Yes	No	No	Yes	No	No	No
Generator Transformer RTU Monitoring	Yes	Yes	No	No	Yes	No	No	No
Unit Instrumentation Display	Yes	Yes	No	No	No	Yes	No	Partial
Intake, Tailrace and Surge Shaft Instrumentation Display	Yes	Yes	Intake only	Tailrace only	No	No	No	No

Vibration Monitoring Display	Yes	Yes	No	No	No	Yes	No	No
AC Auxiliary Systems	Yes	No	No	Yes	No	No	No	No
DC Auxiliary Systems	Yes	No	No	Yes	No	No	No	No
UPS System	Yes	No	No	Yes	No	No	No	No
Function				Location				
	Main SCADA	Unit Control Board UCB	Intake Control Board ICB	Station Service Board SSB	Unit Protection SCADA	Unit Mech Prot & MIV PLC	Unit Exc. & AVR	Unit Gov. Control PLC
DG Set Control and Monitoring	Yes	No	Yes	Yes	No	No	No	No
HVAC Monitoring	Yes	No	No	Yes	No	No	No	No
Fire Fighting Monitoring	Yes	No	No	Yes	No	No	No	No
Auxiliary Mechanical Monitoring	Yes	No	No	Yes	No	No	No	No
Data Interchange with Intelligent Devices and other Nodes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
CCTV and VoIP Interface	Yes	No	Yes	No	Yes	No	No	No

f. Data Acquisition

The CS shall continuously scan and process the information from the input and output modules, and intelligent devices. The information shall be available system wide and shall be displayed, integrated into the control logic, logged, trended, alarmed, integrated into operator displays.

- Digital status inputs shall be processed for changes from the previous status. All digital input changes shall be collected, correlated and time tagged,
- Analog values shall be read, converted to engineering units, and stored periodically.

g. Controls
- The CS shall be capable of performing discrete, continuous, and sequential controls,
- The CS shall respond to control commands initiated from the OWS and HMI screen or by control algorithms in the PLC's or local controllers. The control commands shall be open and close; raise and lower; set-point control; and sequential control,
- The open and close control commands shall be used for the direct opening or closing of circuit breakers, switches and other two-position devices,
- The set point controls shall be used as inputs for MW, MVAR and kV control,
- The sequential controls shall be used for the unit automatic start/stop sequences.

h. Discrete Raise and Lower and Set-point Control
- Discrete raise and lower and set-point control of MW and frequency shall be provided as specified in Chapter, Governing System,
- Discrete raise and lower controls of MVAR and kV shall be provided as specified in Excitation System,
- Discrete raise and lower and set-point controls shall be manually entered by the Operator at the OWS and HMI screens or automatically generated by the control algorithms as part of a control sequence,
- Set-point control of MW, MVAR and kV shall be manually entered, via interactive templates from the OWS and HMI screens or internally generated by the control algorithms.
- Voltage and Frequency discrete raise and lower controls shall be provided at the Synchronizer Panel of the UCB

i. Unit Control Sequences
- The unit PLCs shall perform the automatic starting and stopping of the generating units in conjunction with the excitation and governing system controller and with the start permissive signals,
- The algorithm shall be designed to alarm for any discrepancies between the units' current and expected status at any stage of the sequences,
- The Contractor shall define the exact sequence, pre-start conditions, timers, etc.

j. Governor Control:

The redundant Governor Control shall be directly interfaced to the redundant Unit Process Control Network.

k. Static Excitation and AVR:

The excitation and redundant AVR shall be directly interfaced to the redundant Unit Process Control Network.

l. Substation:

All application software and converters required for the protection, monitoring and control of the Substation shall be developed and implemented in the Substation SCADA and interfaced with the CS.

m. Interlocks and Trips:

Electrical protection interlock and trip signals are hardwired to the Unit Control Board (UCB), Unit Protection Boards (UPB), Excitation (ET), Governor Control, the Intake Control Board (ICB). The redundant soft interlocks and trips shall be implemented from the ICB and VCB to the UCBs. Additional soft interlocks and trip signals shall be provided as required for the safe operation of the turbine-generating units, balance of plant equipment and auxiliary systems soft in addition to the hardwired interlocks and trips.

n. Unit and Switchyard Electrical Protection:

Electrical Protection is comprised of Intelligent Multifunctional Relays installed in Protection Boards. The Intelligent devices are controlled and monitored by application software implemented in the Substation SCADA and interfaced with the CS.

o. Vibration Monitoring System Interface:

All application software and converters required for displaying the reading on the CS shall be provided.

p. Balance of Plant:

All application software and converters required for the monitoring and control of the Electrical Balance of Plant, the Mechanical Balance of Plant and all production related common auxiliary equipment shall be developed and implemented in the Station Service Board (SSB).

Systems which are part of the EBOP include: the 33 kV and 415 V AC Auxiliary Systems, the 220 V DC Auxiliary Systems, the 240 V AC UPS Systems, DG Sets and miscellaneous building safety systems and auxiliaries.

Systems which are part of the MBOP include: the HVAC systems, the Fire Fighting systems, the Drainage, Dewatering and Domestic Water systems, the Sanitary system and miscellaneous building systems.

q. Intake Gates, Spillway Gates, Desilting Gates, Main Inlet Valve Control and Instrumentation:

- All application software and converters required for the monitoring and control of the Intake Gates, Spillway Gates and Desilting Gates shall be developed and implemented in the Intake Control Board (ICB). Interface of gate controls to the ICB shall be done through gate PLCs interfaced through communication links and by hardwiring to the ICB digital I/O modules All instrumentation (position, level, flow, etc.) shall be connected to ICB analogical I/O module.
- I/O modules. Surge Shaft and Pressure Shaft
- instrumentation (pressure, position, level, flow, etc.) shall be connected to VCB analogical I/O module,
- All application software and converters required for the monitoring and control of the main inlet valve shall be developed and implemented in the MIV PLC.
- Draft Tube & Tailrace instrumentation (level) & Tailrace gate control/monitoring panels are to be connected to the powerhouse Station Service Board (SSB).

r. Information Interchange with Intelligent Devices and other Nodes:
The information interchange with intelligent devices and the PCS shall be over the Unit Process Control Network and shall use industry standard communication protocols. Access to real time and historical data shall be via standard open access formats such as Open Database Connectivity (ODBC). The intelligent devices shall be configured to transmit time tagging of events such as relay protective function trips.

s. CCTV and VoIP Interface:
These systems shall be integrated to the SCADA LAN network through dedicated Optic Fibres.

31. **Historical Data Management (HDM) Software**

a. General Requirements
- The HDM software shall be provided for collecting, storing, and reporting historical operating data of the power plant system. Data shall be collected at periodic intervals and stored in historical files,
- The historian shall be synchronized with the plant GPS time system.

b. Performance
- The data historian shall provide a minimum sustained performance rate of 20,000 values per second at the largest tag configuration,
- The HDM shall be capable of collecting and storing a minimum of 100,000 tags on a single computer,
- The data historian shall provide 10 millisecond time stamp resolution,
- It shall be possible to archive historical files on removable media or other hard drives for storage, without the need to stop the historian,
- The data management software shall employ data compression to allow optimal data storage without affecting the performance and without distorting the data,
- The historian storage system shall be sized to hold at least 10 years of history for all project points including 30 percent spares,

- The historian shall support redundant configurations and provide high availability. The data collection system shall automatically switch to the best available source should the primary collector fail. Microsoft Cluster Server 2003 or later shall be supported to enable 24/7/365 data availability for increased uptime.

c. Configuration and Security
   - The system configuration shall be done via web based administration tools;
   - All configuration changes including adding new tags must be “on-line” without the need to stop and restart the data historian,
   - The system shall automatically import the data type, description, tag name, and other data characteristics from the data source, without a need to retype the tag information,
   - Role based security shall be utilized to restrict user access to different administration, system and user functions,
   - All configuration changes, user connections, security violations and other system messages shall be logged, and the log shall be available for monitoring by the administrators. The logs shall not be allowed to be modified or deleted by the users or the administrators.

d. Data Collection
   - The system shall support tags from multiple data sources utilizing a graphical interface. Data sources include all systems interfaced with the CS,
   - The periodicity of data collection and storage shall be configurable for each point type,
   - The system shall support input scaling of analog values,
   - The systems shall support OPC "Alarms & Events" and collect and store alarms and events from any OPC Alarms & Event server.

e. Calculations and Analysis
   - The historian shall provide a calculation engine for automatic calculations and analysis with incoming and archived data and storing the result in an historian tag,
   - The calculation engine shall support installation on remote computers,
   - The calculations shall support an unlimited number of trigger tags,
   - The calculation engine shall be able to perform mathematical and statistical operations, e.g., interpolation, maximum, minimum, average over a specific time, standard deviation, time weighted total, totalizing, etc,
   - The calculation engine shall support data filtering,
   - The calculation engine shall support Visual Basic scripting,
   - The calculation engine shall support time based, tag based and manual triggers,
   - The calculations shall have execution time control and means to disable the calculation if it exceeds a configurable maximum execution time,
   - The historian shall be capable of performing downtime analysis for process areas and subsystems.

f. Multiple Server Configuration

- The system shall support multiple server configuration and data forwarding from one historian to a remote historian,
- Tag browse and import shall be possible from the remote historian, without a need to re-configure the tags at the remote historian.

g. Client Interfaces
   - Interface to Microsoft Excel shall be provided. The interface shall be integrated with the historian package and should utilize drop down menus and toolbars. The interface shall be capable of extracting process, calculations and system data and developing reports using MS Excel. The interface shall provide capabilities for importing and modifying tags, stored data and user comments,
   - Interface to OLE DB shall be provided. The interface shall allow process, calculations and system data to be extracted and viewed by applications such as SQL servers and Crystal Reports TM. Modification of historian data through this interface shall not be allowed,
   - Interface to Human Machine Interface/SCADA Systems shall be provided for monitoring of the historian's process and calculations data. The interface shall be able to convert Universal Time Co-ordinated (UTC) to standard local and daylight savings time,
   - Web based interface to the historian shall be provided to browse, display and chart data.

h. Manufacturer:
   - OSI soft, PI System; Or approved equal.

32. Plant Networks

a. General Requirements

   - The Local Area Networks (LANs) shall provide interconnectivity of the Control Boards (PLCs and HMI), the SCADA Work Station and Servers, the Governor Controls, the AVR and Excitations, the Mechanical Protection, the Vibration Monitoring Systems, the Distributed Control Devices, the Electrical Protection relays and Switchyard SCADA, the Energy Management Meters and Work Station (EMS), the Dispatch Work Station (DWS) etc. The VoIP and CCTV Networks shall use separate Optic Fibres and implement herein. The LANs shall be seamlessly integrated to meet the system performance requirements specified herein,
   - The LAN network shall be as shown on the SCADA System Architecture drawing. The drawings show the general principal and thus not all required components and devices are shown. The Contractor shall provide all additional components and devices required to meet the requirements of the specification.

- One hot redundant Process Control Network (LAN-1 and LAN-2) shall be provided for all PLCs, RTUs, Intelligent Devices, Servers, Work Station Processors, Ethernet Switches, Routers, etc. The Network shall be provided with both redundant hardware and communication links. The Network shall be Ethernet based with a minimum speed of 100Mbps. LAN-1 and LAN-2 networks shall be independent, supplied by different power supplies and physically isolated one from the other,
- All Unit Process Control Networks shall be interconnected to form one redundant common Plant Process Control Network. This network shall be provided with both redundant hardware and communication links. The Plant Process Control Network shall be Ethernet based with a minimum speed of 100 MB/s and shall have 1 GB/s capability,
- One redundant Storage Area Network (SAN) shall be provided to interconnect all the network storage equipment and multipurpose servers,
- The SAN network shall be connected to the Plant Process Control Network via the multipurpose servers,
- The panel mounted HMI workstation shall be connected to the Unit Process Control Network as required to act as backup OPC and I/O servers and provide local control in case of a failure of the multipurpose OPC/HMI servers and/or Plant Process Control network,
- The panel mounted HMI workstations shall be configured to provide backup OPC and I/O server capability,
- Each PCS cabinet shall have two (2) spare RJ45 Ethernet network port for laptop connection.

b. Communication Media
- The communication media for the in-plant networks shall be multimode fibre optic cables. At least 12 spare fibres shall be provided in each cable. Not less than 4 spare fibres shall be provided in each cable for use by others. The cables shall be terminated to a patch panel. Patch cables shall be run from that panel to the devices,
- Category 6 shielded copper cables can be used for short distance runs inside cabinets or as approved by the Engineer In-charge. Standard RJ45 outlets and connectors shall be used as required.

6.7.1. Shop Assembly and Tests

1. Factory Acceptance Test (FAT)
   a. The Contractors shall prepare a FAT Plan and shall submit it to the Employer for review and approval.

   b. The FAT Plan shall consist of the following:
   - FAT Overview:
     This shall describe the test configuration, the hardware and software simulator, the measurement tools, the complete test schedule, the forms for recording test results, the classification of discrepancies, and the processing of test reports.
   - Test Procedures:

This shall describe the test preconditions and assumptions, the detailed steps to be taken for each test and the verification of results of each step.

c. General description; Pre-FAT & FAT Activity
The Test Procedures shall include both hardware and software tests and verification of the Historian System. As a minimum, the step-by step procedures shall include:

- Hardware components and assembly are in accordance with the specifications
- and the latest Employer-approved manufacturer drawings.
- Redundancy testing.
- Software protocols for all external communication ports between the relays or intelligent devices are functional.
- Databases are accurate and contain all of the I/O points identified by the
- Contractor's latest Employer-approved documents.
- Graphical displays are complete and functional.
- All Inputs and outputs are functional and properly calibrated.
- Software operating logic for the various systems complies with the requirements of the specifications and the latest Employer-approved Contractor documents.
- Networks function correctly.

d. Pre-FAT activities & FAT
A Pre-FAT shall be performed by the Contractor to verify that the system, as fully integrated, complies with all of the required functional details and that the system satisfies the response and resource utilization requirements. The Pre-FAT shall follow completely the test procedures of the FAT Plan reviewed by the Employer. The Contractor shall notify the Employer for the start date of the Pre-FAT at least four (4) weeks before the test. The Employer personnel will have an option to witness the pre FAT activities.

- Contractor shall submit the test procedures for approvals of the Employer. The Contractor shall eliminate all discrepancies found in the pre-FAT, before the Factory Acceptance Test can be started.
- Employer shall witness the actual start of the FAT upon notification by the Contractor that the system is ready for the FAT.
- The FAT shall be started with a complete system generation performed by the Contractor. After the completion of the system generation, Contractor shall carry out the FAT test procedures.
- The last part of the FAT shall be devoted to the system performance tests using the normal and high-activity loading scenarios.
- All discrepancies found in the FAT shall be corrected prior to shipment of the system.

2. Installation and Field Test

a. Availability Demonstration for SCADA system

- The system Availability Demonstration (AD) shall be performed for a period of 1000 hours starting at the end of the Site Acceptance Test (SAT) for each controller and for the entire system once all units are in service after all problems have been corrected. Acceptance of the system shall be contingent upon the successful outcome of the availability demonstration.
- The software at the start of the AD shall be assumed to be 100% reliable, i.e., free of all known errors or defects in functionality and performance.
- The objective of the AD is to verify that the Average System Availability, A, for a 500hour period of interest is equal to or better than specified, consistently for two successive time periods.
- The Average System Availability, A, shall be calculated as:
- A = [1- (Downtime)/ (Period of Interest)] x 100
- Where "Downtime" in minutes is defined as the time during which any one or more of the following conditions prevail:
- One Server or Operator station is out of service.
- One Process LAN out of service.
- One or more Controllers out of service,
- HMI functions inoperative at one operator console.
- System events logging function lost
- The Average System Availability, A, shall be 99.98% or better. This is equivalent to a downtime not exceeding 6 minutes during a 500-hour period of interest. Within the AD period of 1000 hours, all two values of A for the two 500hour periods of interest shall satisfy the 99.98% requirement.
- The recording and accumulation of downtime shall be subject to the following conditions:
- Restart and fail over times shall be counted,
- Downtime due to software causes and to repair of software shall not be counted. All software errors and discrepancies found during the AD and during the Warranty Period shall be corrected by the Contractor,
- Downtime due to Contractor-supplied hardware causes shall be counted and shall be the total time from the occurrence of the failure until the restoration to operation of the function lost,
- Downtime due to problems in hardware not supplied by the Contractor shall not be counted,
- Downtime due to undetermined causes shall be counted but will be discounted if later in the demonstration period it can be established as being due to a software problem or a problem in hardware not supplied by the Contractor.
- Repeatable or self-recurring failures may cause a suspension of the demonstration period. Only the first downtime shall be counted. The demonstration shall be resumed only after the failure has been corrected.
- Downtime caused by personnel action, which is not related to operation functions shall not be counted.
- For every downtime that is discounted or excluded, the same amount shall be discounted from the accumulated time of the period of interest.
- Rules for restarting the Availability Demonstration.

- If at time T, before the adjusted period of interest period has reached 500 hours, the adjusted downtime already exceeds 6 minutes by an amount x, the period of interest may be extended by (x/6) * 500 hours.
- If the calculated extension exceeds 500 hours, or equivalently if x is 6 minutes or more, the availability test for that period of interest shall be restarted.
- If the calculated extension is equal to or greater than T, the availability demonstration for that interest period shall be restarted.

b. Repair Procedures
   - Whenever a failure occurs in any hardware or software component, regardless of whether it causes a downtime or not, the Contractor shall analyze the problem and carry out the necessary repairs.
   - If the Contractor is not successful in locating and/ or repairing the problem, the Employer shall be notified immediately. The Contractor shall then undertake the diagnosis & repair.
   - If the failure had caused a downtime condition, the total repair time (diagnosis time plus actual repair time plus time to place the function back in service) shall be considered as downtime. If the Contractor had not succeeded in locating and repairing the problem, only the repair time of the Contractor shall be counted.

c. Loading Scenarios
   - The normal loading scenario shall be simulated as follows:
     - All analog values updated at the specified scan cycles, processed without exception, and updated on the database,
     - Ten (10) analog alarms occurring every 5 minutes,
     - One (1) Intelligent Electronic Device communicating with the Controller,
     - One (1) status change received and alarmed every five (5) minutes,
     - One (1) display call up every ten (10) seconds on each monitor of all stations, each monitor having four active windows,
     - All periodic programs in execution,
     - Online display maintenance in progress,
     - Trending of four (4) variables in operation,
     - Offline software maintenance in progress.
   - The high-activity loading scenario shall be simulated as follows:
     - Same as normal loading,
     - Four (4) analog alarms every five (5) per seconds,
     - Six (6) status alarms every two (2) seconds,
     - Fifty (50) DI or fifty (50) AI from each Controller, resulting in 300 DI or AI changing status within the first five (5) seconds of the disturbance. Then, one hundred (100) DI or AI per second changing status for the duration of the first minute, after which normal load shall be assumed.
   - The performance tests for the high-activity loading scenario shall be repeated for one process LAN out of service.
   - CPU Utilization: During the performance test with the high-activity loading scenario, the average CPU loading in any of the station servers shall not exceed 30% for a 1-hour period.

- Memory Utilization: Memory utilization for Controllers and PCS shall not exceed 30%. The final application software shall not occupy more than 30% of the Controller Station's memory.

d. Control/ SCADA system Performance requirements
   - Response Requirements: The verification of response times for the system shall be made under the following conditions:
     - Process LAN; One device out of service or not used.
     - High-activity loading scenario in effect.
     - All response time requirements shall be wall-clock times.
     - The time duration from the instant of a status change at the equipment location symbol is updated on a workstation HMI screen shall not exceed 1.5 sec.
     - The overall call up time of any display, from the instant the mouse is clicked until the requested display is on the monitor complete with all dynamic data, shall have an average value not exceeding two (2) sec.
     - The overall time for processing an alarm from the time it is generated in the field until it is updated on the alarm list and on the System Events List, the audible sounded, and the logging initiated, shall not exceed two (2) sec.
     - Time-of-day displays on the HMIs shall be within two (2) seconds.
     - The overall time from the initiation of command at visual display on the operator console to the output terminals of the field controller shall not exceed one (1) sec.
   - Periodicity Requirements and Time Synchronization.
     Following periodicity requirements shall be met under normal loading conditions:
     - Status-change scan two (2) seconds,
     - All closed loop variables two (2) seconds,
     - All other analog scan as per scan rate,
     - Data update on a window as per scan rate < three (3) s,
     - Time-of-day update on HMI, as required to maintain two (2) seconds or better.
   - All digital inputs system wide shall be GPS synchronized at ten (10) ms or better. Then sequence of Event (SoE)/ Data logging for Electrical Protection system Alarms shall be time tagged with an accuracy of one (1) ms.
   - System Overload
     - The PCS shall be designed such that it can withstand severe system overloading or any condition worse than those defined for the high-activity loading scenario. No matter what the overload situation might be, HMI screen call up response times shall not be affected. All functions shall be operational although degradation in periodicities within acceptable limits,
     - No alarms shall be lost during system overloads,
     - The Contractor shall describe the methods which shall be used to guarantee that during a system overload all critical functions will be operational, HMI screen call up response times shall be within the requirements specified, and no alarms shall be lost,

- The Employer reserves the right to participate and monitor all installation, testing, trouble- shooting and repair activities.

6.7.2. Spare Parts, Consumables & Special Equipment

The spare parts mentioned hereunder are meant for use by the Employer for 5 years trouble free operation & shall not be used as erection or commissioning spares required during the works.

- All spare parts shall be of the same material, workmanship, and manufacturer as the corresponding original parts, completely interchangeable and packaged for long-term storage.
- If any additional spare parts required for a 5 year trouble free operation period are recommended by Contractor, these shall be listed as "Recommended Spares" and the unit price shall be quoted in the price schedule. The Employer reserves the right to order any or all of such spares.
- All spare parts shall be suitably packed, clearly marked and ready for long term indoor storage.
- The submittal shall include a separate list of additional spares, consumables and special equipment recommended by the Contractor, together with unit and total cost. The submittal shall include handling and storage instructions for all spare parts, consumables and special equipment.
- The submittal shall include a list of any specialty software or hardware tools used during project and not listed or provided under other submittals.
- List of "Mandatory Spare" parts -

S No.	Description	Unit	Quantity
1.	**Spares for Central Control Room Equipment**		
1.1	Operator Work Station PC/ Process Server PC comprising, mouse, keyboard, network interface cards	Set	1
1.2	Monitor- Colour, TFT LED (LED backlit), 22-inch screen, for OWS/Server and EWS PC	No.	2
1.3	**Large Video Screen;** 1 x 55" LED/LED screen with connecting & mounting hardware, DVI cable, network interface and connectors	Set	1
1.4	**Process bus gigabit Ethernet TCP/IP**		

a)	Multimode gigabit Ethernet switch; Two (2) nos. of each type	Lot	1
b)	Single-mode gigabit Ethernet switch; Two (2) nos. of each type	Lot	1
c)	Other network component like patch panels, repeaters/ hubs [Two numbers of each type]	Lot	1
1.6	**Field bus media converter modules**		
a)	Multimode Media converter module with connecting hardware [Two numbers of each type]	Lot	1
b)	Field bus connectors [of each type]	No.	2
1.7	Other cards/ modules [for GPS based Time synchronizing system- synchronizing pulse distribution, power supply etc.] (each type)	No.	1
1.8	Slave clock for GPS based Time synchronizing system (Large Digital display LED/LED)	No.	1
1.9	a) Multifunctional B/W Laser Printer Ink Cartridges b) Colour Laser Printer Ink Cartridges c) Dot Matrix Printer Ink Ribbon d) B/W Laser Printer Ink Cartridges	No No. No. No.	24 12 24 12
2.	**Spares for Group/ Local Control cubicles** (Unit Control Board, Common auxiliary and control cubicles)		
2.1	PLC set [complete with redundant power supply cards, CPUs, communication interface cards, 19" mounting rails/ racks, synchronizing modules, FO	Set	1
	synchronizing cable & connectors, backup batteries, memory card and other accessories]		

2.2	HMI touch screen, Panel mounted Monitor	Set	1
2.3	Process I/O cards (DI, DO, AI and AO cards) (Four (4) numbers of each type)	Lot	1
2.4	Field isolation (Optical/ Electromagnetic) auxiliary relays, front connectors, interface modules, flat intra panel cables and necessary for I/O cards at 2.3 above including, connectors, patch cords and splice box. (Four (4) numbers of each type)	Lot	1
2.5	Field-bus Interface module/ and connecting prefabricated cables, Two (2) numbers of each type	Lot	1
2.6	Ethernet communication processor cards/ module (Two (2) numbers of each type)	Lot	1
2.7	Power supply modules/ DC-DC converters, 220V to 24 V/48V (Two (2) numbers for each type & rating)	Lot	1
2.8	a) Automatic synchronizer b) Synchro check relay Manual synchronizing devices (push buttons, control switches, pilot lamps) and instruments (Voltmeter, Frequency meter, DV, DF). (One (1) number of each type)	Unit Unit Lot	1 1 1
2.9	a) Protection tripping Relays c/w socket (1 of each type) b) Auxiliary Relays c/w socket (4 of each type)	Lot Lot Lot	1 1 1
	Interposing Relays c/w socket (12 of each type)		

2.10	Miscellaneous Indicating lamps, rotary switches, semaphore indicators, push buttons, special relays, indicator and alarm switches; 20% or two (2) no - [whichever is higher] each type	Lot	1
2.11	Terminals, ferrules, ac & dc power supply MCBs, auxiliary contacts, diodes for power supply isolation. 20% or two (2) no [whichever is higher] of each type	Lot	1
2.12	Fuses (200%) of each type	Lot	1
2.13	Other cubicle spares and accessories, Door limit switches, space heaters, illuminating lamp, power sockets, cubicle cooling fan etc. (4 of each type)	Lot	1

- **Special tools and maintenance equipment-**
  - Contractor shall supply, for hand over to Employer one complete set of special tools and maintenance equipment, recommended by Contractor for complete SCADA and LAN system. The list of these tools shall be approved during detailed engineering.
  - However, it shall include at least the following maintenance equipment for repairs and maintenance with descriptions and quantities of the following:

Equipment	**Quantity**
Standard Electronic Tool kit [Comprising Digital Multi-meter, loop check/ Continuity testers, set of screw drivers, wire-stripper, crimping tool]	Two (2) sets
Optical fibre Splicing kit	One (1) set
Optical fibre network testing kit	One (1) set

Tag printer	One (1) no

Any other Maintenance &Testing tool recommended by vendor

6.7.3. Drawings & Documents Submittals

1. General Drawings

At minimum, the following outline drawings of the major components, showing the specific features listed here shall be submitted, as well as any additional submittals requested by the Employer.

Controls

- A system architecture drawing that identifies all boards, panels, controllers and computers that will host the system software modules,
- An overall diagram and subsystem diagrams including major software modules, data structures and data flow, including interfaces with other modules. Location of PLC, HMI, I/O modules, Work Stations, screens, printers and miscellaneous devices for each location shall also be included;
- An overall diagram and subsystem diagrams including major software modules, data structures and data flow, including interfaces with other modules. Location of PLC, HMI, I/O modules, Work Stations, screens, printers and miscellaneous devices for each location shall also be included;
- An overall diagram and subsystem diagrams including major software modules, data structures and data flow, including interfaces with other modules. Location of PLC, HMI, I/O modules, Work Stations, screens, printers and miscellaneous devices for each location shall also be included;
- Front, rear and side views for all cabinets,
- Furniture of the Control Room,
- layout with dimensions and weights.
- Detailed Drawings

At minimum, the following detailed drawings of the major components, showing the specific features listed here shall be submitted, as well as any additional submittals requested by the Employer.

Controls Detail Drawings

- Instruments and control devices details, including location and size,
- Inside view of equipment arrangements, including terminal blocks and cable entrance details for external cables for control cabinets,
- Inside view of equipment arrangements, including terminal blocks and cable entrance details for external cables for protection cabinets,
- Inside view of equipment arrangements, including terminal blocks and cable entrance details for external cables for machine monitoring system cabinets,
- Conduit and cable entrances,

- Schematic diagrams, elementary and three-line diagrams for measuring and protections,
- Wiring diagrams and cable schedules for control protection and machine condition monitoring systems,
- Termination drawings/schedules and external connections diagrams for installation,
- System architecture and network diagrams overall and for each system, network configuration descriptions, managed Ethernet switches configuration, communication devices programming and configuration,
- PID's, loop diagrams, block diagrams and logic diagrams, including ISA Form 20 for all instrumentation,
- Recommended settings for protective and timing relays and instruments, including all alarm/trip points, time constants, gains and timing circuits,
- Logic Schematic drawings of the Auto-sequencer for normal and emergency operations including the interfaces with all external systems. Sequence of operations shall be detailed for each possible command and/or event,
- Control and wiring drawings of each Control Board,
- Interface drawings for PLC system and manual control system,
- The Electrical and Mechanical protection logic drawings indicating all start permissive interfaces.

Instructions, Procedures and other Drawings and Documents

At minimum, the following instructions, procedures and other drawings and documents of the components, showing the specific features listed here shall be submitted, as well as any additional submittals requested by the Employer.

Bills of material:

- A General bill of material listing all major elements of the Unit Control, SCADA and Automation systems,
- Secondary bills of materials detailing the components within a Board shall be submitted with the corresponding drawings, on the drawings.
- Factory tests and shop inspection schedules, test and inspection procedure, checklists, and data collection sheets,
- Handling and storage instruction manuals,
- Storage details for all applicable components including square footage, temperature, and humidity control requirements,
- Assembly schedule, procedures and checklists,
- Installation instruction manuals,
- Site test non-destructive test program schedules, test procedures, checklists, and data collection sheets,
- Field Check up, start-up, testing procedures and manuals;
- List of instructions for all tests and checks to be performed at each stage including inspections and measurements, assembly, start-up and commissioning, and final signature Test,
- Manufacturer's data sheets for all of the HMI components used in the system including but not limited to, server computers, workstation computers, monitors, printers, software, etc;

- Manufacturer's data sheets for all control and protection switchboard components including but not limited to, control switches, pushbuttons, indicating meters, indicating lights, auxiliary control relays, power supplies, system protective relays, etc;
- Manufacturer's data sheets for instrumentation and other field devices,
- Data sheets and specifications of PLC, I/O modules, Work Stations, Screens,
- Printers, Ethernet Switches, Routers, etc,
- Overall dimensions and layout;
- Nameplates Schedule.

2. Controls Documents

Technical specifications and interfacing requirements including data format for equipment furnished by others.

Application Software Functional Design, including a functional description of the application software for the unit and plant monitoring and control. Each module shall be described in detail and include the functions of the module and its interface with other modules, field input/outputs and HMI. Application software functional design submittal shall include, but not be limited to:

- Description of the functions to be performed by each software module,
- Detailed description of all interfaces between the system and the operator shall be provided. All related HMI graphics shall be shown,
- Description of the distribution of the modules, loading of controllers and memory requirements,
- Naming convention for the input, output and software points,
- Input, output and software points' database,
- Description of the impact of power failures, system failures, redundancy switch over, normal restarts for all systems and subsystems and application software approach for mitigating issues,
- Description of the original vendor software and programming environment with a list of software licenses provided with the system,
- Controller programming details: The programming shall be fully annotated with sufficient information for determining operation of the system,
- HMI programming details: HMI programming for the servers and workstations and all of the graphic screen configurations, alarm system configuration, short term history configuration, historian configuration, reports configuration, etc,
- Input, output and software database,
- Manufacturer's Information,
- The Manufacturer's information shall be tabulated / located in subfolders based on the usage of the devices and equipment. • Manufacturer's data sheets for all Controller components used in the system including but not limited to CPUs, power supplies, I/O modules, communication modules, software, etc,
- Manufacturer's data sheets for all network and communication components used in the system including but not limited to: Ethernet switches, cables, connectors, radios, antennas, power supplies, software, etc.

- Contractor shall furnish four (4) sets of all drawings for approval. After approval and after work completion at site, six (6) sets of as built drawings and one (1) set of electronic files as CD shall be submitted.

6.7.4. Operation And Maintenance Manuals

Operations and Maintenance instructions, including descriptive text detailing operation of the new system controllers shall be included. All modes of operation shall be covered including, but not limited to: generator start, stop, synchronizing, loading, unloading, automatic and manual operation, emergency stop, graphics and alarm system utilization, short and long term history, reports, etc. The maintenance procedures shall include the weekly, monthly, quarterly, six-monthly and annual maintenance schedules, including the trouble-shooting details.

The Contractor shall submit to the Employer Six (6) sets of O & M manuals for review and approval. After approvals & incorporating comments of the Employer, the Contractor shall submit Six (6) sets of the O & M Manuals and one (1) set of electronic files as CD.

6.8. Optic Fibre Communication System (ADSS & OPGW)

6.8.1. General

1. In this specification, the term “Remote Site” refers to the following project site located outside the Powerhouse.
    - Intake Location,
2. The communication system used for the communication to the 33/220 KV proposed substation is of the OPGW Communications type communicating to the central dispatch.
3. The purpose of the communication system is to provide a full duplex path of communication between the Powerhouse SCADA and the Intake. For the Monitoring of miscellaneous Gates and the instrumentation for the measurement of gate positions, water levels, water flows, and HPU pressure monitoring. The communication system also serves for the future provision of a redundant VoIP and CCTV system.
4. The communication converters, ethernet switches, routers, hubs, etc. shall be housed in the Control Board (VCB & ICB) and Patch Panels.

6.8.2. Scope of Work

The Contractor shall design, supply, transport to site, deliver at site storage and preservation, install, test and commission a complete communication system such as described below. All devices, parts, accessories and special tools necessary for the equipment and contract complete system shall be supplied by the Contractor, even if those are not individually listed or specified

- An Optic Fibre communication system between the Control Room, Switchyard, the Surge Shaft and the Intake. The Fibre Optic cable shall be supplied, laid, terminated, tested and commissioned by the Contractor as specified,
- At each site, the Optic Fibre Cables will be connected to Fibre Patch Panels,
- At the Powerhouse, the Optic Fibre communications integration to the powerhouse LAN-1 and LAN-2 networks.

The communication Contractor in charge of the whole communication shall ensure that the data flowing between the different locations, and issued from two different communication systems, are correctly transferred to the final points without collision.

6.8.3. Communication System Description

The Contractor shall provide a complete communication system taking into account the limitations of the topology of the area.

The communication system shall be tied to the SCADA network communication interfaces supplied by the Contractor by connecting it to Optic Fibre Patch Panel.

The data transfer rate shall be sufficient to ensure that the SCADA system screen and update the data at an interval of two (2) seconds.

6.8.4. Technical Requirements

1. The main HUB shall be installed at the Control Room. The Contractor is responsible for the supply, installation and commissioning of the complete system.
2. The data requested to be transmitted and received will come from the mono mode Optic Fibre link supplied by the Contractor. This Optic Fibre will be terminated in a Fibre Patch Panel located in the Control Room. It is the Contractor responsibility to connect the transmission equipment to the Fibre Patch Panel at the Control Room.
3. The required characteristics are as follow:
   - The system shall provide full duplex communication,
   - The system shall be capable of transmitting and receiving of VoIP and CCTV signals in addition to the SCADA signals,
   - The communication system shall assure a reliable data transfer and communication under all the possible weather conditions in this area. Heavy rain, surge storms, fog and snow should not adversely affect the communications. Reflected signals from a moving object such as a plane shall not endanger the reception or the transmission of the signal.

6.8.5. Optical Line Terminal Equipment (OLTE)/ Telecommunication Equipment,

The scope of work comprise of supply, installation, testing and commissioning of Optical Line Terminal Equipment (OLTE)/ Telecommunication equipment at both ends of 33 kV Overhead line, including necessary accessories for fibre termination / splicing in splice box and approach OFC between splice box and FDP (Fibre Distribution Panel) located in control room to establish connection with the existing Remote terminal Unit (RTU) at 33/220KV proposed Substation and to establish connection with RTU to be installed at Karbi Langpi HPP.

For the above scope of work, the contractor shall make necessary studies and investigations of the existing SCADA systems in order to design and supply of appropriate equipment. Contractor shall co-operate and coordinate with other related Contractor employed by the Employer in this connection and also with proposed Substation Substation/LDC for integration of Karbi Langpi Middle II HPP into the LDC SCADA system.

Bidders shall offer the OLTE and their accessories from reputed manufacturer

The qualified manufacturer of OLTE should possess ISO 9001 certificate with minimum of 3 years' experience in design and manufacturing of OLTE.

All fibre splices shall be of the fusion type, except where demountable connectors are specified. Fusion splicing shall be carried by trained personnel using automatic fusion splicing equipment designed for the fibre type.

The accurate alignment of fibre cores, prior to splicing, shall be verified using a technique that monitors the optical power transmitted across the splice interface.

Fusion splice optical losses shall average 0.1db per splice. No single splice loss shall exceed 0.15 db. Splices shall be mechanically strengthened and protected from the environment by means of splice sleeves or enclosures. The finished splice shall be supported within the spliced box by means of suitable clips or restraints. It shall be possible to remove and replace the splice in the support device without risk of damage to the splice or fibre. Each fusion splice shall have a spare length of fibre of approximately 1 m associated with it. This excess fibre shall be coiled neatly and clipped (or otherwise retained) within the splice box.

The splicing shall be performed at ground level. Splice boxes conforming to IP55 shall be mounted onto the poles/ towers at least 5 meters above the ground. The cable shall be fastened into the tower structure. In each splicing location at least 15 meters of free cable must be included for future splicing at ground level.

A single splice box conforming to IP 55 shall be provided on each sub-station Gantry / poles with capacity for two cable terminations. It shall accommodate all individual fibre splices between any of the four possible cables. It shall be fitted with suitable cable clamping glands at its base for cable strain relief. The four cable entries shall be located on the underside of the splice box and shall be easily removable to ground level. All cable entries used or unused, shall be weather proof and sealed but still accessible for future use and weatherproof sealing. The box shall be suitably dimensioned to accommodate the excess loops of optical fibre associated with each splice. Easily removable splice tray assemblies shall be used to provide mechanical support for the supplies and to afford a means of neatly retaining the excess fibre. Then splice box shall be of steel construction, finished internally and externally using a durable paint system. Access to the box shall be by means of a bolted front panel. The splice box shall be fitted with an approved identity label (e.g engraved laminated).

The telecommunication equipment for the substation shall, however, be provided and installed under this Contract. The telecommunication equipment for the Power House shall include:

- Supply and installation of Fibre Optic Approach Cables (FOAC) including all trenching, protection pipes, civil works, cable trays etc for the safe and proper installation of the cables from the OPGW-FOAC joint boxes at the gantries to the ODF at the power house control room.
- Supply and installation of suitable Optical Distribution Frames (ODF) / Fibre Distribution Panel (FDP) with single mode pig tail terminations at the control building.
- SDH STM-1 line terminal and add / Drop multiplex equipment with:
  - 1 (one) Optical Interfaces with protection for proposed Substation.
  - Redundant Power Supply Module
  - Redundant control board
  - 21 (twenty one) E-1 interfaces (at least). The E-1 interfaces shall, be-side other connections, allow direct connection of 2 Mbit/s links for the Tele protection signal transmission and 2 Mbit/s trunk lines between PABXs
  - 4 (four) 10Base-T/100Base-TX fast Ethernet ports with LAN Switch (at least)
- 1 (one) PCM access multiplexer with 1+1 equipment protection with redundant Power
  - Supply Module
  - Redundant control board
  - 4 x 2 Mbit/s interfaces for interconnection with other access multiplexers over the SDH network
  - 8 (eight) 4 wire E & M interfaces
  - 8 (eight) 2-Wire Subscriber interfaces to facilitate 8 Subscribers with ringer
  - 4 (four) Ethernet interfaces for LAN or RTU data channels
  - 4 (four) Data Interfaces for transmission (V.24 / V.28)
- 1 (one) Party Line Telephone System (PLTS) with integrated decoder (4-wire)
- 1 (one) set of cables and accessories including Optical patch cords to connect MUX to the patch panel with suitable connectors

- 2 (two) Tele-protection equipment at both ends with 2 commands for direct and 4 commands for transfer trip
- 1 (one) digital comfort telephone set and 3 (three) digital standard telephone sets for connection to the central PABX via the respective interfaces at the PCM multiplexers.

The Bidder shall supply all cabling, accessories and services required for proper operation of the telecommunication equipment at the substation as well the integration into the overall telecommunication system.

6.8.6. Integration into Load Dispatch Centres

The switchyard shall be integrated into the existing Load Dispatch Centre. The integration shall include all hard and software required at the control centre as well as the necessary data base and HMI display generation and upgrades for proper control and monitoring of the stations.

6.8.7. Integration into Communication Network Management System

The Contractor shall fully integrate the new SDH equipment into the existing Network Management Systems (NMS) and shall provide all hard and software that may be required for this purpose. The Contractor shall also reconfigure and parameterize the existing NMS to integrate the new SDH nodes.

The Network Management Systems shall incorporate the following systems:

- A Synchronous Digital Hierarchy (SDH) Network Management System
- A Primary Multiplexer Network Management System
- A Fibre Cable Monitoring System (FCMS)

The installation of the new SDH equipment shall cause no degradation to the existing NMS. Testing shall be performed on all network elements provided under or affected by this contract. Testing shall be done by causing each network element faults and monitoring on all new network elements on a one by one basis. All material and equipment that is required to accomplish the integration shall be provided by the CONTRACTOR.

6.8.8. Site Acceptance Testing

Upon completion of the installation of the whole system, site tests shall be conducted to verify the correct operation of all of the systems. Intake, Spillway and Desilting gates shall be cracked, opened and closed. Intake, Spillway and Desilting gates position and forebay water levels shall be correctly received, calibrated and displayed. All the equipment status, position, level and pressure indications and availability shall be correctly displayed as well as all the alarm conditions shall be tested.

6.8.9. Operation And Maintenance Manuals

The Contractor shall submit for approval of the Employer, a complete set of Operation and Maintenance Manuals showing the operation of the communication system and the maintenance procedures to follow in order to maintain a high degree of availability of the communication system.

The Operation Manual shall show in detail how the system works, the limitations and the explanation of the technology chosen. The Manual shall explain how to put the system back in service upon a failure or after a blackout.

The Contractor shall submit to the Employer four (4) sets of O & M manuals for review and approval. After approvals & incorporating comments of the Employer, the Contractor shall submit six (6) sets of the O & M Manuals and one (1) set of electronic files as CD.

The Maintenance Manual shall explain the operation of the system and present under a flow chart format, how to troubleshoot the system and perform an electronic card or module replacement.

6.8.10. Operation And Maintenance Personnel Training

The Contractor shall arrange a training session for operation and maintenance personnel at site with the real equipment and using the Operation and Maintenance manuals supplied. Drawings and Documents Submittals

The Contractor shall submit the overall communication network diagram, including the major components of the system, RTU and AC/DC auxiliary power supply systems for the approval by the Employer.

6.8.11. Special Tools

The Contractor shall supply all the special tools and testers necessary for normal and routine maintenance of the communication system.

6.8.12. Spare Parts

The Contractor shall supply all the spare parts deemed necessary to maintain the high availability of the communication system for a period of five (5) years. The spare parts supplied shall be easily replaceable by a maintenance technician with no expertise in communication systems.

Minimum spare parts are to include a complete set of antennas transmitter/receiver components as well as a power supply, a router, a hub, a medium converter and an Ethernet Switch of each type.

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7. DC SYSTEM

7.1. SCOPE

This section of the specifications covers the provision of all labour, plant and material and performance of all works necessary for the design, manufacture, shop assembly, shop testing, delivery, erection, testing and commissioning, handing over to the Purchaser 220 V DC system complete with racks and all accessories including battery banks, chargers and distribution board with all its accessories for making the equipment complete and for warranting a trouble free safe operation. The detailed scope is as follows:

Two nos. of 220V DC, 400AH VRLA type (adequate for 1 hr backup) complete with supporting racks and other accessories, two nos. Float cum boost chargers, 220V DC Main Distribution Board & sub distribution board (if any) complete with circuit breakers, contactors, switches, connecting clamps and other accessories as required for trouble free and safe operation.

Two nos. 10 KVA uninterrupted Power Supply system connected to DC Distribution Board.

The required 48 V DC shall be arranged by providing necessary DC-DC convertor.

7.2. GENERAL ARRANGEMENT:

The storage battery shall be installed in the battery room while the battery chargers, D.C. Distribution board etc. shall be located in the adjoining Switchgear room.

The control and protection circuits in the Powerhouse/switchyard shall be supplied from the 220 V DC systems.

The AC power supply for 220V DC battery charger shall be taken from 415V 50 HZ station service boards respectively and the chargers shall be so designed that they can give full charging currents within the voltage variation given on the 415V bus.

The battery bank shall be capable of supplying successfully the load connected to it, at maximum load, for at least 1 hours for the 220 V system without any assistance from the charger and without its terminal voltage falling below 190 V.

The capacities of the batteries given in this specification are estimated values. The Contractor shall make detailed calculations based on the actual power consumption of the connected equipment and submit these data to the Engineer/Purchaser for approval.

7.3. STANDARDS

S. No	Code	Specification
1	IS: 266	Battery grade sulphuric Acid. (Battery electrolyte)
2	IS: 1069	Water for storage batteries
3	IS: 1146	Rubber & Plastic containers for lead Acid storage batteries
4	IS: 1248	Electrical Indicating Instruments
5	IS: 1885	Electrical vocabulary, secondary cells and batteries
6	IEEE: 485	IEEE Recommended practice for sizing of large lead acid storage batteries for generating stations and substations
7	IEEE: 484	IEEE Recommended practice for design and installation of storage batteries
8	IEC 896-2	Stationary Lead acid Batteries-General requirements and method of Test (VRLA type)
9	IEEE-1188:1996	IEEE Recommended Practice for Maintenance, Testing & Replacement of VRLA Battery for stationary Application
10	IEEE-1187:1996	IEEE Recommended Practice for Design & Installation of VRLA Battery for stationary Application
11	IEEE-1189:1996	IEEE Guide for selection of VRLA Batteries for stationary application (with technical comparison between conventional and VRLA batteries
12	IS: 8320	General requirement and methods of

		tests for lead acid storage batteries
13	IS: 6071	Synthetic separators for lead acid batteries
14	IS: 4540	Non-crystalline semi-conductor rectifier assemblies & equipment

The equipment covered under this specification shall comply with the requirements of latest editions of the Indian Standards Specifications as amended to date except where specified otherwise.

Equipment meeting any other authoritative national or international standards which ensure equal or better quality than the standards mentioned above are also acceptable. Where the equipment conforms to any other standards than those mentioned above, salient points of difference between the standards adopted and standards mentioned above shall be brought out in the tender.

7.4. BATTERY UNIT

7.4.1. TECHNICAL REQUIREMENTS

- The Valve regulated cell / battery shall be suitable for float duty operation at constant voltage permanently applied to its terminals which is sufficient to maintain it in state close to full charge and shall be designed to supply load in event of normal supply failure. The charge / discharge curves of offered battery shall be suitable for application in a Hydro Power Generating station;
- The rated ampere hour capacity of the cell / battery shall be at reference temperature of 27°C, constant current discharge at 8 hours rate and end cell voltage of 1.85V / cell;
- Ampere hours of battery selected based on operating site temperature and discharge duty cycle based on minimum one (1) hour for full load as given in enclosed data sheet. Type of discharge duty cycle shall be based on the load cycle, duration and end cell voltage. An overall aging factor of 1.25 shall be considered while arriving at ampere hour capacity of battery;
- The numbers of cells and end cell voltage shall be decided on the basis of maximum permissible voltage to the load when batteries are float charged while feeding the load. The system output voltage at the end of design duty cycle shall not be less than 90% of nominal system voltage;
- On float, the cell / battery shall be suitable for being recharged to 90% of ampere hours removed within 24 hours and to 100% within 4 days;
- The component such as containers, lids, covers, and seals used in manufacturing shall meet the fire, flame, and smoke resistance rating as defined in ANSI / UL94 and have an oxygen index of at least 28 in accordance with ASTM D-2863;
- The design of valve regulated cell shall be such that regulating valve shall not allow gas (air) to enter into cell but shall allow the gas to escape from the cell above certain internal pressure which shall not lead to deformation or cause container to crack or cause failure of seals;
- The hydrogen released from valve regulated lead acid cells shall be sufficiently low to make these suitable for use in office, control rooms and equipment environment. The gas leakage rate of cell shall not exceed

0.05cm3 / hr at 27°C and101.3kpa;

- Valve regulated stationary lead acid cells shall be designed to withstand the mechanical stress encountered in normal transportation and handling;
- Flame arrestor shall be mounted on the cell so that all the vented gasses diffuse through the arrestor to the outside environment. The construction of arrestor shall be such that the hydrogen burning on the external surface of the arrestor shall not propagate back into the cell to cause explosion;
- The terminal post shall be of nickel plated steel. The terminal shall be suitable for discharge current and short circuit current without damage to cell as a result of terminal heating;
- The temperature of the valve regulated lead acid cells shall be sufficiently low to prevent thermal runway (critical condition arising due to constant voltage charging);
- Battery shall be supplied with all necessary accessories including but not limited to the following;

i. Mild steel stand pretreated and epoxy painted / PVC coated;
ii. Inter cell, inter row and interbank connectors and end take offs. These shall be of lead plated copper;
iii. Cell number plates, fixing pins, lugs for cable terminations as required;
iv. Other accessories and their quantity as per project data sheet.

- The following information shall be permanently marked on the cell;

a. Nominal voltage;
b. Name of the manufacturer / model reference;
c. Rated capacity in ampere hours(Ah) with end cell voltage;
d. Voltage for float operation of 27˚C with tolerance of $\pm$ 1%;
e. Month and year of manufacture.

7.4.2. CELL CONSTRUCTION

The plates shall be of first class material and workmanship and shall be free from blow holes, cracks and other imperfections. Flat type positive plate shall consist of a suitable bar with spines cast of suitable alloyed lead to give adequate mechanical strength;

The separators shall be impervious of the chemical action inside the cell and oxidation resistant;

The containers shall be made from hard rubber. They shall be sufficiently robust and free from flaws and flame retardant;

Electrolyte shall be gelled sulfuric acid of specific gravity varying from 1.160 to 1.180.

7.4.3. INSTALLATION OF BATTERY

The battery shall be mounted on Steel racks, supported by insulating posts in a battery room. It is proposed to lay the racks in row, single tier fashion. The racks supplied shall be so arranged as to present a neat and aesthetic appearance. The racks shall be robust in construction. As a safeguard against dislocation during earth-quake, the racks shall be rigidly supported and anchored. Each cell as well as its locations shall be numbered for proper record of maintenance operations. Suitably coated copper / lead connector shall be employed for inter cell, and inter row inter tier connectors. Tee off connections shall be made with acid resisting cables of suitable size. A suitable terminal box shall be provided. The connectors shall preferably be of bolted type and the bolts and nuts shall be of similar material as that of connectors and the same shall be provided with corrosion resistant coating. The battery

shall be connected to Battery Charger by copper cables. Suitable terminal arrangement with glands shall be provided for this purpose.

7.4.4. TESTS

Acceptance tests

Each cell and the complete battery shall be subjected to the following acceptance tests in accordance with relevant standards in presence of the Employer's representative / inspection agency, if so desired by the Employer. The date and place of testing shall be subjected to agreement between the Employer and supplier. All test reports shall be submitted and shall be got approved from the Employer before dispatch of equipment in case of tests to be carried out in manufacturer's works.

i. Test for capacities of individual cells and complete battery;

ii. Dimensional checking of plates;

iii. Visual inspection;

iv. Endurance Test.

The acceptance tests shall also be carried out at the discretion of the Employer on battery or each cell after installation at site.

Type test

The batteries shall have been type tested to meet the performance requirements for design and AH rating of cells as per IEC standard certified copies of the test reports for the following type tests shall be supplied for the approval of the Employer.

i. Test for retention of charge;

ii. Specific gravity of a charged cell;

iii. Test for gas emission;

iv. Test for cycling duty operation (discharge / charge cycle operation);

v. Test for short circuit current and internal resistance;

vi. Test for recharge efficiency and time;

vii. Test for fire resistance (oxygen Index, flammability).

Test for thermal runaway

The design integrity of the seals of valve regulated lead acid cells shall be tested for the following tests:

i. Thermal cycling test;

ii. Mechanical tests (vibration, Bump and free fall).

In addition to above, the batteries shall have been type tested for service life test on float duty as per ANSI T1 330.

Routine tests

Following routine tests shall be carried out as a minimum as part of acceptance tests for each AH rating of cell / battery.

i. Marking and packing;

ii. Verification of dimensions;

iii. Tests for voltages during discharge;

iv. Test for AH capacity;

v. Test for charge retention if specified in the data sheet.

Battery duty cycle test to meet the duty cycle shall also be performed at site after installation as part of commissioning by the battery manufacturer.

A discharge test at rated 8 hour current is to be repeated until 8 hour discharge is attained or exceeded and until cell voltages are equalized. (Minimum 2 discharges shall be carried out at the time of commissioning)

7.5. BATTERY CHARGERS

The battery chargers shall be of the Solid State (Silicon Controlled Rectifier or any better design) type designed for individual or parallel operation to charge the lead-acid tube battery. Under normal operating conditions, the chargers will cater to the normal equalizing and float charge requirements. In the case of complete discharge or when the battery drain is faster than the charging rate, the boost charger shall operate to charge the battery.

The trickle (float) and quick (boost) charging equipment shall preferably employ solid state full wave rectifier in a 3-phase full wave bridge circuit, suitable for operation in conjunction with 3 phase, 415 V, 50 Hz air cooled dry type transformer. A.C. and D.C. circuit breakers with thermal overload and instantaneous short circuit releases shall be provided on input and output sides of chargers respectively.

The trickle charger shall have a constant voltage characteristic throughout its ampere rating to keep the battery fully charged but without harmful over-charge. The charger shall be capable of providing the floating voltage between 2.15 V to 2.2 V per cell with the variation of not more than + 1% irrespective of input supply voltage fluctuations within + 10% throughout its ampere rating with ambient temperature of 50 °C.

The trickle charger unit shall be capable of supplying continuous D.C. load and trickle charge to the battery.

The trickle charger shall have `Auto' and 'Manual' modes for regulating D.C.

output voltage. In 'Auto' mode, the regulating system shall maintain constant D.C. voltage within ±1% of the set value with an A.C. Voltage variation of ±10% and frequency fluctuations of ±3%. It shall hold the voltage nearly flat from zero to full load but with definite drop at loads greater than full load so that such loads are transferred to the battery.
A changeover switch shall be provided to switch from 'Automatic' mode to 'Manual' mode of operation.

The boost charger shall have an arrangement for regulating D.C. output voltage manually. During quick charging, the battery shall be connected to the quick charger at a higher stage and a reduced number of cells shall be connected through blocking diode to the load for meeting any sudden load requirements. Connection of reduced number of cells to load through blocking diode shall be provided, so that voltage across the load shall not exceed 110% of rated value. The blocking diode shall be part of supply of the quick charger. The tendered may, however, offer an alternative arrangement which he considers equal or better.

The trickle and quick charging rates shall both be adjustable from the front of the charger panels. The chargers shall be stable in operation which shall be free from sustained oscillations over the entire operating range. Also, for any surge input alternating current/ voltage and for any sudden changes in charging rate within the entire operation range, the charger output shall not oscillate for more than 10 seconds.

The maximum temperature attained by any part of trickle and quick chargers when in service at site under continuous full load conditions shall not exceed the permissible limits fixed by relevant standards and as corrected to site conditions.

The trickle and quick charger units shall be complete with necessary voltmeters, ammeters, selector switches, necessary controls, indications, interlocks etc. as well as protection against short circuit and system voltage surges. The indicating meters shall be square type in size 96 Sqmm suitable for flush mounting.

Provision shall be made with necessary contacts/relays for centralized annunciation in the event of power failure to the charger and automatic shutdown of the charger by overcurrent devices. Annunciation shall be prevented when the charger is manually shut down.

The panels shall be of rigid, self-supporting structure, completely assembled totally enclosed cubicle type constructed out of structural steel members with not less than 2.5 mm thick sheet steel. The panels shall have hinged front and rear doors with concealed type hinges, locks and latches. The panels shall have adequate ventilation arrangement to avoid any undue rise in temperature. The panels shall have means for easy access to the maintenance of components. The panels shall be vermin proof.

Necessary terminals with lugs for earthing the panels with two distinct separate earthing for each panel shall be provided. In addition, separate terminals for earthing of equipment shall be provided.

The charger panels shall have space heaters suitable for 240 volts A.C., located suitably. Clamps type cable lugs shall be provided for connecting external power circuits. The control cables shall be terminated at a terminal block located inside the cubicle. All external cables to the charger panels shall be arranged for bottom entry and suitable glands and supports shall be provided.

7.5.1. Floating And Equalizing Voltage

The charger shall be designed to provide necessary floating voltage and equalizing voltage to the Battery as per the requirements of the type of Battery offered.

Each charger shall have two built-in controls, one for each voltage level, providing for a ±5% variation of these voltages above and below their rated value. the voltage range shall span at least a whole turn of potentiometer.

7.5.2. Output Current

The continuous output rating of each charger shall be such that it will cater to a continuous drain of 30 A DC. The charger shall be equipped with an adjustable device to limit the output from 60% to 100% of the maximum current. However, the rating given above is only indicative and the supplier shall choose and specify the correct rating for the charger to suit the battery proposed to be supplied.

7.5.3. Automatic Switching

The charging system shall be equipped with an automatic switching device to transfer from floating voltage to equalizing voltage under the following conditions:

When the voltage of the connected battery reaches the minimum value of 196V for a time longer than one (1) minute once in every thirty days.

The contractor shall recommend the duration of supplying equalizing charge and shall provide an adjustable timer to monitor the charging time. A pilot lamp to indicate equalizing charge condition shall be provided.

7.5.4. Manual Switching

The charger shall be equipped with facilities for switching from the floating to the equalizing voltage or vice versa. Manual switch shall have priority over automatic switching.

7.5.5. Output Voltage

The automatic voltage regulating equipment shall regulate the battery voltage within ±1% of the set value from no load at full load for plus 10% minus 20% variation of AC supply.

7.5.6. Supply Voltage

The charger shall be rated for operation on a 415 Volts 3 Phase, 50 cycles AC system.

7.5.7. Connections

All battery AC supply, load and alarm connections shall be brought out to solder

less clamp type terminals located near the bottom of the unit for connection to cables entering from top/bottom.

The terminals for the incoming and outgoing cables shall be suitable for connecting aluminum conductor cables.

7.5.8. Grounding

The charger shall be supplied with a grounding connector suitable for a 220 sq. mm (4/0 AWG) copper conductor.

7.6. TRANSFER AND METERING PANEL

These panels are required for maintenance purpose and shall provide protection and metering facilities for the 220 V DC system.

A metallic partition shall segregate control section from power section. Its depth shall be such, that the panel is free standing and its height identical to the height of the chargers.

7.7. CHARGING/DISTRIBUTION PANEL

220V Battery charger and DC distribution board shall be housed in separate panels and shall be mounted side by side. Panels shall be of same height and color finish. Each panel shall have panel light with a front mounted toggle switch.

The charger and DC board shall be fabricated with 2 mm thick sheet steel and structural steel. It shall be free standing with suitable louvers for ventilation and must be suitable for use in tropical climate. Hinged doors shall be provided at the front and back where required.

Inter panel sheet steel barriers shall be provided. The sheet steel used for fabrication shall be thoroughly cleaned and de-greased to remove mill scale, rust, grease and dirt. Fabricated structures shall be pickled in the acid and then rinsed to remove any trace of acid. The under surface shall be prepared by applying a coat of phosphate paint and a coat of zinc oxide/phosphate primer. The under surface shall be free from all imperfections before undertaking the finishing coat. It shall then be spray painted with two coats of stoving paint. Color chips of final paint shall be approved by Owner before painting is taken in hand. The finished panel shall be dried in stoving ovens in dust free atmosphere.

All instruments shall be switchboard type and back connected. Standard copper wires of 2.5 sq. mm minimum shall be used for secondary wiring. The insulation for all equipment provided shall be heat resistant, moisture proof and tropicalized. All fuses shall be provided inside the panel. All fuses shall be link type. Terminal blocks shall be "Elmex" type.

All potential free metallic parts shall be earthed with soft drawn copper conductor. The main earth connection shall be brought out to two terminals for connection to station earthing system.

All live parts shall be properly shrouded. This shall ensure complete safety to personnel intending routine maintenance by opening the panel doors. Busbars shall be color coded. All the equipment inside the panel shall have suitable name plates.

Distribution board shall comprise busbars and switch gear as specified on material requisition or as indicated on the single line diagram.

7.8. ALARM

The following alarm circuits shall be provided for each charger:

- One alarm circuit, indicating fault in the components.
- One alarm circuit indicating an AC supply failure for more than one minute.
- One alarm circuit indicating low voltage on the DC side for more than one minute.
- One alarm circuit indicating a high tension on the DC side for more than two minutes.
- Earth fault/battery leakage alarm.

This alarm shall be automatically disconnected when supplying the equalizing voltage.

Each alarm shall illuminate a separate lamp located in front of the cubicle. All alarms shall be grouped to operate a normally open contact which will be used for remote annunciation on the annunciation panel in the machine hall.

7.9. INSTRUMENTS AND ACCESSORIES

The following equipment shall be supplied with each charger:

1. Fully controlled rectifiers in a 3-phase full bridge circuit along with transient voltage suppressor and current limiter circuits etc.
2. Double wound impregnated, natural air cooled, 3 phase main transformer, with suitable no. of Taps.
3. Controller to stabilize the D.C. voltage within + 1% of the set value with an A.C. voltage variation of + 10% and frequency variation of + 3% and load varying between 0-110%.
4. Auto/Manual switch for selecting the mode of operation.
5. 0-250 volts range Bush type D.C. voltmeter suitable for panel mounting and 1.5% FSD accuracy.
6. One D.C. Ammeter to suit the charger output, flush type, suitable for panel mounting and + 1.5% FSD accuracy.
7. One D.C. Ammeter for measuring the trickle charging current of the battery, scale range 0-5 amp flush type, panel mounted and + 1.5% FSD accuracy.
8. A.C. failure alarm.
9. D.C. earth check arrangement.
10. Double pole moulded case D.C. contactor of suitable capacity for annunciation. 415 volts, triple pole A.C. contactor suitable capacity for annunciation for ON/OFF operation of the unit.

11. D.C, breaker and DC contactor of suitable capacity in output circuit of each charger to be closed/opened during neat charging/boost charging operation to suit the operation requirements.
12. Indicating lamps for A.C. mains to show 'ON' and 'OFF'
13. Compression type cable glands of suitable rating for PVC unarmored cable, suitably mounted in the panel for cable entry from the bottom for A.C. & D.C supplies.
14. Laminated name plates with engraved lettering identifying the cubicle and each of its instruments and controls.

7.10. MECHANICAL REQUIREMENTS

The battery charger set shall be assembled in a free-standing type of sheet metal cubicle completely wired for indoor installation. Access to internal equipment shall be through a hinged door equipped with latches. Louvers should be provided for ventilation as necessary. The ventilation openings shall be screened to prevent access to insects and other foreign material. The charger compartment shall be provided with a door operated light for internal illumination.

7.11. PAINTING

Painting shall include at least one coat of anticorrosive prime, one coat of finishing undercoat and two coats of grey shade as per relevant IS. The painting shall render the surface scratch resistant.

7.12. SHOP TESTS

The following tests shall be performed in the shop in addition to design tests or any other tests normally performed by the Contractor.

Functional Tests:

- Floating and equalization voltage regulation.
- Check of current limit.
- Check of parallel mode of operation by simulation of master charger failure.
- Operation of alarms.
- Measure of ripple voltage at zero and full load.

Dielectric Tests:

A DC voltage equal to 2 U + 1000 V where U represents the highest input or output voltage. The voltage shall be applied to the two interconnected output terminals.

An AC voltage equal to 500 V applied between the live parts of the low voltage circuits and the rack.

Commissioning Tests

All tests which shall be made preparatory to placing the equipment on the system for commercial operation are included in this group. They shall be carried out under the supervision of the Contractor's representative. All scheduling and actual testing will be done with the Engineer's approval.

Capacity and retaining charge tests shall be carried out at site as a commissioning test.

All tests which are required to verify the contract specifications and to prove the guarantee shall be done.

7.13. TYPE & ROUTINE TESTS

Each switchboard shall be assembled at the manufacturer's works with all apparatus, instruments and meters connected and various components shall be tested in accordance with the requirements of the latest relevant standards. Each circuit breaker shall be subjected to routine tests in accordance with the latest IS. The tests shall be performed in the presence of the purchaser's representative, if so desired by the purchaser.

The following routine tests shall be done:

1. Mechanical operation test
2. High voltage test.
3. Test for variation of calibration of releases.
4. Millivolt drop test.

Type test reports for proof of having tested the circuit breakers as per latest IS for the following type tests shall be furnished.

5. Temperature rise test for main circuits.
6. Temperature rise test for control circuit.
7. Temperature rise test for auxiliary circuits.
8. Verification of the rated short circuit making and breaking capacities.
9. Verification of the ability to carry rated short time current.

All test reports shall be submitted and approved by the purchaser before dispatch of the equipment.

7.14. DRAWINGS, DATA AND INSTRUCTION MANUALS

The Bidder shall furnish along with the tender the following technical information:

1. A sheet identifying the sources of the Amp Hour (AH) demand to justify the AH capacity of the Battery.

2. Descriptive data and literature describing each type of equipment offered.
3. Electrical schematic diagram showing connections and controls.

Within 90 days after the award of the contract, the Manufacturer shall supply the following technical information that will describe the equipment in detail for approval.

1. General arrangement of battery, as proposed, with size of individual cell and overall dimensions, along with sectional views, method of connection etc.
2. Drawing showing constructional features of the cell.
3. Characteristic curves of battery showing:
    i. Ampere-hour capacity for 1 minute to 10-hour discharge rates with reference to the rated 10 hour discharge rates.
    ii. Battery capacity - temperature curve for range of temperature between 0 deg C to 50 deg C for 1 minute, 1 hour and 10-hour discharge.
    iii. Battery terminal voltage drop with ampere-hour discharge.
4. General arrangement and layout of battery-charger and D.C. distribution boards with overall dimension, along with sectional views showing cable entry position etc
5. Characteristics and curves pertaining to battery charger.
6. Detailed schematic, connection and control wiring diagrams.
7. Complete outline and foundation drawings of all the equipment and general arrangement drawing showing terminals, cable entries, foundation details etc. with dimensions and bill of material.

After approval, 6 copies of all drawings and instruction manuals covering instructions for installation, operation and maintenance shall be supplied by the contractor.

7.15. SPARE PARTS AND SPECIAL TOOLS

The contractor shall separately indicate the price of spare parts and special recommended tools. Each item shall be clearly described.

All spare parts shall be identical electrically and mechanically to the corresponding parts of the equipment supplied and shall be suitably packed and clearly marked, ready for long-term indoor storage.

If dismantling of certain parts requires the use of special tools, Contractor shall supply them with the equipment. Each tool shall be described, and its unit price indicated in the Tender.

MANDATORY SPARES PARTS

Sr. No.	**Description**	**Qty.**
A. DC System		
1	Control Cards.	1 no. of each type

2	PCBs of each type used.	--do--
3	Discrete components like SCRs, diodes, capacitors, resistors, potentiometers etc.	--do--
4	Trip indicating fuses, fuses and fuse base (as applicable).	3 Nos. each
5	Power / auxiliary contactors, contactor coils and contact kit	1 no. of each type
6	MCCB auxiliary switch / contact.	--do--
7	Indicating lights.	--do--
8	Push buttons.	--do--
9	Toggle switches.	--do--
10	CT and Shunt.	--do--
11	Under voltage, over voltage, earth fault relay.	--do--
12	Motorized MCCB	1 no. of each type
B. UPS System		
13	Control Cards	1 no. of each type
14	PCBs of each type used	--do--
15	Discrete components like SCRs, diodes, capacitors, resistors, etc.	--do--
16	Trip indicating fuses, fuses & fuse base (as applicable)	3 Nos. each
17	Power / auxiliary contactors. Contactor coils and contact kit	1 no. of each type

18	MCCB auxiliary switch / contact	--do--
19	Indicating lights	--do--
20	Push buttons	--do--
21	Toggle switches	--do--
22	CT & Shunt	--do--
23	Undervoltage relay	--do--

If any additional spare parts required for trouble free operation are recommended by bidder, these shall be listed and the unit price shall be quoted in the price schedule. The Employer reserves the right to order any or all of such spares.

TOOLS AND INSTRUMENTS

The Supplier shall supply all necessary tools, devices, testing Instruments / equipment etc. for installation, repair and maintenance at site. These shall remain the property of the Supplier unless otherwise agreed to be taken over by Employer any / all of these at mutually agreed conditions.

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8. POWER & CONTROL CABLES AND CABLE TRAYS

8.1. POWER AND CONTROL CABLES

8.1.1. Scope

This section covers design, manufacturing, testing at manufacturer's works before dispatch, packing and transportation at site, erection, testing and commissioning, handing over to the purchaser of power cables, control and instrumentation cables, cable trays, support structures, complete with cable terminations, thimbles, cable glands and all accessories required for making the system complete and warranting a trouble free and safe operation.

The contractor shall perform all necessary work for the supply and installation of cables and accessories, as shown in the drawings or as required by the Purchaser and as specified below.

8.1.2. Supply

The following sizes are for tender purposes only. The Bidder is required to estimate the quantities based on the drawings attached with the specifications. The Purchaser reserves the right to vary the quantities by (±) 25% at Order/detailed engineering stage. However, Purchaser shall ensure finalization of quantities based on recommendations of the Contractor/ Supplier at the earliest so that the delivery schedule of Supplier is not adversely affected.

- FRLS PVC POWER CABLES
  1. 33 kV, Copper. Conductor, XLPE insulated FRLS cables.
  2. 11 kV, Copper. Conductor, XLPE insulated FRLS cables.
  3. 1.1 kV, Aluminium conductor XLPE Insulated FRLS type power cables.

  All power and control cables will be armoured type.
- FRLS PVC CONTROL & INSTRUMENTATION CABLES (ARMOURED & SCREENED)
  1. Electronic circuit cable:2C x 1.5 mm^2 annealed copper Screened cable.
  2. AC/DC Power supply cable: 2C x 6 mm^2annealed copper Stranded conductor.
  3. For CT circuits:4C x 4 mm^2 screened cable with stranded conductor (annealed copper).
  4. For PT circuits: 4C x 2.5 mm^2 screened cable

5. Other control cable: 4C, 7C and 12 C screened cable of 2.5 mm^2 with stranded copper conductor.

- Communication Cables - required size for suitable VHF system
- Cable trays, supporting structure, cable terminals, termination kit, cable lugs, cable glands, 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.
- All LT power cables shall be of stranded Aluminium conductor except DC power cables which shall be of stranded copper conductor. All control and instrumentation cables shall be of stranded copper conductor.

8.1.3. Standards

The cables shall comply with the latest issue of the following Standards:

Code	**Specification**
IS: 694:	Specification for PVC Insulated Cables for Working Voltages Up to and Including 1100 V
IS: 732:	Code of Practice for Electrical Wiring Installations
IS: 1255:	Code of Practice for Installation and Maintenance of Power Cables Up to and Including 33 kV Rating
IS: 1554 (Part I):	Specification for PVC Insulated (Heavy Duty) Electric Cables (for Working Voltages Up to and Including 1100 V)
IS: 3961 (Part II):	Recommended Current Ratings for Cables (PVC Insulated and PVC Sheathed Heavy Duty Cables)
IS: 3961 (Part V):	Recommended Current Ratings for Cables (PVC Insulated Light Duty Cables)
IS: 3975	Mild steel wires, strips and tapes for armouring of cables.
IS: 5831:	Specification for PVC Insulation and Sheath of Electric Cables
IS: 7098 (Part II):	Specification for Cross linked Polyethylene Insulated PVC Sheathed Cables (for Working Voltages from 3.3 kV up to and Including 33 kV)
IS: 8130:	Specification for Conductors for Insulated Electric Cables and Flexible Cords

IS: 9968 (Part II):	Specification for Elastomer Insulated Cables (for Working voltages from 3.3 kV up to and Including 11 kV)

8.1.4. General Construction

All cables shall be brand new and in good condition and of FRLS (Fire Retardant Low Smoke) type. These shall be suitable for laying in trays, trenches, ducts, conduits, and underground buried installation with uncontrolled backfill and possibility of flooding by water. The terminating and straight through joint kits for the cables shall be suitable for the type of cables offered and for storage without deterioration at 50 °C ambient temperatures. The cables shall be designed to withstand all electrical and mechanical stress under steady state and transient operating conditions.

LT power cables

The 415 V / 240 V AC and 220 V DC cables shall be required to interconnect the different auxiliary service boards/ station transformer/ DG set and connect various equipment to various distribution boards as required in Powerhouse complex and other area in vicinity of Powerhouse.

8.1.5. Control, Instrumentation, Coaxial and Communication Cables

These shall include all cables required for the installation of the complete instrumentation, control, protection and communication systems in the powerhouse, switchyard area. The Bidder shall indicate the quantity, size and core of cables included in the scope.

PVC Cables

1. All control cables shall be of copper suiting to following specification.
2. All control cables for use on low voltage systems shall be heavy duty type, 1100 V grade with copper conductor, PVC insulated, inner sheathed, unarmoured and overall PVC sheathed.
3. The construction of the conductors shall be stranded. Conductors of nominal area less than 25 sq. mm shall be circular only. All control cables shall be 2.5 sq mm except CTs connecting cable. CT control cable shall be of 4 sq mm and for PTs 2.5 sq mm. All CT's & PT's connecting cables shall be screened cables. All the cables shall pass fire resistance & FRLS tests as per IS: 1554 (Part-I)/ ASTMD-2863/ IEC 754 as specified.
4. The core insulation shall be with PVC compound applied over the conductor by extrusion and shall conform to the requirements of Type "A" compound of IS: 5831. Control cables having 6 core and above shall be identified with prominent and indelible core nos. on the outer surface of the insulation. Colour of the numbers shall be white with a spacing of maximum 500 mm between two consecutive numbers.
5. The inner sheath shall be applied over the laid-up cores by extrusion and shall be of PVC conforming to the requirements of Type STI PVC compound of IS: 5831.

6. The extruded inner sheath shall be of uniform thickness of size not less than 0.5 mm up to 16 sq. mm, 0.8 mm from 25 sq. mm up to 120 sq. mm. Above 120 sq.mm conductor size the thickness of sheath shall be as per relevant standard. Taped inner sheath is not acceptable.
7. The outer sheath for the cable shall be applied by extrusion and shall be PVC compound conforming to the requirements of type ST1 compound IS: 5831. To protect the cables against rodent and termite attack, suitable chemicals shall be added into the PVC compound of the outer sheath.
8. The dimension of the insulation and outer sheath materials shall be governed by values given is Section VI of IS: 1554 (Part I).

XLPE cables

1. Power cables for 11 kV /33 KV system shall be of copper conductor, XLPE insulated, sheathed, armoured and overall PVC sheathed as detailed below.
2. The construction of the conductors shall be stranded and compacted circular for all cables.
3. These cables shall be provided with both conductor screening and insulation screening. The conductors shall be provided with non-metallic extruded semi-conducting shielding.
4. The core insulation shall be with cross-linked polyethylene unfilled insulating compound. It shall be free from void and shall withstand all mechanical and thermal stresses under steady state and transient operating conditions.
5. The insulation shielding shall consist of non-metallic extruded semi-conducting compound in combination with a non-magnetic metallic screening of copper. The insulation screen shall be strippable without application of heat. The copper screen shall be capable of carrying the single line to ground fault current for duration of one (1) second.
6. The conductor screen XLPE insulation and insulation screen shall all be extruded in one operation by “Triple Extrusion” process to ensure perfect bonding between the layers. The core identification shall be coloured strips or by printed numerals.
7. The inner sheath shall be applied over the laid up cores by extrusion and shall conform to the requirements of type ST 2 compound of IS: 5831. The extruded inner sheath shall be of uniform thickness of size not less than 0.7 mm for all sizes of cables.
8. The outer sheath for the cables shall be supplied by extrusion over the armouring and shall be of PVC compound conforming to the requirements of Type ST 2 compound of IS: 5831. To protect cable against rodent and termite attack, suitable chemicals shall be added into the PVC compound of the outer sheath.
9. The dimensions of insulation, outer sheathing materials shall be governed by values given in Tables 1.2 and 4 of IS: 7098, Part II.

Cable Accessories

1. The termination and straight through joint kits for use on medium voltage system shall be suitable for the type of cables offered as per this specification. The termination and joints shall be supplied in kit form. The kit shall include all insulating and sealing materials apart from conductor fitting and consumable items. An installation instruction shall also be included in each kit. Kits shall be of reputed Make & shall be subject to the Purchaser's approval.
2. Terminating Kits

   The terminating kits shall be suitable for termination of the cable to an indoor switchgear or to a weatherproof cable box of an outdoor mounted transformer. The terminating kits shall preferably be one of the following types:

- "TAPEX" of M-SEAL make or equivalent using non-linear resistance material for stress grading,
- "PUSH-ON" type of CCI make or equivalent using factory moulded silicon rubber insulators,
- "TROPOTHEN-X" type of CCI make or equivalent.
- Heat – Shrink sleeve type of M/s Raychem or equivalent.

   For outdoor terminations, whether shields/sealing ends and any other accessories required shall also form part of the kit.

3. Jointing Kits

   The straight through jointing kits shall be suitable for underground buried installation with uncontrolled backfill and possibility of flooding by water. The jointing kits shall be one of the following types:

- "TAPEX" of M-seal make or equivalent,
- "TROPOTHEN-X" type of CCI make or equivalent,
- Heat shrinkable sleeve type of M/s Raychem or equivalent.

8.1.6. Testing and Inspection

The cables shall be tested and examined at the manufacturer's works. All the material employed in the manufacturing of the cable shall be subjected, both before and after manufacture of the cable to examination, testing and approval by the Purchaser. Manufacturer shall furnish all necessary information concerning the supply to Purchaser's inspectors. The inspector shall have free access to the manufacturer's works for the purpose of inspecting the process of manufacture in all its stages and he will have the power to reject any wire or other material which appears to him to be of unsuitable description or of unsatisfactory quality.

A) **PVC and XPLE Cables**

1. After completion of manufacture of cables and prior to dispatch, cables shall be subjected to type, routine, acceptance and special tests as detailed below. Purchaser reserves the right to witness all tests with sufficient advance notice from Bidder. The test reports for all cables shall be got approved from the Purchaser before dispatch of the cables.

2. All routine tests, acceptance tests, type tests as well shall be carried out on cables as listed in IS: 1554, Part I and IS: 7098, Part II.
3. The inner and outer sheath of XLPE cables shall be subjected to all the tests applicable for PVC cables. The test requirements for insulation and sheath of PVC cables shall be as per latest revision of IS: 5831.
4. In addition to above, the following special tests shall also be performed on the cables.

    a) Accelerated water absorption test for insulation as per NEMA-WE-3.11.

    b) Dielectric Retention Test: the dielectric strength of the cable insulation tested in accordance with C1.6.7.4 of NEMA WE-5 at 75 Degree shall not be less than 60% of the original dielectric strength.

    c) Oxygen Index Test: the test shall be carried out as per ASTMD 2863 – 1974 and the minimum oxygen index number should be 30.

    d) Test for Rodent and Termite Repulsion Property: the bidders shall furnish the test details to analyze the property to chemical method.

B) Cable Accessories

Type tests shall have to be carried out to prove the general qualities and design of a given type of termination/jointing system. The type test shall include the following tests conforming to the latest IEC 502-2, 466 and VDE 0278 specifications. The type test certificates shall be submitted along with the offer.

- AC Voltage withstand dry test for 1 minute,
- Partial discharge test – Discharge magnitude shall be less than 20%,
- Impulse voltage withstand test with 10 impulses of each polarity,
- AC high voltage test following load cycling test with conductor temperature at 90□C,
- Partial discharge test – Discharge magnitude shall be less than 20%,
- Thermal short circuit test at 250□C for 1 second,
- Impulse voltage withstand test with 10 impulses of each polarity,
- DC Voltage withstand test for 30 minutes,
- Humidity test,
- Dynamic short circuit test,
- Salt fog test,
- Impact test.

8.1.7. Contractor's Information

Contractor shall supply the following information for comments:

- Catalogue and brochure giving technical and physical details of the cable like current rating, derating factors, etc
- Type test certificates and special tests results for cables offered.

8.1.8. Installation

1. Contractor shall install cables and accessories in accordance with the requirements of this Specification and as required by the Purchaser.

2. Cable installation work comprises, without being limited to it, handling, transportation, storing, measuring, cutting, cleaning, furnishing and installing supports) placing, supplying and applying the appropriate pulling compounds pulling, supplying all materials to hold the cables fastening in the trays, installing these materials, supplying and installing cable protectors, supplying all identification materials identification and maintenance of test records. None of these works shall be paid for separately, and their prices shall be included in the price for the installation of cables tendered in the bid schedule.
3. Installation of cables and wire shall be done according to approved methods and as per cable schedule and special care shall be taken to avoid damage to insulation in any form including kinks or excessive tension which could damage the conductors when pulling cables. The maximum tension indicated by cable manufacturer shall not be exceeded at any time. Pulling of cables in the conduits shall be done using a compound specially designed for this purpose. Contractor shall replace at its own expense all cable damaged while pulling.
4. Protectors shall be used to protect the cables where they are pulled near sharp edges which could damage the insulation.
5. No cable connections shall be made in cable trays or conduits. Junctions boxes shall be used for all connections.
6. At the connecting points, the cables shall be identified by number corresponding to the cable list. This identification shall be done by means of fibre labels of a type approved by the Purchaser.
7. Cables shall be placed in order in cable trays and fixed by means of “Tie Wrap” or an equivalent cable strap in horizontal runs and clamps in vertical runs. When multi-conductors are unsheathed, the conductors shall be tied up together up to the connection points using “Tie Wrap” or an equivalent cable strap.
8. The cables shall extend sufficiently inside the connection boxes to compensate for the expansion effects without imposing stress in the boxes. Power supply cables to panels supplied and installed by Turbines, Generators and Auxiliaries Contractor (generator panel, data subsystems, battery chargers, etc.) shall have a 3 m length inside panels to allow connection by Electrical-Mechanical Contractor.
9. For connection of aluminium conductors:
    - Before cutting a cable to make a connection, it shall be tied up with wire, tape or other, on both sides of the cut to be made, to prevent deformation of the ends,
    - The Contractor shall use a steel brush to remove the layers of rust from the contact surfaces of the connectors and apply a coat of rust-inhibiting preparation,
    - This grease shall be allowed to penetrate between to strands as far as possible before the connection is made. Manufacturer’s instructions shall be followed,
    - Particular care shall be taken when terminating a cable inside connectors. The cable shall not extend beyond the connector. In no case shall connectors be tightened to the extent that they cause the cable to bulge,
    - Whenever a copper-aluminium connection is made, the contract surface of the copper shall be tin-plated in order to avoid electrolytic corrosion.

Every cable shall be checked with a 1000 V megger. The results shall be entered on an approved form and submitted to Purchaser before energizing. As required by the Purchaser and without additional charge, Contractor shall repair or replace cables with defective insulation.

The insulation of 33 and 11 kV cables and heat shrinkable termination shall be tested between each conductor and ground or between each conductor and all other conductors and ground, depending on the cable type. These tests shall be completed before cable connections are made. Unless otherwise specified, the cables are to be connected to equipment on terminal blocks or connectors supplied with the equipment. The proposed method of testing these cables shall be got approved beforehand.

8.1.9. Packing And Marking

Cable shall be dispatched in wooden drum of suitable barrel diameter, securely battened, with the take-off end fully protected against mechanical damage. The wood used for construction of the drum shall be properly seasoned, sound and free from defects. Wood preservatives shall be applied to the entire drum.

On flange of the drum necessary information such as manufacturer's name, type size voltage grade of cable, length of cable in metres, drum No., cable code, ISI Certification mark, gross weight etc. shall be printed. An arrow shall be printed on the drum with suitable instruction to show the direction of rotation of the drum.

Cables shall be supplied in drum lengths as follows:

Medium voltage power cables from 10 sq.mm upto and including 300 sq. mm- 500 M.

Medium voltage power cables up to and including 6 sq mm – 1000 M.

Control cables upto and including 27 cores - 1000 M

11 kV XLPE Cables - 500 M.

33 KV XLPE Cables – 250 M

8.1.10. Information Required with Tender

1. Catalogue and brochure giving technical and physical details of the cable like current rating, derating factors, etc.
2. 'Type Test' certificates and 'Special Test' results for cables offered.
3. Shelf life of cable accessories for the ambient temperature of 50-degree C.

8.2. ELECTRICAL CONNECTIONS

8.2.1. Scope

Contractor shall perform all necessary work for electrical connections, as required by the Purchaser and as specified below.

8.2.2. Description

Contractor shall make the connections of all the cables.

The cable electrical connections comprise mainly,

- The 33kV, 11 kV, 415 V, and 240 V AC power supply cables,
- The 220 V DC power supply cables,
- The AC control cables,
- The DC control and annunciation cables.
- Communication cable

8.2.3. Installation

Contractor shall connect the cables, in accordance with the requirements of this Specification and as required by the Purchaser.

Each connection includes workmanship and material necessary for terminating the end of a single or multi-conductor cable such as:

- The removal of the sheath and insulation from the cable and conductors,
- The supply and installation of lugs, when required,
- The supply and installation of heat shrinkable terminations for the 11 kV and 33 KV cables,
- The connection of conductors to terminal blocks, tests switches or other accessories,
- The connection of conductors to pigtails in small equipment, if required with compression connectors.
- The grouping and tying of conductors with straps, when required,
- The supply and installation of identification tags,
- The supply and installation of a cable identification tag,
- The identification of conductors,
- The earthing of the control cable shield or connection between them, when required,
- The seal-tight connectors for cables entering panels and/or cubicles, when required.

8.3. CABLE TRAYS, FITTINGS AND SUPPORTS

8.3.1. Scope

Contractor shall perform all work necessary for the supply and installation of cable trays, fittings, supports and accessories as required by the Purchaser and as specified below.

8.3.2. Supply

The technical specifications of the cable trays and fittings supplied and installed by Contractor are defined hereafter.

8.3.3. Standards

Unless otherwise specified, the cable trays and fittings shall comply with the latest issue of applicable Indian or British Standards.

8.3.4. Cable Trays

Cable trays shall be ladder/perforated type as specified complete with matching fittings (like brackets, elbows, bends, reducers, tees, crosses, etc.), accessories (like side coupler plates, etc.) and hardware (like bolts, nuts, washers, G.I. strap, hook etc.) as required. Cable tray shall be ladder type for power & control cables and perforated for instrumentation cables.

Cable trays, fittings and accessories shall be fabricated out of rolled mild steel sheets free from flaws such as laminations, rolling marks, pitting etc. These (including hardware) shall be hot dip galvanized after fabrication as per relevant IEC and IS standards. Cable trays shall have standard width of 300 mm, 600 mm & 750 mm and standard lengths of 3.0 meter. Minimum thickness of mild steel sheets used for fabrication of cable trays and fittings shall be 2 mm. The thickness of side coupler plates shall be minimum 3 mm. Ladder type trays shall have a rung spacing of 300 mm for power cable application and 150 mm for control and communication cables.

Cable troughs shall be required for branching out few cables from main cable route. These shall be U-shaped, fabricated of mild steel sheets of minimum thickness 2 mm and shall be hot dip galvanized after fabrication as per relevant standards. Troughs shall be standard width of 50 mm & 75 mm with depth of 25 mm.

Cable trays shall be designed and manufactured in accordance with the Indian regulations, the North American National Codes (CSA Standard C 22.1) or NEC ANSI/NFPA-70-1981 and NEMA standards Publication No. VE 1-1979. The trays shall be hot dip galvanized after fabrication in accordance with ASTM A 386.

The cable trays shall have the following design characteristics:

Width	**Design Support**	**Design Load**
300 mm	1.5 m	67 kg/m
600 mm	1.5 m	67 kg/m
750 mm	1.5 m	112 kg/m

The table above is based on tray sections of 3 meters long that are supported every 1.5 meters. Shorter sections result in requirement of more supports. Each section, no matter its length, must have at least one support.

All ladder and perforated tray bends, T's and crosses shall have a 600 mm inner radius.

Horizontal and vertical elbows and tees shall have an appropriate inside turning radius.

All the above elbows shall be factory performed to provide a single welded unit. Elbows made with short lengths of cable trays and flexible slotted straps shall not be accepted.

Adjustable horizontal elbows shall be provided only as indicated in the bill of material for angles of less than 10 degrees.

Adjustable vertical elbows shall be provided only as indicated in the bill of material for angles of less than 6 degrees.

Connectors shall be supplied complete with the necessary bolts, nuts and lock washers. Expansion joints shall provide for expansion of plus or minus 25 mm and shall not reduce the rigidity of the installation.

The barrier strips shall be made of sturdy aluminium 90 mm high and shall be provided complete with a strip clamp for every meter of length.

The Contractor shall provide embedded steel inserts on concrete floors/walls to secure supports by welding to these inserts on available building steel structure, for the purpose of casting in the control room/ switchyard etc.

The supports shall be fabricated from standard structural steel members. Suitable cable glands, thimbles, cable ferrules numbers & aluminium plates, cable racks etc. shall be provided.

ISMC-100 Channel will be provided at an interval of 750 mm wherever cables are to be supported without the use of cable trays, while at all other places these will be at an interval of 2000mm. In trenches ISMC-100 Channel shall be used vertically for providing support to different tiers of cable trays which shall rest on 50 x 50 x 5 mm MS angles. These MS angles shall be welded with the ISMC-100 Channel. For wall mounting, Insert plates with expansion bolts shall be used for providing support to different tiers of cable trays which shall rest on 50 x 50 x 5mm MS angles. These MS angles shall be welded with the Insert plates before fixing the same on the wall. The MS angles, ISMC Channel & Insert Plates shall be supplied after application of two coats of red oxide paint.

8.3.5. Cable supports & accessories

Cable tray support system shall be pre-fabricated galvanized steel U shaped channels and hardware similar or equivalent to «Unistrut» brand.

Support system for cable trays shall essentially comprise of the two components i.e. main support channel and cantilever arms. The cable tray support shall be designed to support twice the rated weight of the cable tray. As an example, a 600 mm tray with supports spaced 1500 mm can carry 200 kg (67kg × 3m); thus the support must be designed to support 400 kg. The main support channel shall be of two types: C1:- having provision of supporting cable trays on one side and

 C2: - having provision of supporting cable trays on both sides.

The support system shall be the type described hereunder.

a) Cable supporting steel work for cable racks/cables shall comprise of various channel sections, cantilever arms, various brackets, clamps, floor plates, all hardware such as lock washers, hexagon nuts, hexagon head bolt, support hooks, stud nuts, hexagon head screw, channel nut, channel spring nuts, fixing studs, etc.

b) The system shall be designed such that it allows easy assembly at site by using bolting. All cable supporting steel work, hardware fittings and accessories shall be prefabricated factory galvanized.

c) The main support and cantilever arms shall be fixed at site using necessary brackets, clamps, fittings, bolts, nuts and other hardware etc. to form various arrangements required to support the cable trays. Welding of the components shall not be allowed. However, welding of the bracket (to which the main support channel is bolted) to the overhead beams, structural steel, insert plates or reinforcement bars will be permitted. Any cutting or welding of the galvanized surface shall be brushed and red lead primer, oil primer & aluminum paint shall be applied.

d) All steel components, accessories, fittings and hardware shall be hot dip galvanized after completing welding, cutting, drilling and other machining operation

e) The main Support channel and cantilever arms shall be fabricated out of minimum 2.5mm thick rolled steel sheet conforming to IEC and IS.

f) Cantilever arms as required shall be provided. The arm portion shall be suitable for assembling the complete arm assembly on to component constructed of standard channel section. The back plate shall allow sufficient clearance for fixing bolt to be tightened with tray in position.

The size of structural steel members or thickness of sheet steel of main support channel and cantilever arms and other accessories as indicated above or in the enclosed drawings are indicative only. Nevertheless, the support system shall be designed by the Tenderer to fully meet the requirements of type tests as specified. In case the system fails in the tests, the components design modification shall be done by the Tenderer without any additional cost to the Employer. The tenderer shall submit the detailed typical drawings of the system offered by him along with the bid.

Cable trays shall be supported on MS angle support from the wall/roof of the powerhouse. Cables shall run on the cable trays in single tier/two tier/three tier formation. These MS angle supports are fixed to the wall/roof through anchor fastener. These supports shall be able to carry the load of cables carried on cable trays. The distance between two supports shall be 1.5 metre.

Cable terminals shall be provided with ferrule clearly indicating the wire numbers for proper connection. Cables entering into the electrical control panels shall be clamped with bolts at both sides. Copper strips are to be used where the cables are crimped.

8.3.6. Installation

Contractor shall install the cable trays and fittings in accordance with the requirements of this Specification and as required by the Purchaser.

Cable trays and fittings installation work comprise, without being limited to it, handling, transportation, storing, measuring, cutting, cleaning, installation of the system of tray supports, erection, aligning, fixing to the tray supports, the supply and installation of anchors, the supply of all identification materials, and identification. None of these works shall be paid for separately, and their prices shall be included in the price for the installation of the cable trays tendered in the bid schedule.

The cable trays shall be grounded to the Station earthing system. The expansion joints of the cable trays shall have flexible braid jumpers so as to maintain electrical continuity.

Control cables/ communication cables and power cables shall be placed in separate cable trays.

8.4. Spare Parts & Special Tools

The spare parts mentioned hereunder are meant for use by the Employer for 5 years trouble free operation & shall not be used as erection / commissioning spares required during installation. All the spare parts shall be interchangeable & shall be of the same material and workman ship as corresponding parts of the main equipment.

If any additional spare parts required for a 5 year trouble free operation period are recommended by contractor, these shall be listed and the unit price shall be quoted in the price schedule. The Employer reserves the right to order any or all of such spares.

All spare parts shall be protected against corrosion suitably packed and shall be marked with identification labels in the English Language. The identification shall be in accordance with the agreed Works Identification System.

All spare parts, tools and materials shall be delivered in marked boxes of sufficient sturdy construction to withstand long term storage. Material that is subjected to long term storage shall be stored in a dry, ventilated room with low humidity.

Acceptance of any spare parts will not take place before the Contractor has submitted the complete final list of all spare parts and tools. They shall be replaceable without cutting or destruction of adjacent components. Before issue of the Completion Certificate, the spare parts shall be checked at the Site by the Contractor in presence of the Engineer / Employer.

8.4.1. Mandatory spares

S. No	Item	Quantity
1	Spare cable lengths of each type and size of power cables used	10% as spare, for each size consolidated lengths upto 2000 metres and 5% spare for lengths beyond 2000 metres subject to minimum 200 metre spare length for cable sizes beyond 2000 metres
2	Termination kits for each type and size of cable	5% of the total scope of each accessory but not less than 2 pcs of each item

If any additional spare-parts required for trouble free operation are recommended by bidder, these shall be listed, and the unit price shall be quoted in the price schedule. The Employer reserves the right to order any or all such spares.

8.4.2. Tools and Instruments

The Supplier shall supply all necessary tools, devices, testing Instruments / equipment etc. for installation, repair, and maintenance at site. These shall remain the property of the Supplier unless otherwise agreed to be taken over by Employer any / all of these at mutually agreed conditions.

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9. ILLUMINATION

9.1. SCOPE

Contractor shall perform all necessary work for the design, supply, installation, and commissioning of the illumination system, as per relevant standards and as required by the Purchaser as per specification hereafter.

9.2. SPECIFICATION

The technical specifications of the lighting equipment to be supplied, installed and commissioned by Contractor are defined hereinafter.

9.3. DESCRIPTION

Contractor shall design, build, guarantee, deliver, perform the factory and commissioning tests, install the supplied Equipment and wire the following lighting equipment and carry out all activities relating to illumination etc.:

- Lighting fixture including lamps.
- Lighting poles including lamps.
- Lighting switches including the appropriate boxes and wall plates.
- Conduits, wires, connectors, junction boxes, distribution boards and any other item required to complete the work.
- The 240 V AC, 5A/15A receptacles (indoor and outdoor type) including the appropriate boxes and wall plates etc.

9.4. STANDARDS

The material equipment and its installation under the scope shall comply with all applicable provisions of the latest Indian standards and codes of practice. Some of the relevant standards are given below:

Code	**Particular**
IS: 3646	Code of practice for interior Illumination (Part I, II, III)
IS: 6665	Code of Practice for Industrial Lighting
IS: 732	Code of Practice for Electrical wiring installations
IS: 375	Marking & arrangements for switchgear, busbars etc.

IS: 9537	Conduits for Electric installations (Part I & IV)

The installation shall generally be carried out in conformity with the requirements of Indian Electricity Act 19I0 (latest Amendment) & Indian Electricity Rules.

9.5. ILLUMINATION LEVELS, FITTINGS & LAMPS

The Illumination Levels, type of fittings and lamps as proposed for each area shall be as below. The system shall be designed in accordance with these stipulations.

POWERHOUSE

Indoor Area	**Average Illumination (Lux)**	**Type of fitting**	**Lamps**
Machine Hall	200	High Bay Fixture	1X220/280/360W LED Lamps
Service bay	300	-------do----------	--------do-------
Outdoor area	100	Flood light Fixture	--------do-------
Control room	400	Recessed type decorative luminaire with heavy gauge steel housing, stove enamelled white opal acrylic diffuser, suitable for flush mounting with false ceiling	2x36W LED Light
Office	300	Trough type fluorescent luminaries with reflector for surface/pendant mounting	2x36W LED Tube Light
Workshop	300	Trough type fluorescent luminaries with reflector for surface/pendant mounting	2x36W LED Tube Light
Cable spread room	70	Trough type fluorescent luminaries with reflector for surface/pendant	1x36W LED Tube Light

		mounting	
Toilet	100	Universal mounting channels fluorescent luminaries	1x40W LED Tube Light
Battery Room	100	Corrosion proof luminaries, cast aluminium housing with specially designed vapour proof lamp holder	1x40W LED Tube Light

OUTDOOR AREAS

Outdoor Area	**Average Illumination (Lux)**	**Type of fitting**	**Lamps**
Switchyard	100	Anodized aluminium reflector stove enamelled white inside, with clear, heat resistant flat toughened glass duly gasket with IP 55 enclosure protection mounted on switchyard structure.	100 W LED Lamps
DC Emergency Lighting	50	Die cast aluminium housing painted white fitted with heat resistant glass dome and wire guard bulkhead luminaries.	40W Incandescent GLS lamp fittings:
Street Light	100	Pressure die cast LM6 Aluminium housing with polycarbonate cover with heat resistant silicon gasket, ingress protection of IP65.	100W/ 70W LED street light fittings

In addition to the above, bidder shall arrange suitable illumination for outdoor areas such as PH upstream, PH downstream, PH main gate, road leading to Switchyard, intake & Switchyard areas etc. The type of fixture for each location shall be approved by the owner during detailed engineering stage.

The Contractor, is required to design and submit the complete Illumination System indicating the quantity of fitting of each type as required, conduit/cable layouts, Location of Distribution /Sub distribution /Switchboard/ Power boards etc. For lighting design calculations, product of maintenance factor and coefficient of utilization shall be approximately 0.4. The design and layout of Illumination System shall be subject to review and comment of Purchaser during detailed design stage.

9.6. PROPOSED ELECTRICAL DISTRIBUTION SCHEME FOR ILLUMINATION

9.6.1. A.C. Distribution Scheme

The entire lighting network of the powerhouse shall be supplied from Main Lighting Distribution Board divided into two sections. Each section of the MLDB shall be fed from Station Service Board i.e., SSB via Lighting Transformers. MLDB shall cater the LVAC power distribution to various lighting panels, single phase power outlet sockets.

The MLDB shall be properly equipped with isolation (Lighting) Transformers to ensure system's control and electrical isolation. Main Lighting Distribution Board shall be indoor metal enclosed 415V, 50 Hz. The incoming feeders MCCBs shall be draw out type with thermal and short circuit releases.

Entire electrical network for plant illumination system comprises of:

- Normal lighting circuits fed by the power plant AC auxiliary services (main supply), illumination transformers, MLDB and finally to switchboards and luminaires.
- Emergency lighting circuits fed from 220VDC system for emergency illumination at strategic locations.
- Operation Principles
- Normal Lighting System

Normal lighting system shall include indoor and outdoor lighting of complete power house and areas as indicated above. The quantity and layout of switchboards shall be finalized as per the equipment installation during detailed engineering.

The lighting distribution scheme shall be so designed that adjacent fixtures in the Machine Hall and Service Bay are fed from different sources so that half the lighting can be turned off to conserve energy.

9.6.2. DC EMERGENCY DISTRIBUTION SYSTEM

DC emergency lighting fixtures operated on the DC system will be provided in the strategic locations so that the operating personnel can safely find their way even during emergency of a total AC failure. These lights will be normally 'ON' from AC supply from Emergency Lighting Distribution board and in case of AC power failure these lights will be on from 220V DC supply.

Emergency lighting distribution board will have two incomers, one from ac supply and the other from 220V DC Distribution board. In case of AC failure there will be automatic change over to DC supply so that lights fed from this board will remain continuously ON.

The emergency lighting shall consist of incandescent GLS lamps and emergency EXIT lights.

9.6.3. REMOTE EMERGENCY LIGHTING

This will be provided in isolated building / area where station DC supply is not available.

9.6.4. CONSTRUCTION DETAILS OF DIFFERENT BOARDS

1. All switch boards/boxes shall be of steel construction, fabricated of 16 SWG sheet with 6 mm thick bakelite.
2. Switch board/boxes located in office/building areas shall be flush mounted type.
3. Switch boards /boxes shall have provision for entry of conduits on all the sides. Adequate provision shall be made for ventilation of these boxes.
4. Flush type receptacles shall be provided.
5. Switches shall be of piano key type having quick make and quick-break mechanism complete with position indicator and shall conform to relevant Indian Standard.
6. All the components housed in the switchboard shall be wired to an outgoing terminal block by 2.5 sq.mm. stranded copper wire for lighting circuits and 4 mm2 Cu for power circuits (Receptacles). The terminal block shall be of adequate rating.
7. The exact number of switches and layout of the same in the switchboard shall be to suit the requirement during installation.

9.6.5. LIGHTING ACCESSORIES

All lighting fixtures and other accessories shall conform to the latest issue of relevant Indian Standards and code of practices. These shall be of reputed make and of proven design, suitable for use in Industrial application.

1. Illumination Fittings: All LED tubes, incandescent lamps, high bay LED lamps shall be rated for 230V A.C. Supply and shall be of reputed/approved make.

2. Lamp holders: Lamp holders for LED lamps shall be suitable to receive different types of lamps without getting displaced by severe vibrations.

3. Brackets & Supports: If required, brackets and supports shall be provided. These shall be hot dip galvanized after fabrication. The brackets shall be bolted or welded to the structure.

4. Light Switches: For individual/ Group control of light and fan circuits' Piano type ON/OFF Switches shall be installed on sheet, for speed control of fans, regulators shall be installed on the switchboard along with ON/OFF control through Piano type switch.

5. Power Sockets: Power Sockets shall be 230 V, 3 pin industrial type with MCB for control of the circuit fitted on 18-gauge Galvanized sheet steel Box with provision of conduit entry. Power outlet sockets may be single phase and three phase fixed wall mounted sockets to be provided in powerhouse all floors, control rooms, offices, facilities, utilities etc.

6. Junction Boxes: Junction Boxes made of galvanized sheet steel & provided with epoxy connectors shall be used to house the bends & extra length of wires.

7. Lighting Poles: The poles shall be complete with junction boxes for outdoor lighting to facilitate loop in loop out of the armoured cables. The lighting poles shall be suitable for mounting of streetlights and flood lights. The embedded portion of the poles shall be painted inside and outside with two coats of bituminous preservation paint. The exposed outside surface of pole (portion above ground) shall be coated with two coats of metal primer. Finally, poles shall be given two coats of Aluminium paint.

8. High mast Tower: The high mast shall be of continuously tapered, polygonal cross section presenting a good and pleasing appearance and shall be based on proven In Tension design conforming to the standards to give an assured performance and reliable service. The structure shall be suitable for wind loading as per IS875 Part-2. The mast shall be fabricated from special steel plates conforming to BS-EN10-027/DIN 17100 or equivalent, cut and folded to form a polygonal section shall be telescopically jointed and welded.

9.6.6. LIGHTING AND HEATING CIRCUIT WIRES

The wiring used for lighting shall be standard products of reputed manufacturers. The wires shall be of 1100 V grade, PVC insulated. The conductor sizes used for point wiring beyond lighting panel shall be single core, stranded, 2.5 sq mm and 4 sq mm, copper wire. 16 Gauge Copper Wire shall be used as Earthwire. The wires used for connection of a lighting fixture from a nearest junction box or for loop-in loop-out connection between two LED tube fixtures shall be single core copper stranded conductor, 1100 V grade flexible PVC insulated cords, unsheathed, conforming to IS: 694 with nominal conductor cross sectional areas of 2.5 sq. mm.

The wires shall be color coded as follows:

- Red for - R-Phase
- Yellow for - Y-Phase
- Blue for - B-Phase
- Black for - Neutral

Wiring shall be generally carried out by PVC wires in conduits. All wires in a conduit shall be drawn simultaneously. No subsequent drawings of wires are permissible.

Wires shall not be pulled through more than two equivalent 90 deg. bends in a single conduit run. Where required, suitable junction boxes shall be used.

Wiring shall be spliced only at junction boxes with approved type terminal strip.

For lighting fixtures, connection shall be teed off through suitable round conduit or junction box, so that the connection can be attended without taking down the fixture.

For vertical run of wires in conduit, wires shall be suitably supported by means of wooden/hard rubber plugs at each pull/junction box.

No joints shall be made at intermediate point in the run of cables, unless the length of final sub-circuit or sub main or main is more than the length of the standard cable coil.

Power & heating sub -circuit shall be kept separate and distinct from lighting sub circuits. All types of wiring whether concealed or unconcealed shall be capable of easy inspection.

9.6.7. MCCB

MCCB shall be hand operated, air brake, heavy duty, quick make, quick break type conforming to IS: 13947. The rating of MCCB shall be so chosen as to get complete protection under all normal/abnormal conditions such as full load, overload, short circuit etc. All fuses shall be plug in HRC cartridge link type. Fuses shall be provided with visible operation indicator to show that they have operated. All accessible live connections shall be adequately shrouded, and it shall be possible to change fuses with the circuit alive, without danger of contact with live metal.

9.6.8. MINIATURE CIRCUIT BREAKER (MCB)

The miniature circuit breakers shall be suitable for manual closing, opening, automatic tripping under overload and short circuit. The MCB shall also be trip free. Single pole as well as three pole versions shall be furnished as required in the Schedule of Lighting Panels. The MCB and panel incomer fuse together shall be rated for full fault level. The MCB shall be suitable for housing in the lighting panels and shall be suitable for connection with stranded copper wire connection at both the incoming and outgoing side by copper lugs or for bus bar connection on the incoming side. The terminals of the MCB, and the 'open' 'close' and trip' conditions shall be clearly and indelibly marked. The Contractor shall check and co-ordinate the ratings of MCB with respect to starting characteristics of discharge lamps. The Contractor has to furnish overload and short circuit curve of MCB. The MCB shall generally conform to IS: 8828.

9.6.9. CONDUITS & ACCESSORIES

Galvanized Rigid Steel conduits of following sizes shall be used.

a) 20 mm .

b) 25 mm

c) 32 mm

Conduits shall be supplied with fittings, expansion joints and all other accessories.

Conduits shall be handled, stored, transported, and installed in a manner to prevent any damage or contamination of their interior or exterior surfaces.

The Contractor shall propose his own method for installing any given conduit run, subject to the following.

- When a run has more than three (3) right-angle ends, pull-boxes shall be installed,
- Conduits shall be attached or supported every 2 m for 25 mm diameter conduits or smaller, and every 3m for sizes above 25 mm diameter.
- The bending radius shall be at least 9 times the conduit diameter, and the bending process shall not flatten the conduit by more than 0.1 times its diameter,
- Connections of rigid conduit to equipment shall be made with a watertight flexible conduit having a minimum length of 0.6 m and a maximum length of 1.0 m.

The conduits shall be cut, bent and their ends threaded and carefully reamed to present a smooth interior surface after assembly. Cuts shall be made at 90 degree to the axis of the conduit, and exposed surfaces of such cuts shall be protected with a zinc rich paint.

Conduits shall be installed following parallel axis to the building structural lines wherever possible.

The Contractor shall apply a coat of zinc rich paint in places where the galvanization has been damaged.

All joints and connections shall be made watertight with an appropriate coating. Moreover, they shall be assembled so as to provide electric continuity for each run.

9.6.10. TESTS

All equipment shall comply with the type & routine tests as prescribed in the relevant standards. The successful Contractor shall furnish certified test reports of all routine tests for review and comment by the Purchaser before the equipment is dispatched to site.

The Contractor in the presence of the Purchaser shall subject the installation to the following tests.

- Insulation resistance
- All other test specified in the Indian standards.
- Testing the effectiveness of all earthing connections.
- Complete operational tests on the whole of the installation.

- Details of all tests carried out at site shall be recorded & copies given to the Purchaser.

9.6.11. DRAWINGS

The following drawings shall be submitted by the Contractor for review and comment by Purchaser:

1. Key distribution Scheme for A.C. & D.C. illumination system.
2. Illumination calculations for arriving at the number of lighting fixtures for different areas & rooms.
3. Lighting fixtures layout drawings showing location of fittings, location of distribution, sub distribution & switchboards, conduit/cable routing etc.
4. Catalogues, leaflets and other details of Lighting fixtures, with data on reflection factors and room indices etc.
5. Scheme for earthling as applicable to Illumination system.
6. General arrangement drawing of boards & panels.

9.6.12. SPARE PARTS & SPECIAL TOOLS

The spare parts mentioned hereunder are meant for use by the Employer for 5-year trouble free operation & shall not be used as erection / commissioning spares required during installation. All the spare parts shall be interchangeable & shall be of the same material and workman ship as corresponding parts of the main equipment.

If any additional spare parts required for a 5-year trouble free operation period are recommended by contractor, these shall be listed and the unit price shall be quoted in the price schedule. The Employer reserves the right to order any or all of such spares.

All spare parts shall be protected against corrosion suitably packed and shall be marked with identification labels in the English Language. The identification shall be in accordance with the agreed Works Identification System.

All spare parts, tools and materials shall be delivered in marked boxes of sufficient sturdy construction to withstand long term storage. Material that is subjected to long term storage shall be stored in a dry, ventilated room with low humidity.

Acceptance of any spare parts will not take place before the Contractor has submitted the complete final list of all spare parts and tools. They shall be replaceable without cutting or destruction of adjacent components. Before issue of the Completion Certificate, the spare parts shall be checked at the Site by the Contractor in presence of the Engineer / Employer.

Mandatory Spares:

S.No	Description	Quantity
1.	Lighting Boards / Panels	

a.	Each rating of isolator	2 Nos.
b.	Each rating of HRC fuse	Minimum 3 (10% of quantity used).
c.	Each rating of MCB and MCCB	Minimum 6 (10% of quantity used).
d.	Each rating of contactor	1 Nos.
e.	Each rating of push button	1 Nos.
f.	Synchronous Timers	1 No
2.	Lighting Fixtures	
a.	Each type of fixtures complete with accessories without lamps	10% of total quantity with minimum 1 of each type.
b.	Lamps	20 % of each type and rating with minimum of one of each type and ratings.
3.	Receptacles	
a.	Each type of receptacle	10% of total quantity
b.	Junction boxes (each type)	5 % of total quantity
c.	Trunking / conduits	2 % of total quantity of each type / size

If any additional spare-parts required for trouble free operation are recommended by bidder, these shall be listed, and the unit price shall be quoted in the price schedule. The Employer reserves the right to order any or all of such spares.

Tools and Instruments

The Supplier shall supply all necessary tools, devices, testing Instruments / equipment etc. for installation, repair and maintenance at site. These shall remain the property of the Supplier unless otherwise agreed to be taken over by Employer any / all of these at mutually agreed conditions.

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10. EARTHING SYSTEM

10.1. SCOPE

Scope of work under this section covers the provision of labour, tools, plants, materials and performance of work necessary for the design, manufacture, quality assurance, quality control, shop assembly, shop testing, delivery at site, site storage and preservation, installation, commissioning, performance testing, acceptance testing, training of Employer's personnel, handing over to Employer of the complete Earthing system for power house, tailrace, Switchyard and remote sites (Intake& Colony) as per the specifications hereunder, each complete with all auxiliaries, accessories, spare parts and warranting a trouble free safe operation of the installation. The design is to start with measuring of earth resistance at suitable places where mat is to be laid. It shall also include the lightning protection of Power House building. In switchyard, the lightning protection shall be achieved by use of lightning mast and overhead ground wires, the quantities for lightning protection of Power House building & switchyard shall be estimated and included by contractor.

The scope of work shall be a comprehensive functional system complete in every respect including but not limited to as defined hereafter.

10.2. SUPPLY AND INSTALLATION

The intent of scope is to supply, install and supervise complete earthing system for power house, transformer area, Switchyard, adjoining functional areas and remote sites (Intake & Colony). The erection of earthing system shall have to be done with respect to the actual progress of work by civil contractors and slippage on this account shall not be acceptable. The Switchyard earth grid, power house and tailrace earth grid shall be interconnected to achieve a low value of earth resistance.

The underground earthing network and near surface earth grid shall consist of underground earth mat in power house, transformer area, tailrace, Switchyard, adjoining functional areas and Remote sites (Intake & Colony). The purpose of this earthing network is to lower the overall grid resistance to a value of 0.5 Ω. The network shall consist of suitably spaced meshed grid embedded in ground. The technical specifications of the earthing equipment supplied and installed by Contractor are defined hereafter.

10.3. DESCRIPTION

The work includes all the buried and surface work.

The description of earthing equipment supplied and installed by Contractor, mainly include the following articles:

- Earth conductors shall be mild steel rods of minimum diameter 32 mm for embedded earthing system.
- Risers shall be galvanized MS flats of minimum size 50x6 mm.
- Earth rod (Electrodes) shall be mild steel, minimum 3 metres long having a minimum diameter of 40 mm and buried in the ground with bentonite treatment.
- Extension of earthing mat shall be by 32 mm MS rods at power house, transformer area, tailrace and switchyard area,
- Connectors for strip to cable tray, strip to strip, strip to plate, strip to pipe,
- Lugs
- Hardware such as bolts, nuts and lock-washers
- The welded and bolted joints.

The material to be supplied shall be new and of first quality.

10.4. STANDARDS

The grounding system shall conform to the requirement of following standards:

Code	**Particular**
IEEE: 80	Guide for safety in AC Substation Grounding
CBI&P Publication. 223	Design of Earthing Mat for High Voltage substation
IS: 3043	Code of Practice for Earthing Indian Electricity Rules

10.5. DESIGN OF EARTHING SYSTEM

Neutral points of the systems of different voltages, metallic enclosures and frame works associated with electric system shall be connected to a double earthing system unless stipulated otherwise.

Earthing and lightning protection system installation shall be in strict accordance with the latest editions of Indian Electricity Rules, relevant Indian Standards and Codes of practice and Regulations existing in the locality where the system is installed.

A number of ground rods (40 mm diameter - 3000 mm long) shall be added to the earth mat to obtain consistently lower resistance under all weather conditions.

All non-current carrying metal parts of electrical equipment and apparatus shall be earthed through two separate diametrically/diagonally opposite connectors.

The apparatus shall include:

1. The neutral point of each system through its own independent earth
2. Equipment framework and other non-current carrying parts
3. All extraneous metallic framework not associated with equipment
4. The earth point of lightning arrestors, voltage transformers, and lightning conductors through their permanent independent earth electrodes
5. Fence of switchyard at the spacing of every 3 meter of switchyard boundary.
6. Shielding of cables and electrical wiring conduits
7. Metallic structures of switch gear, cable racks, casing of cable boxes
8. Switchyard and equipment structures

The fault current value of 40KA shall be considered for sizing of conductors for main grid and risers. The conductor shall be of adequate cross-section to safely withstand the system fault current 40KA for three seconds of fault clearance by the remotest/back up protective system Also sufficient allowance need 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.

The Contractor will submit full detailed calculation for fault level and earth mat design including the layout for all underground mat works & over ground earthing network to the Employer for their approval.

The bidder shall have to measure the resistivity on his own and design the earthing system subsequent to the Purchaser's approval.

10.6. SIZE OF THE CONDUCTOR

The size of the steel conductor for earth mat shall be based on thermal stability and ground resistance and it is proposed to use standards MS Steel rod for construction of Earthing Mat.

10.7. LAYOUT OF THE EARTHING MAT

The earth mat shall be laid on the excavated surface of power house. Separate earth pit shall be provided for neutral earthing.

The switchyard mat shall be designed to obtain safe touch/mesh and step potentials as applicable for a man of 70 kg bodyweight. Considering requirements of risers, laying of the mat over an uneven area due to excavation profile, and also to account for wastage actual requirement of the conductor over the calculated length shall be nearly 25 % extra.

The contractor shall make a detailed design of the earth mat based on soil resistivity recorded at various places of the power station and switchyard area, which shall also be within the scope of the Contractor, so as to ensure the availability of safe touch/mesh potential, safe Step potential & low ground mat resistance less than 0.5 Ohm.

Wherever earthing conductor crosses cable trenches, underground service ducts, pipes, tunnels, railway tracks etc, it shall be laid minimum 300 mm below them and shall be re-routed in case it fouls with equipment/structure foundations.

Tap-connections from the earthing grid to the equipment structure to be earthed shall be terminated on the earthing terminals of the equipment/structure as per relevant standards/practice if equipment is available at the time of laying the grid. Otherwise, "earth riser" shall be provided near the equipment foundation/pedestal for future connections to the equipment earthing terminals.

Earthing conductors or leads along their run on cable trench ladder columns, beams, walls etc. shall be supported by suitable welding/cleating at intervals of 750 mm. Wherever it passes through walls, floors etc, galvanized iron sleeves shall be provided for the passage of the conductor and both ends of the sleeve shall be sealed to prevent the passage of water through the sleeves.

In outdoor areas, tap connections shall be brought 300 mm above ground level for making connections in future in case equipment is not available at the time of grid installation.

Earthing conductors crossing the road shall be laid 300 mm below road or at greater depth to suit the site conditions.

Earthing conductors embedded in the concrete shall have approximately 50 mm concrete cover.

After placing the earth mat conductors, the trenches and electrode pits shall be back filled with bentonite clay.

10.8. EQUIPMENT AND STRUCTURE EARTHING

Earthing pads shall be provided for the apparatus/equipment at accessible position. The connection between earthing pads and the earthing grid shall be made by two short earthing leads (one direct and another through the support structure) free from kinks and splices. In case earthing pads are not provided on the item to be earthed, same shall be provided in consultation with Purchaser.

Dedicated earth pits along with earth electrodes shall be provided for electronic equipment earthing. The connection between electronic earth point in the panel to the earth pit shall be with insulated cable.

Steel/RCC columns, metallic stairs etc. shall be connected to the nearby earthing grid conductor by two earthing leads. Electrical continuity shall be ensured by bonding different sections of handrails and metallic stairs.

Metallic pipes, conduits and cable tray sections for cable installation shall be bonded to ensure electrical continuity and connected to earthing conductors at regular interval. Apart from intermediate connections, beginning points shall also be connected to earthing system. Metallic conduits shall not be used as earth continuity conductor.

A separate earthing conductor shall be provided for earthing lighting fixtures, receptacles, switches, junction boxes, lighting conduit etc. Wherever earthing conductor crosses or runs along metallic structures such as gas, water, steam, conduits, etc. and steel reinforcement in concrete it shall be bonded to the same.

Light poles, junction boxes on the poles, cable and cable boxes/glands, lockout switches etc. shall be connected to the earthing conductor running along with the supply cable which in turn shall be connected to earthing grid conductor at a minimum two points whether specifically shown or not.

Rail tracks within switchyard area shall be earthed at a spacing of 30 m and also at both ends. All the gates and every alternate post of the fence shall be connected to earthing grid. Flexible earthing connectors shall be provided for moving parts.

All lighting panels, junction boxes, control cabinets, Bay Marshalling kiosks etc. shall be grounded in compliance with the provision of Indian Electricity Rules.

50mmx6mm GS flat shall run on the top tier and all along the cable trenches and the same shall be welded to each of the racks. Further this flat shall be earthed at both ends and at an interval of 30 metres.

Each penstock shall be considered to be an auxiliary mat and shall be connected to the main Mat so as to effectively reduce the grid resistance. Two flats in parallel on either side of penstock shall connect each penstock with the main earth mat.

10.9. JOINTING

Earthing connections with equipment earthing pads shall be bolted type. Contact surfaces shall be free from scale, paint, enamel, grease, rust or dirt. Two bolts shall be provided for making each connection. Equipment bolted connections, after being checked and tested, shall be painted with anticorrosive paint/compound.

Connection between risers and main earthing conductors of the grid shall be welded type. For rust protections, the welds should be treated with red lead and afterwards coated with two layers bitumen compound to prevent corrosion.

The M.S. rods shall be welded to the earth mat at all peripheral joints, at and around riser junctions and other strategic locations for equipment connections.

Steel to copper connections shall be brazed type and shall be treated to prevent moisture ingression. For protection against rusting, the welds shall be treated with Barium Welded surface shall then be painted with red lead and Aluminium paint and afterwards coated with bituminous paint. If joints are not brazed, bimetallic washers must be used as separators at all joints of dissimilar metals to prevent electrochemical corrosion of the joint.

For end connections of Earthing of indoor LT Panels, Control panels, outdoor Junction Boxes, Control Cabinets, Lighting Panels, Motors etc. with G.S. flat, Copper Braided Wire along with copper lugs as per IS: 2121 at both ends shall be used.

Resistance of the joint shall not be more than the resistance of the equivalent length of the conductor.

All ground connections shall be made by electric arc welding. All welded joints shall be allowed to cool down gradually to atmospheric temperature before putting any load on it. Artificial cooling shall not be allowed.

Bending of earthing rod shall be done preferably by gas heating. All arc welding with large dia. conductors shall be done with low hydrogen content electrodes.

The 50 x 6mm GS flat shall be clamped with the equipment support structures at 1000mm interval.

10.10. SPECIFIC REQUIREMENT FOR EARTHING SYSTEMS

Each earthing lead from the neutral of the power transformer shall be directly connected to two pipe electrodes in treated earth pit separately (as per IS) which in turn, shall be buried in Cement Concrete pit with a cast iron cover hinged to a cast iron frame to have access to the joints. All accessories associated with transformer like cooling banks, radiators etc. shall be connected to the earthing grid at minimum two points.

Earthing terminal of each lightning arrester & capacitor voltage transformer shall be directly connected to rod earth electrode, which in turn, shall be connected to station earthing grid.

There shall be separate earthing pit for electronic item away from earth grid and connection to main equipment shall be by cable.

Auxiliary earthing mat comprising of closely spaced (300mmx300mm) conductors may be provided at depth of 300mm from ground level if the design of earth mat so requires.

10.11. EARTHMAT RESISTANCE

The earth mat shall be so designed & constructed with MS rods that with the measured soil resistivity at powerhouse site, the mat resistance is less than 0.5 Ohm. Measurement of the earth mat resistance of the powerhouse mat and the switchyard mat after these have been laid shall be a part of the bid. Also, the potential rise of the mat during passage of fault current shall remain within the tolerable limits. To limit the potential rise within safe limits, with the object of reducing the effective resistance, the main mat may be connected to each penstock, which can be considered as separate mat for this purpose. Also, to maintain the earth mat resistance of powerhouse within safe limits, the later may be extended to the switchyard mat to obtain composite resistance of both the mats within permissible limits. All interconnections shall be with MS rods only.

10.12. DRAWING & DATA TO BE FURNISHED BY THE BIDDER

The following drawings & data shall be submitted by the Bidder along with the bid

1. A general arrangement drawing indicating the layout, size and any notable features of the proposed earthing grid.

Within 90 days of the award of contract, the Manufacturer shall submit to the Engineer/Purchaser, for review and approval, 6 copies of the following drawings:

1. Calculations for Conductor Size
2. Calculations for conductor length and no. of Rods
3. Calculations for determination of Earth mat Resistance
4. Calculations for safe and calculated values of touch &step potentials.
5. Calculations for safe & calculated values of ground potential rise touch & step potentials.
6. Drawing for earth mat showing disposition of the mat along-with proposed gird arrangement, of conductor with ground rods, welding arrangement of risers with the mat etc. location of terminals for measurement of mat resistance, details of junction boxes etc.
7. Any special measures proposed by the tenderer to limit the potential rise within the safe values.

10.13. INSTALLATION

Contractor shall install the earthing equipment in accordance with the requirements of this Specification and as required by the Engineer.

All surface to receive earthing connections shall be cleaned. Painted or varnished surfaces shall be cleaned to bare metal in order to ensure a good electric contact.

All connections shall be made as shown on the drawings. The types considered in this contract are generally as follows:

- Bolted connection to the earthing mild steel rods,
- Bolted connection by lug to certain equipment.

Equipment supplied by the Contractor shall include earthing lugs. Contractor shall also supply earthing lugs for motors supplied by him.

The end of an embedded conduit not connected to equipment shall be connected by the Contractor to the earthing grid at one point.

All conduits terminated close to a cable tray or any other equipment shall be earthed by means of an earthing ring or bushing and by a mild steel strips.

The installation of earthing material covered in this section includes, without being limited to, earthing of motors, switchgears, lighting and distribution panels, lighting poles, control panels, cubicles, DC equipment, transformers, disconnect switches, air handling units, heaters and steel plates supporting electrical equipment.

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11. EMERGENCY DIESEL GENERATOR SET

11.1. SCOPE

This specification covers the design, manufacturing, testing at manufacturer's work, supply, loading at manufacturer's work, transportation, delivery at site, storage, insurance, erection & commissioning of One (1) number of sound attenuated 250 kVA DG set with AMF panel along with required accessories, mandatory spares for 5 years of operation of the HEP. All the required accessories, documents and equipment whether specified here in or not but required for successful commissioning and operation of the equipment is in the bidder's scope.

The bidder shall make his own assessment of the rating of the DG set keeping in view of the essential loads.

11.2. STANDARDS

The design & manufacture of DG set with AMF panel and its accessories shall conform to the provisions of the latest applicable IS /ISO/BS codes.

11.3. DESCRIPTION

The DG set shall be used for the following loads inclusive of black start condition for one unit during its service life:

1. Emergency Lighting loads
2. Battery & Battery charger system
3. Lubrication system (if any)
4. Compressed Air system
5. Cooling water system
6. Brake dust collection system
7. Fire protection system
8. Field flashing

The DG set engine shall be preferably of Cummins make having a four stroke cycle, multi cylinder, turbo charged after cooled and comprising of the systems as described in the following clauses.

The rated output of the unit fitted with all its auxiliaries is defined as the continuous output available at the generator terminals when the diesel engine is operated at nominal speed at the specified ambient conditions while using the specified fuel.

The Contractor shall specify the method used to determine the force of the engine and shall give the engine power curves.

The DG set Lubrication system shall be provided with the following:

1. Lubricating oil pump
2. Lubricating oil priming pump
3. Lubricating oil filter
4. Bypass filter

The lubrication system shall also include a pressure regulator, an oil cooler, and adequate ventilating system with accessible oil gauge to check the crankcase level, whether engine is running or stopped.

Oil filters with easily accessible and replaceable cartridges shall be provided.

Oil filters and cooler shall be automatically by-passed, should they become clogged.

This lubrication system shall be equipped with easy to reach devices to fill and to drain completely the lubricating oil.

The first filling of lubricating oil for the diesel engine shall be the Contractor's responsibility.

The DG set **Fuel injection system** shall be provided with the following:

1. Fuel pump
2. Fuel Injectors
3. Fuel Filter
4. Fuel Hoses
5. Day tank for fuel of capacity sufficient to house fuel required for 8 hours of continuous running of DG set at 100% load.

The injection system shall be individual interchangeable pumps with replaceable, calibration free, nozzles.

The transfer pump, operating through the fuel filter, shall be sufficiently powerful to pump the fuel over a height of 1.2 meters.

The equipment shall include the necessary valves to empty or purge the injection system whenever air or water has entered the pipes.

The fuel system shall have replaceable and easily accessible primary and secondary filters.

An automatic bypass to return the excess shall be provided.

All the piping required to be done to connect the fuel tank & the engine shall be in the scope of the supply & erection of contractor/supplier of DG set.

The DG set **Governor** shall be mechanical type and should be complete with all required controls.

The DG set **coupling system** shall be such that the engine is directly coupled to the Alternator through a flexible/ rigid coupling complete with all accessories.

The DG set **Starting system** shall comprise the following:

1. Electrical starter motor 12V DC

2. Battery and leads: The diesel engine shall have an electric starter operating at 12 V DC. The battery shall be of the lead-acid type, designed for rugged service of reputed make, and shall have sufficient capacity to crank the motor three times for ten seconds every time at intervals of ten seconds. A stand made of galvanized steel and connecting cables of sufficient length shall be supplied.
3. Battery Charging alternator: The storage battery shall come with a two-rate automatic battery charger at a voltage of 12 V DC. The battery charger shall have a low voltage and loss of AC supply contact. These alarms shall be transmitted to the control panel.
   The length of the equalizing charge shall be adjustable from 1 to 5 hours and shall be set for 2 hours. A pilot light shall be on when the charger is operating at the equalizing voltage. The charger will be fed from a source of 240 V, single phase, 50 Hz and shall have input and output protection. The battery charger shall consist of rate selector switch OFF/Trickle/Boost.

The DG set Air intake system shall comprise the following:

1. Air Intake Manifold
2. Air cleaners

One or more heavy duty, high efficiency, dry type air filters with easy to replace cartridges shall be provided.

The DG set Exhaust system shall comprise the following:

1. Exhaust gas turbocharger
2. Exhaust Manifold
3. Residential type Silencer
4. Flexible pipe for silencers
5. Exhaust piping

The exhaust piping shall be of class “B” MS pipes which shall be let out at height 2m above the terrace level or as statutorily required and including pipe supports, bends, flexible joints, insulation with at least 50mm thick layer of rock wool (of density at least 96kg/m3) clad with 26SWG aluminium sheet cladding etc.

The D.G. set Cooling system shall involve the radiator type cooling and shall comprise of the following:

1. Corrosion inhibitor
2. Bypass thermostat

The cooling system shall be able to cool the engine with an ambient temperature of 50 degree C and a 10% overload. The radiator shall be designed to handle the cooling load of the aftercooler in addition to the above requirements. The engine cooling shall be affected by an air-cooled radiator and a gear driven coolant pump. Fan shall be fabricated and tested in accordance with the AMCA and shall bear its certification seal. Fan wheel shall be dynamically and statically balanced. The diesel motor shaft shall drive fan motor with a belt drive. The belt drive system shall be protected with a removable guard including openings facing shaft to permit speed measurements. The cooling system shall be provided with devices to fill and to drain completely the coolant.

Cooling system should be equipped with antifreeze arrangement and will operate when temperature goes below '0' centigrade.

The D.G. set Engine safety controls should have at least the following:

1. Low lub oil pressure
2. High water/coolant temperature
3. Over speed

The D.G. set Engine instrument panel shall comprise of at least the following:

1. Starting switch and key
2. Indication for battery voltage, water/coolant temperature, lub oil pressure, Lub oil temperature, Engine speed (tachometer), and Engine hour meter.
3. Emergency shutdown button

The DG set Generator shall be of Stanford make suitable for continuous operation with the Diesel engine at 415V, 0.85 pf (lag) suitable for 3 phases, 4 wire system. The alternator shall be brush less, type screen protected, revolving field with damper windings, self-excited through an AVR & single bearing type.

The Contractor shall provide the torsional analysis of the system. The generator shaft shall have a connecting clamp for coupling to the diesel motor by means of high tensile bolts. Welded steel sheets shall shield the stator frame. All parts of the generator shall be designed to withstand all electrical and mechanical stresses which may be experienced during normal operation, including cases of short-circuits, faulty synchronization and over-speed conditions. The alternator should also have the following features:

1. ±1.5% Voltage regulation (max.) in static conditions.
2. IP:23 protection with insulation class F/H.
3. Permissible overload of 10% for one hour in 12hrs. duration.

Alternator should also be suitable for operation in the abovementioned conditions & shall conform to the requirements of BS: 2613/IS: 4722.

The alternator supplied shall be fitted with the space heaters of suitable rating to keep the moisture out.

The D.G. set **Mounting arrangement** shall be as per the following description:

The engine & alternator shall be mounted on a common MS fabricated rigid base frame with anti vibration mounting pads to provide at least 98% vibration isolation. The base frame shall be of skid type design and of such construction that the assembly can be skidded without danger of disturbing the alignment.

The D.G. set **AMF control panel** shall be relay based and made of 14 gauge CRCA sheet and powder coated for a weatherproof, long last finish. Microprocessor based relay of reputed Make shall be provided. The control logic shall be PLC based and shall be such that in case of station supply fails, the DG shall start automatically. In view of this, interlock shall be provided between station Transformer and DG set. The control panel shall comprise of at least the following:

1. 2Nos. 415/500V,200A, TP, Power contactor with thermal overload relay one each for main & DG supply duly interlock
2. 2Nos. 415/500V, 40A, TP, Power Contactor for neutral
3. 1 No. LCD display digital AC voltmeter, 0-500V
4. 1 No. Voltmeter selector switch OFF/RY/YB/BR with HRC fuse
5. 1 No. Voltmeter selector switch OFF/ALT/MAINS/LOAD
6. 1 No. LCD display digital AC Ammeter, 0-200A for load
7. 1 No. Ammeter selector switch OFF/R/Y/B for LOAD
8. 1 set of under voltage relay
9. 1 set of over voltage relay
10. 1 set of under frequency relay
11. 1 set of over frequency relay
12. 1 set of reverse power and reactive power relay
13. 1 set of DC control relays incorporating engine Start/Stop, three attempts starting facility and failure to start lockout.
14. One set of relays for automatic closing & opening of mains and alternator power contactors as required.
15. 1 no. of frequency meter for LOAD
16. 1 no. of kWh meter.
17. 1 no. of power factor meter
18. 1 selector switch for Manual/Automatic/ test mode.
19. 1No. LCD display digital DC voltmeter
20. 1 No. LCD display digital AC ammeter
21. 1 push button for emergency stop of DG
22. 1 push button for DG start
23. 1 No. of push button for DG stop
24. 1 No. of push button for DG reset
25. 1 No. of push button for mains contactor ON
26. 1 No. of push button for mains contactor OFF
27. 1 No. of push button for DG contactor ON
28. 1 No. of push button for DG contactor OFF
29. 1 No. of push button for Hooter reset.

The panel should have indication lamps for the following:

1. Set running/Generator ON
2. Load on DG
3. Load on mains
4. Battery charger ON
5. Low Lub oil pressure
6. High water/coolant temperature
7. Overload
8. Engine over speed
9. Emergency stop
10. DG fail to start (after three attempts)
11. Short circuit

The DG set shall have the following Tripping and annunciation modes:

1. Over/under frequency – DG tripping with annunciation
2. Over/Under voltage- DG tripping with annunciation
3. Overload- Alternator tripping with annunciation
4. High water/coolant temperature- DG tripping with annunciation
5. Low Lub oil pressure- DG tripping with annunciation

6. Short circuit- DG tripping with annunciation

Each alarm shall illuminate a separate lamp located in front of the cubicle. All alarms shall be grouped to operate a normally open contact which will be used for remote annunciation on the annunciation panel in the control room.

11.4. TESTS

Contractor shall conduct the standard factory load testing. Prior to acceptance of the installation (commissioning), equipment shall be tested for all the tripping modes, indications, annunciation, automatic starting on mains failure etc. to show it is free of any defects or bad workmanship and be subjected to full load test, or that load which is available at the job site.

11.5. MANUALS/ DRAWINGS

Following manuals shall be provided with the equipment

1. Engine's operation & maintenance manual along with the necessary drawings.
2. Alternator's operation & maintenance manual along with the necessary drawings.
3. Operation & maintenance manual along with necessary drawings of electrical control Panel shall also be provided.

6 Sets of electrical drawings shall be supplied along with the delivery of the equipment. Each set of drawing shall be consisting of general arrangement, single line, wiring & schematic drawings.

The panel shall be fabricated only after the drawings regarding Operation scheme, SLD etc have been approved by the purchaser.

11.6. SPARE PARTS & SPECIAL TOOLS

The spare parts mentioned hereunder are meant for use by the Employer for 5 year trouble free operation & shall not be used as erection / commissioning spares required during installation. All the spare parts shall be interchangeable & shall be of the same material and workman ship as corresponding parts of the main equipment.

If any additional spare parts required for a 5 year trouble free operation period are recommended by contractor, these shall be listed and the unit price shall be quoted in the price schedule. The Employer reserves the right to order any or all of such spares.

All spare parts shall be protected against corrosion suitably packed and shall be marked with identification labels in the English Language. The identification shall be in accordance with the agreed Works Identification System.

All spare parts, tools and materials shall be delivered in marked boxes of sufficient sturdy construction to withstand long term storage. Material that is subjected to long term storage shall be stored in a dry, ventilated room with low humidity.

Acceptance of any spare parts will not take place before the Contractor has submitted the complete final list of all spare parts and tools. They shall be replaceable without cutting or destruction of adjacent components. Before issue of the Completion Certificate, the spare parts shall be checked at the Site by the Contractor in presence of the Engineer / Employer.

Mandatory Spares

The mandatory spares are listed below for DG set.

Item No.	**Description**	**Qty.**
1.	Oil filter	3 nos. of each type
2.	Fuel filter	3 nos. of each type
3.	Nozzle	2 nos. of each type
4.	Complete set of belts	1 set.
5.	Air filter element	4 nos. of each type
6.	Relay	Minimum 1 no. of each type
7.	Pressure switch	Minimum 1 no. of each type
8.	Temperature switch	Minimum 1 no. of each type
9.	Level switch	Minimum 1 no. of each type.
10.	Fuses	2 nos of each type
11.	Indicating lamps	2 nos of each type
12.	Electronic card	Minimum 1 no. of each type.
13.	Sets of gaskets and “O” ring	2 sets for each rating
14.	Fuel injectors	1 set for each rating (if different)
15.	AVR	1 no. for each rating (if different)

16.	Trip & closing coil of ACB	1 set for each rating
17.	Rotating diode assembly	1 set for each rating

The above are bare minimum. Any other spares (over and above mandatory list) shall be recommended by contractor along with unit prices for consideration of Employer. Employer reserves his right to order any or all the spares.

Tools and Instruments

The Supplier shall supply all necessary tools, devices, testing Instruments / equipment etc. for installation, repair and maintenance at site. These shall remain the property of the Supplier unless otherwise agreed to be taken over by Employer any / all of these at mutually agreed conditions.

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12. COMMUNICATION SYSTEM (CCTV, VoIP AND PA SYSTEM)

12.1. Scope of Work

Scope of work under this section covers the provision of labour, tools, plants, material and performance of work necessary for the design, manufacture, quality assurance, quality control, shop assembly, shop testing, delivery at site, site storage and preservation, installation, commissioning, performance testing, acceptance testing, training of Employer's personnel, handing over to Employer for trouble free operation of communication and surveillance system.

The scope of work shall be a comprehensive functional system covering all supply and services/works including but not be limited to following.

12.1.1. VoIP and PA System

The communication system shall comprise of following:

1. Public Address system,
2. VoIP system.

Public address (PA) system comprising of:

- Master Control Station (MCS) including microphone and all accessories required for the system.
- Central control equipment consisting of Central-switching system (CSS); Central paging control and amplifier rack, preamplifier, power amplifiers and all required accessories.
- Loudspeakers / Hooters with wall / column / structure mounting arrangements; ii. Microprocessor based (digital) VoIP system comprising of:
- 128 lines VoIP,
- 25 Telephone sets,
- Sockets / telephone jacks for the telephone wiring network.
- The telephone cabling system.

Spare parts as per spare parts clause.

12.1.2. CCTV system

CCTV system shall be comprising of:

- Fixed colored cameras with varying focal length lenses.
- Camera mounting platforms / structures,
- Receiver Driver unit,
- Matrix switcher,
- CCTV Station,
- Keyboard unit;

- Digital video recorder,
- Control console,
- Color video monitors,
- Interconnecting power, video and control cables,
- Video distribution amplifiers / Video cable equalizers, as per requirement,
- Alarm annunciator,
- All other auxiliary equipment, connectors, erection accessories etc. as required.

12.1.3. Specific parameters and layout conditions

1. The major areas covered are as follows (8 CCTVs for Remote sites & 14 CCTVs for Powerhouse, 4 CCTVs for Switchyard):
   - Powerhouse Block (all floors),
   - All floors of control block (including priority distribution in rooms on different floors),
   - Staircases lift well and other utility areas,
   - Entrance gate and facilities.

CCTV data shall be made available at Powerhouse Control Room CCTV station through Optical fiber system. to be available for interfacing with ADSS optical fibre system.

2. Available Power Supplies:
   - 230V, 50Hz, 1 Phase UPS supply.
   - 220V DC supply at Powerhouse Location.

12.2. Communication System

The communication system shall consist of zones, sub-zones and exchanges to interface all the zones among themselves and with Employer's existing telephone exchange (If any).

The communication system shall cover all operational areas of Power house complex and tail race outlet area including interfacing with switchyard and inlet chamber area.

The entire system shall comprise of following:

- Public Address system,
- VoIP system.

The main panel of the public address system shall be located in the control room of the powerhouse. The loud speakers, Hooters, the head microphones, the call station connecting points and the other telephone connecting points shall be located at various points.

The system shall be adequately protected from signal and power line noise and meet the surge withstand capability requirements of ANSI C37.90 A / IEEE standard 472-1989 equivalent.

12.2.1. Rating and functional characteristics

Capacity and bandwidth (±3dB) for outdoor wall / column mounted horn type loudspeakers shall be at least 4W (rms) and 100 -7000 Hz respectively.

Capacity and bandwidth (±3dB) for indoor wall / column mounted cone type loudspeakers shall be at least 4W (rms) and 100 -7000 Hz respectively.

12.3. Performance guarantee

The communication along with all auxiliaries and accessories shall be capable of performing intended duties under specified conditions. The Contractor shall guarantee the reliability and performance of the individual equipment as well as of the complete system

12.4. Design and construction

12.4.1. Standards

The system and equipment shall be designed, built, tested and installed to the latest revisions of the following applicable standards. In the event of other standards being applicable they will be compared for specific requirement and specifically approved during detailed engineering for the purpose.

Standards	Description
IEC 60065	Audio, video and similar electronic apparatus-Safety requirements
IEC 60326	Printed Boards
IEC 60446	Basic and safety principles for man-machine interface, marking and identification, identification of conductors by colours or numerals
IEC 60478	Stabilized power supplies, DC output
IEC 60870-5	Tele-control equipment and systems

12.4.2. Public address system

Public address system shall be a microprocessor-controlled software programmable, centralized amplifier based system.

System shall comprise of two main channels:

- Page channel: This provides loud speaking facility and is used to broadcast / announce messages, instructions and to locate field people in the plant. The loudspeakers can be arranged indifferent groups and the announcements can be made either to individual groups or all groups together.
- Party channel: It shall be used for carrying prolonged conversations in private mode, which shall not be heard over the loudspeakers. The system possesses multiple party channels i.e. one dedicated channel for each field handset station.

1. Master Control Station (MCS)
   Master Control Station shall be microprocessor based and of modular design. It shall be desktop type construction and installed in the control room.

The MCS shall comprise of at least the following-

- Two (2) dynamic microphones,
- All zone / Individual zone selection switches,
- Field paging 'ON' indication,
- Press to talk switch,
- Digital display for identification of calling station number and area name,
- Dial keypad,
- Function keys (programmable for different features of the system like call answer, call transfer, call release, call end, call hold, call wait, memory dialling, Redial etc.),
- Hand free dialling,
- Monitor the functionality and status of individual field handset stations,
- Automatic fire alarm tone generation.

It shall be possible that during an emergency, control room operator can broadcast siren / alarm tone in selected or all zones.

Control room operator shall have page priority over the paging from field.

2. Central control equipment

Following Central control equipment shall be in the control room,

a. Central switching system (CSS)

CSS shall be in non-blocking architecture and based on TDM / PCM technology or state of art technology which shall have improved speech quality and the noise interference, and the distortion is reduced to minimum.

b. Central paging control and amplifier rack

The racks shall be designed for free floor standing. The system shall have high reliability amplifiers with built in protection circuitry. The system shall be provided with standby amplifier with changeover circuitry to always ensure continuous operation. The system shall have provision in the amplifier for further expansions to meet the requirements. The rack shall have preamplifier with built in MIC and AUX input, Control panel, Power supply unit, Individual / all zone selection switch, Chime module, siren access, Priority matrix, etc.

Central paging control and amplifier rack shall have solid state, class-B, Push-pull type Power amplifiers fully conforming to international standard.

Total harmonic distortion shall be less than 1 % at rated output at 1 KHz, Signal / Noise ratio shall be 60 dB.

All the heat generating devices shall be operated well within their rated limits to minimize the thermal stresses. The temperature sensors shall be provided on the heat sinks to monitor the temperature. The Amplifier shall comprise of at least following minimum features:

- Mains power supply,
- Mix and match capabilities,
- Adjustable sensitivity as volume control with facility for coarse and fine setting,
- Bass and treble control,
- Electronic protection.

3. Field handset stations

The field handset station shall be weatherproof and located / installed at multiple locations in the indoor and outdoor field locations. These shall be wall / column / structure mounted.

The handset stations in the noisy areas shall be housed in acoustic hoods. The design noise level within the hood shall be limited to a maximum of 60 db SIL.

Handset transmitter / microphone shall be noise cancelling type for effective communication from noisy areas. The handset shall consist of push button type keys, handset cord protected in SS metallic tubing and external canopy in fibre for extra protection. Handset transmitter / microphone shall have filters to protect from dust.

The weatherproof station for outdoor areas shall, be made of corrosion resistance aluminium alloy.

4. Loudspeaker / Hooters

The loudspeaker and Hooters shall be weatherproof and located / installed at multiple locations in the indoor and outdoor field locations. These shall be wall / column / structure mounted.

Loudspeaker shall have control switch to vary the loudspeaker output. Its cabinet shall be treated with acoustic under-coats to prevent resonance.

12.5. VoIP SYSTEM

It shall be an industrial-grade, IP-native SIP (Session Initiation Protocol) intercom system to facilitate high-reliability, real-time voice communication between the Powerhouse Control Room, Machine Hall & Barrage Control Room. The system shall utilize a decentralized, peer-to-peer (P2P) architecture, functioning directly over the plant's existing fiber-optic Ethernet backbone. The system shall be integrated with public address system. Control rooms, offices, facilities, utilities, cabinets, cubicles and rooms containing equipment requiring maintenance shall be equipped with sockets for the telephone network.

The type and standard shall be submitted to the Employer for review and approval.

The system shall provide a web-based management interface for remote configuration, endpoint registration, and status diagnostics. The network interface shall be a standard 10/100 Mbps RJ45 port, allowing for direct integration into existing managed industrial switches.

The system shall strictly adhere to the following technical requirements to ensure seamless integration into the Karbi Langpi HEP network environment:

- Audio Quality & Codecs: Support for G.711 (a-law/u-law) and G.729 audio codecs to maintain high-fidelity voice transmission. The system must support Full-Duplex audio with integrated Active Noise Cancellation (ANC) to ensure clarity in environments with ambient noise levels up to 95 dB.
- The system shall support IEEE 802.3af/at (Power over Ethernet - PoE) for single-cable power and data connectivity.
- All wall-mounted units in the Machine Hall shall be encased in an IP65/IP66 rated enclosure (dust-tight and water-jet resistant). Given the proximity to high-voltage equipment, the hardware must be compliant with relevant EMI/EMC (Electromagnetic Interference/Compatibility) standards to prevent crosstalk or signal degradation.

12.6. CCTV System

12.6.1. General

The Closed-Circuit Video Monitoring (C.C.V.M) System will be provided for comprehensive round the clock surveillance for control and supervision of technological processes at points which are difficult to be observed directly or which require monitoring from a remote-control centre by operational people as well as access monitoring (powerhouse and barrage only). The system consists of colour cameras (CCD type) with fixed lens, weatherproof housing, TFT colour monitor at powerhouse location, monitor console, Receiver Driver unit, matrix switcher, Digital Video recorder, camera mounting platforms / structures, control console with control units for complete control of the cameras. Interconnecting video and control cables, Video distribution amplifiers / Video cable equalizers (if required), and all other auxiliary equipment, connectors and erection accessories etc. as required for completeness of the system.

12.6.2. System requirements.

The cameras will be of Charge Coupled Device (CCD) type, and these will be mounted in such a manner as to provide continuous monitoring of the critical processes / operation of the shop floor as required.

The system will provide clear and sharp picture on monitors in industrial lighting conditions at any time of the day or night.

The complete CCVM Systems will work on 230 V ± 10%, 50Hz ± 2 Hz, single phase AC supply / DC supply. In case any other power source is required, the same will be arranged from the above available source. The CCVM system will be provided power from an uninterrupted power supply system for feeding stabilized and continuous power supply to all equipment.

All equipment for C.C.V.M systems covered in this specification will comply with the IEEE / IEC standards.

All control functions related to the CCVM Systems comprising Cameras and Monitors of the weatherproof housing will be operated from the control units, which are to be installed in the control room.

All the CCTV Cameras shall be multiplexed to suitable number of monitors. The CCTV Cameras along with multiplexing and control shall be interfaced to the operator stations.

12.6.3. Equipment details

1. Camera
   The cameras will be compact, of rugged design and suitable for industrial continuous monitoring applications. These will be specially designed and tested to provide continuous good quality video output throughout wide variations in environment conditions like temperature, humidity, shock and vibrations and varying light condition prevalent in the hydro power plant. The cameras will use 1 / 3" format interline transfer CCD imager and have virtually zero lag, no image burns and no geometric distortion. These will be of latest state of art technology ensuring high operational reliability. The cameras shall deliver well defined, clear, high resolution coloured picture, with sufficient contrast to allow for good object recognition even in poor light conditions. A highly sensitive automatic light compensation circuit will ensure constant video signal independent of wide variations in light levels. The cameras will have long life and require virtually zero maintenance in adverse environmental conditions prevalent in the hydro plant.

The Cameras will also possess the following features:

- High resolution,
- Low power consumption,
- Phase adjustable line lock facility,
- All controls like back focus, lens select, phase adjustment, power ON / OFF etc,
- The camera unit will be complete with all electronic circuitry, devices, components, control switches, standard mount for lenses, mounting assemblies etc. The mounting assemblies of the cameras will be individually selected depending upon the special requirements as per actual site conditions.

A. Colour Cameras:

Colour cameras of 1 / 3" or 1 / 4th format with iris lenses are envisaged to suit different requirements of site. The camera shall be colour CCD type, high resolution of minimum 450 TV lines. All outdoor cameras shall be provided with sun shield. It will also possess the following features:

- Pick-up device- 1 / 3rd inch or 1 / 4th inch format, interline transfer, CCD image sensor,
- Minimum illumination- 0.5 lux at f 1.2,
- Signal to noise ratio- 46dB minimum,
- Electronic Shutter- Automatic, On / off selectable,
- Video outputs- Composite video - 1.0 V p-p, 75 ohm,
- AGC- On / Off selectable,
- Aperture Correction- Horizontal and Vertical,
- Synchronization- Line lock- for roll-free vertical interval Switching- Crystal lock,
- CE and UL certification.

B. Camera lens: The camera lens will be suitable for the camera on which it is to be mounted. The lenses chosen will be Auto iris, vari focal lens so as to meet the operational requirements. The choice of lenses, their focal length and viewing angle will be judiciously done for effective monitoring suited to the specific application requirements.

C. Camera mounting platform: The camera mounting platform will be suitable for mounting the camera assembly on walls / column / structures as per the actual requirements at site and keeping in view the area to be covered by the individual camera. The mounting will be with adjustable support so as to have flexibility to move the camera assembly as and when required. Wherever necessary, structures / vertical poles to mount the cameras shall be fabricated.

D. Receiver Driver Unit: The receiver shall be able to receive command signals from the operators keyboard through the CPU / Matrix and execute them. The unit shall generate the power for the enclosure, camera, lens etc. Receiver driver unit shall comply min IP65 for outdoor. The equipment shall be CE / UL certified. The receiver driver unit shall withstand the temperature indicated for the corresponding area.

E. Microprocessor based Matrix Switcher: To control the C.C.V.M system microprocessor based matrix switchers are envisaged. The system shall have matrix switchers at control rooms. At control rooms matrix switchers of suitable inputs and outputs and alarm interface units are provided for switcher to handle the alarm events.
The switcher system shall provide minimum the following basic features

- Full matrix switching,
- Synchronized video switching,
- A logging printer port which provides a hardcopy printout of either the system status changes or system Tables and Sequences; Keyboard log-on / log-off with password protection,
- 16-character camera titling, Accommodation of alarm points;
- CE / UL certification.

The matrix switcher must be modular in construction i.e. should have Main base having CPU, power supply and main bay, and required number of input and output cards must be put in the bay for configuring a solution. The system should allow multiple number of keyboards to be directly connected to it in star configuration. It should allow prioritizing the keyboards as per the requirement.

It will also possess the following features:

- Video Inputs - as per requirement,
- Video outputs - as per requirement,
- RS-232 Ports - 1 each for PC, printer and alarm signals,
- Input voltage level - 0.5 V p-p to 2.0 V p-p, Composite Negative Sync,
- Gain - Unity (75 ohm terminated,
- Switching - Cross point Matrix,
- Features - Full matrix switching, any camera to any monitor,
    - Programmable switching sequences,
    - Salvo switching capability,
    - min 40 character on screen display for time- date, camera number, camera ID, monitor or status information and 16 character alarm titling - With the keyboard,
- EMC - CE / UL certified

An additional alarm interface unit shall be also supplied along with the above switcher. The unit shall have the ability to automatically display video under alarm conditions. It shall accept upto 32 contact closures or logic level inputs from remote sensing devices. The unit shall also provide 8 relay closure outputs upon alarm conditions.

F. Keyboard for matrix switcher

Keyboard is envisaged for full function, for system control and programming at control rooms.

It will also possess the following features:

- Control of Matrix switcher,
- Soft backlit keys with user friendly menu and easy to read display,
- interfaced to Matrix switcher for control of Camera selection.
- display (LCD) of complete menu for selection of various functions.
- CE / UL certification.
- RJ11 connector for matrix switcher (power / data).
- Aux. power, for extended distances.
- RS-232 port for remote programming.
- Other standard connectors.

G. Digital Colour Multiplexer Cum Recorder

This multiplexer and integrated digital recorder provide multi-camera recording and playback with the added capability of multi-screen viewing. Programming is easily accomplished via front panel control keys and on-screen displays menus.

The duplex multiplexer / recorder can encode up to 8 / 16 colour video inputs on its internal hard drive while simultaneously displaying video in the full screen or any of the multi-screen modes.

The multiplexer specified shall be designed to record (encode) and playback (decode) up to 8 / 16 colour cameras. The unit shall also have the added capability of multi-screen viewing.

In playback (DECODE mode), the multiplexer shall provide a full screen display of any of the sixteen previously recorded cameras, or it can display a selection of any of the cameras in various multi-screen modes.

The multiplexer / recording shall allow instant access to critical recordings by alarm, time, date, and camera searches.

The multiplexer / recorder, in addition to camera video, shall provide the time and date, camera number, and a user programmable 16-character camera title, which is recorded.

The multiplexer / recorder shall provide, but not be limited to, the additional following features:

- On-screen menu programming,
- Sequencing of cameras,
- Video loss with on-screen indication,
- Freeze function,
- Action / Alarm output relay contacts,
- Password access protection,

The multiplexer / recorder shall use good compression technology for high quality video and shall include a minimum hard drive capacity for storing data for 24hrs X 15 days. The multiplexer / recorder shall include a SCSI-2 / USB port for archiving video to external media.

A 21" colour monitor shall also be supplied along with above for viewing multiplexed / recorded video.

The multiplexer / recorder shall be designed for use as a desk top unit or may rack mounted using an optional rack mount kit.

It will also possess the following features:

- Video Standard - PAL, 625 lines, 50 Hz.
- Digital Memory - 720H x 576 V.
- AGC - Automatic or manually adjust for each video input.
- Inputs - Camera: 8 /16inputs; 16 / 32 BNC connectors. Automatic looping termination,
- Outputs - min 2 composite monitor outputs.
- Recording - extremely high quality video recording for 15 days storing capacity
- Recording modes - Selectable from 0.1 IPS to real time recording, max recording speed 50 IPS for 16 cameras (max); Resolution of recording - High, medium and low quality,
- Input voltage level - 0.5 V p-p to 2.0 V p-p, Composite Video signal,
- Display Modes - On monitor A - Full, quad and various combinations of multiscreen viewing,
- Features - controls with keyboard
  - Motion detection with direction sensing
  - Programming via included software
  - Sequencing of cameras

- Video loss with on-screen indication
- Instant access to critical recording by alarm, time, date and camera searches
- Display of time, date, camera number and user programmable 16-character camera title for viewing and recorded information;

- Ethernet port (RJ-45) -- For network video access, shall be provided. Remote viewer software to allow simultaneous access shall be also provided; EMC - CE / UL certified.

H. CCVM Monitors: The CCVM monitors will be suitable for industrial applications and compatible for the cameras. These will be of fully solid state type, modular in design, have low radiation and provide a bright, clear, well defined and high resolution picture display on the Screen.

All controls for power supply on / off, brightness, contrast, colour, vertical hold, horizontal hold, etc. will be provided on the front panel behind the flip open protective cover for readily adjusting the video signal. The input and output video connectors for coupling the video input / output to other equipment, DC restoration switch and power supply connections will be provided on the rear panel. The monitor will have easy access for servicing and other adjustments.

The monitors will be housed in a dust-proof metal enclosure with anti-dazzling light shield. It will be suitable for rack mounting / mounting on control console / ceiling hang type as per the site requirement at a convenient viewing angle.

I. Control Console

The control console shall house matrix switcher, Keyboard, Multiplexer and recorder and other control equipment, interfacing modules required for control of complete system. The console shall be of industrial usage, dust and vermin proof. It shall be located in control room. The console shall be of pre-wired ready for installation and commissioning.

Required protections and cooling arrangements shall be incorporated. The equipment shall meet IP54. Control of temperature indication of camera and audio-visual alarm indication in case the temperature violates the desired limits shall also be housed.

J. Video cable equalizers

The video cable equalizers will be used to compensate for high frequency losses due to long runs of coaxial cable used between the camera and video monitor.

K. Surge Protection

Surge protection for video, power and control signals shall be given for cameras.

and associated equipment at both ends. The equipment shall protect cameras and associated equipment in case of surge. It shall be as per IEEE / IEC standards.

Required junction boxes and associated equipment shall be supplied to complete the installation in all respects.

Surge capability shall be of min 10kA, and UL / CE listed.

L. Cables

For connecting the control room equipment with field equipment following cables are envisaged. Co-axial cable for video signal transmission, twisted pair shielded cable for controlling cameras are envisaged.

- Co-axial cables are envisaged for video signal transmission for cameras which are up to 300mts distance. Beyond 300 mts post equalizing amplifier shall be used.
- Independent control and video cables are envisaged for these cameras.
- Independent power cable for each camera to be provided,
- Booster amplifier shall be used wherever video signal is weak,
- The following criteria shall be used for selection of cables-

- Power supply cable: min 2.5 sq.mm
- Control cable : min 2.5 sq.mm

While designing cable layout and selection of multi core cable the following criteria must be satisfied.

- Minimum 20% of pairs shall be considered as spare subject to min one pair.
- All cables shall be of FRLS type.

Video Cable:

The specifications shall be as under:

- Centre conductor size - 7 / 0.4 mm Annealed Tinned Copper (ATC);
- Di-electric material. - Polyethylene (PE), White colour,
- Shield material - Copper braided,
- Jacket material - FRLS PVC BLUE,
- Armour - 1.4 mm GI wire round,
- Outer jacket thickness - 1.2 mm FRLS,
- Outer jacket - FRLS PVC BLUE.
- Nominal impedance. - 75 ohms.

Power Supply Cable:

The specifications shall be as under:

- No of cores - min 3 (three);
- Conductor size - min 2.5 sq mm, 7 / 0.68 multi strand with standard annealed electrolytic copper conductor,
- Primary insulation - PVC insulated of 85º C PVC,
- Thickness of PVC insulation - 0.8 mm,
- Colour code - Red, Black and Green,
- Inner and Outer Jacket - Extruded Flame retardant and 90º C PVC.
- Armouring -- Galvanised Steel Wire / flat

The above cables shall also have the following:

- Fire retardant shall be as per standard IEC 332-part III Cat A.
- The insulation grade shall be 1100V as a minimum and shall meet insulation resistance, voltage and spark test requirement.
- Armour over inner jacket shall be of galvanized steel wire / flat.

M. Twisted Pair Cable

The specifications shall be as under:

- No of pairs - as required,
- Conductor size - 2.5 sq mm standard annealed electrolytic copper.

Conductor,

- Primary insulation - Low density polyethylene (LDPE) / PE,
- Thickness of insulation - 0.5 mm,
- Pair shielding - Aluminium backed by mylar / polyester,
- Drain wire - 0.5 sq mm multistrand bare tinned,
- Inner and Outer jacket -- Extruded flame retardant and 90º C PVC,
- The cable shall be as per IEC / IEEE standard.

12.7. Junction boxes

Junction boxes shall be used for connecting field handset stations, loudspeakers, etc from central equipment. The Junction box shall be constructed with suitable locking arrangement.

All junction boxes shall have minimum 20% spare terminals for future requirements.

Junction box shall be of 4-way type having opened on each side. The degree of protection shall be minimum IP65. Disconnecting (sliding) cage clamp type terminal blocks shall be provided, to facilitate testing and maintenance without disconnecting the cables.

12.8. Cables

Cables for use in communication shall be of FRLS PVC sheathed cables and shall conform to latest edition of international standards. Cables shall be suitable for installation as follows:

- Above ground in open air location (tray / ducts) in tropical, humid and corrosive atmosphere prevalent in power plant,
- Direct buried in underground Frenches conduits with uncontrolled back fill and possibility of flooding by water and chemicals,
- Laid underground in RCC lined cable trenches with possibility of flooding by water.

Cabling shall be done at various important location of the powerhouse to ensure the portable camera connection wherever needed.

Redundant single mode underground optical fibre link, complete in all respects, shall be used for public addressing between power house and dam.

12.9. Drawings, Documents and Design Calculations

12.9.1. Drawings and documents

The list of drawings / documents which are to be submitted to the Employer shall be discussed and finalised by the Employer at the time of award.

The Contractor shall necessarily submit all the drawings / documents unless anything is waived. The Contractor shall also supply calculations, studies, bills of material, Input and Output lists, operating sequences, setting reports, cable schedule, wiring and connection schematics and pre commissioning test procedures and reports.

12.9.2. Design calculations

The Contractor shall submit the design calculation covering at least the following, for review / acceptance.

- Calculation for echo sound generated in the powerhouse,
- Design calculation for selecting number of loudspeakers with power output,

The Contractor shall also provide other calculations as required by the Engineer for his approval of the Contractor's design.

12.10. Spare Parts & Special Tools

The spare parts mentioned hereunder are meant for use by the Employer for 5 years trouble free operation & shall not be used as erection / commissioning spares required during installation. All the spare parts shall be interchangeable & shall be of the same material and workman ship as corresponding parts of the main equipment.

If any additional spare parts required for a 5-year trouble free operation period are recommended by contractor, these shall be listed and the unit price shall be quoted in the price schedule. The Employer reserves the right to order any or all of such spares.

All spare parts shall be protected against corrosion suitably packed and shall be marked with identification labels in the English Language. The identification shall be in accordance with the agreed Works Identification System.

All spare parts, tools and materials shall be delivered in marked boxes of sufficient sturdy construction to withstand long term storage. Material that is subjected to long term storage shall be stored in a dry, ventilated room with low humidity.

Acceptance of any spare parts will not take place before the Contractor has submitted the complete final list of all spare parts and tools. They shall be replaceable without cutting or destruction of adjacent components. Before issue of the Completion Certificate, the spare parts shall be checked at the Site by the Contractor in presence of the Engineer / Employer.

12.10.1. Mandatory Spares

The mandatory spares are listed below:

S.No	Description	Quantity
1.	Each type of loud speakers with wall mounting arrangements	10% of installed quantity
2.	Telephone sets with wall / column / structure mounting arrangements	10% of installed quantity
3.	Head microphones	10% of installed quantity
4.	Power supply cards used in the amplifier system	4nos
5.	Electronic cards of each type used in the system	4nos
6.	Cables of all type	10% of installed quantity
7.	CCTV system equipment Camera of each type	One each

The above items are bare minimum. Any other spares (over and above mandatory list) shall be recommended by contractor along with unit prices for consideration of Employer.

Employer reserves his right to order any or all the spares.

12.10.2. Tools and Instruments

The Supplier shall supply all necessary tools, devices, testing Instruments / equipment etc. for installation, repair and maintenance at site. These shall remain the property of the Supplier unless otherwise agreed to be taken over by Employer any / all of these at mutually agreed conditions.

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13. SWITCHYARD EQUIPMENT

13.1. GENERAL

The specification described hereinafter covers the technical requirements, design, fabrication, manufacture, assembly, testing at manufacturers works and the supply, delivery of the equipment for outdoor installation, consisting of 33KV outdoor vacuum circuit breakers, current transformers, potential transformers, disconnecting switches, earthing switches, lightning arrestors, supporting steel structures and sub-station gantry structures as outlined below as well as in schedule of requirements and covers all other equipment not explicitly mentioned but is essential for the complete and reliable as well as safe operation. The scope covers the installation, testing, commissioning, testing for field acceptance and handed over to the purchaser. The entire switch yard equipment described hereinafter is for installation at an altitude < 1000 meter (approx) above mean sea level.

The bidder is at liberty to supply equipment other than those confirming to ISS provided the reasons for adopting a specification other than ISS are highlighted in the bid.

The following drawings shall form a part of the specification:

1. Main Single Line Diagram
2. Main Single line Diagram Relaying and Metering
3. Single Line Diagram LTAC / MV System

13.2. 33 KV VACUUM CIRCUIT BREAKER

13.2.1. Scope

Contractor shall perform all necessary work for the design, manufacture, assembly and testing at works, supply, installation, and commissioning of the 33 kV circuit breakers as shown on single line diagram or as required by the Purchaser and as specified hereafter. All necessary parts to provide a complete and operable circuit breaker installation such as main equipment, terminals, control parts, connectors and other devices whether specifically mentioned in this specification or not shall be in the scope of circuit breaker supplier.

13.2.2. Supply

The technical specifications of the 33 kV circuit breakers supplied and installed by Contractor are defined hereafter.

13.2.3. Description

Contractor shall design, build, guarantee, deliver, perform the factory and commissioning tests, install, and connect six (6) nos (for generating end, for line bays and for 33 kV Switchgear) of 33 kV, three phase circuit breakers. Circuit breaker shall be of outdoor type. The circuit breaker shall be complete with supporting structure, control cabinet and all other accessories required and shall comply with the requirements of latest edition of IS:13118.

13.2.4. Electrical Characteristics

S.No	Parameter	Description
1.	Type	Outdoor, Vacuum Circuit Breaker
2.	No. of Pole	3
3.	Frequency	50Hz
4.	System neutral earthing	Effectively grounded
5.	Nominal system voltage (kV_{rms})	33
6.	Highest system voltage (kV_{rms})	36
5.	Rated short circuit current breaking capacity at rated voltage	25 kA with percentage DC component as per IEC: 56 corresponding to minimum opening time underoperating conditions specified.
6.	Symmetrical interrupting capability	25 k A_{rms}
7.	Rated short circuit making current capacity	62.5 kA_p
8.	Short time current carrying capabilityfor one second	25 k A_{rms}
10.	Rated operating duty cycle	O-0.3s - CO-3 min-CO
12.	Total closing time (ms)	Not more than 100
13.	Total break time for any current uptorated breaking current (ms)	80
14.	Trip and closing coil Auxiliary supply voltage	Trip coils: 2 nos. Closing coil: 1 no. a) 415V +/-10% variation,

		3-Phase, 50Hz,AC b) 220V+/-10% variation, DC
15.	Auxiliary contacts:	
a)	Continuous thermal rating	10A at 220 V DC
b)	Breaking capacity	2A DC with circuit time constant not less than 20ms.
16.	No. of auxiliary contacts	Besides requirement of this specification the bidder shall wire up 10 NO +10 NC contacts for future use of Purchaser.
17.	Noise level at base and upto 50 m distance from base of breaker	140 dB (max.)
18.	Rated terminal load	The breaker shall be designed to bear all expected loads including the short circuit forces, wind loads earthquake load& other applicable loads.
19.	Temperature rise over the design ambient temperature	As per IS: 13118/ IEC: 56
20.	Type of operating mechanism	Spring operated mechanism
21.	Rated voltage	36 kV_{rms}
22.	Rated continuous current at rated ambient temperature	1250 A
23	One minute power frequency withstand voltage (wet and dry)	70 kV_{rms}
24	Lightning impulse withstand voltage	170 kVp
25.	First pole to clear factor	1.5
26.	No of Terminals in common Control cabinet.	All Contacts & controls circuits to be wired up to common control cabinet plus 20% terminals exclusively for Purchaser's use.
27.	Provision for manual closing in case of failure of supply	Yes
28.	Mechanical indicator for indication of open / close.	Yes

29.	Mounting structure	Galvanized steel structure
30	Phase to phase spacing	1500 mm
31	Grounding terminals	2 Nos. to be provided for connection to earth mat.

13.2.5. Mechanical Operation

1. The circuit breakers shall be Vacuum type. The operating mechanism shall be spring.
2. All circuit breakers shall be built to sustain a mechanical endurance test of 2000 CO operations.

13.2.6. Operating Principles

1. All the circuit breakers shall be suitable for three-phase operation.
2. The circuit breakers shall be equipped with an energy accumulating system for storing enough energy to enable prescribed duty cycle. The circuit breaker shall be restrike free as per IEC under all duty conditions and shall be capable of performing their duties.
3. The circuit breaker(CB) shall provide rapid and smooth interruption of current under all operating conditions, completely suppressing all undesirable phenomenon even under most persistent and severe short circuit conditions or when interrupting small leading or lagging current. Detail of devices used for controlling the RRRV across the CB contacts shall be stated.
4. In the three pole operation of the circuit breaker, all the three poles should operate simultaneously. There shall not be any time gap betweenthe closing contacts of all the three poles. If there is any such discrepancy in the operation of the circuit breakers, it shall be indicated as a discrepancy in the C & R Panel located in the control room.
5. Interlocks shall be provided to avoid any incorrect operation of circuit breaker.

13.2.7. Control Cabinet

1. All circuit breakers shall be equipped with a three-pole control cabinet.
2. The control cabinet shall be IP: 55 protections, weatherproof, thermally insulated and protected against condensation.
3. The control cabinet shall be of sufficient dimensions to allow accessories installation and all control and auxiliary circuits connections on terminal blocks.
4. A double 240 V receptacle, weatherproof with a tight cover, shall be provided and installed in the inside of the control cabinet housing.
5. The wiring shall be made with PVC insulated stranded copperconductors.
6. A main earthing bus bar is required inside control cabinet to connect conductor sheaths. This earthing bus bar shall be copper silver plated, 3 x 25-mm minimum, solidly bolted to the housing and provided with threaded holes.

13.2.8. Insulators

All the circuit breaker insulators shall be made of porcelain. The bushing insulators shall be suitable for installation in normal and lightly polluted atmosphere. These shall be homogenous and free from cavities and other flaws and shall be designed to have ample insulation and mechanical strength and rigidity for specified operating conditions. The bushing shall be free from radio disturbances and shall be free from external and internal corona effects. The electrical characteristic of the insulator shall be as under:

S.No	Particulars	Details
1.	Type	Outdoor
2.	Installation	Exposed
3.	Rated Current	1250 Amps.
4.	Rated Voltage	33 kV_{rms}
5.	Rated Frequency	50 Hz.
6.	Limits of temperature rise	As per IS:13118/ IEC:56
7.	Altitude of the site where the breaker shall be used	Less than 1000m.
8	Minimum value of creepage distancefor the degree of pollution (Heavy)	31 mm/kV

13.2.9. Terminals

1. All circuit breaker power terminals shall be a NEMA four hole aluminium pad.
2. Terminals shall be suitable for its connection with the “Panther” conductor & 33 KV XLPE cable.
3. Two (2) earthing terminals shall be located at the bottom of each supporting structure to allow bolted connection to the switchyard earthing grid through a flexible Aluminium connector. The earthing terminals shall have provisions of two 14 mm diameter holes, 38 mm spacing.

13.2.10. Supporting Structures

All circuit breakers shall be provided with their hot dipped galvanized steel supporting structures with all foundation material and fasteners.

13.2.11. Accessories

All circuit breakers shall include at least the following accessories:

1. Main contact position indicator visible from ground without opening door,
2. Operation counter,
3. Local Electrical/ Local Manual/Remote Electrical Change over switch
4. Opening and closing devices operated from control cabinet andwired for remote operation,
5. Fuses as required
6. D.C. Supervision relay
7. Control switch to cut off control power supply
8. Devices and necessary contacts for remote indication of maincontacts position,
9. Other necessary accessories not mentioned here in the specificationbut required for the circuit breaker and other plant control operations.

13.2.12. Name Plates

All circuit breakers shall be provided with a nameplate giving the followinginformation:

1. Marking “Circuit Breaker,
2. Manufacturer’s name,
3. Circuit breaker type and serial number,
4. Year of manufacture,
5. Frequency (Hz),
6. Rated Normal Current (A),
7. Rated Voltage (kV),
8. Lightning impulse withstand voltage (kVp),
9. Rated short-time withstand current (kA),
10. Purchase order number.

13.2.13. Tests

1. **Routine Tests:**

Contractor shall perform the routine tests as per the requirements ofIS:13118/IEC-56 & IEC-694.

- Power Frequency Voltage withstand dry test
- Voltage withstand test on control and auxiliary circuit
- Measurement of the contact resistance Mechanical and environmental tests, including mechanical operation test at ambient temperature, low and high temperature tests, humidity test, static terminal load test

2. **Type Tests:**

Contractor shall provide to the Purchaser the following type test reports:

- Temperature-rise,
- Lightning impulse voltage,

- Power frequency voltage test on main, auxiliary and control circuit
- Measurement of the resistance of the main circuit
- Short circuit making & breaking test including terminal fault test & out ofphase test
- Capacitive current switching test including line charging test
- Magnetizing and small inductive current switching tests (transformer magnetizing current)
- Short time withstand current and peak withstand current tests
- Test for degree of protection of enclosure
- Mechanical and environmental tests, including mechanical operation testat ambient temperature, low and high temperature tests, humidity test, static terminal load test

13.2.14. Contractor's Drawings

Contractor shall supply the following drawings for comments:

- Outline dimensioned drawing showing circuit breaker, control cabinetsand supporting structure,
- Assembly and sub-assembly drawings with part numbers
- Sectional drawing of the VCB highlighting construction features as wellas arc extinguishing chamber
- Detailed drawing of operating mechanism
- Control cabinets general arrangement drawing,
- Supporting structure installation details drawing along with foundationdrawing,
- Drawing showing weights and loads location,
- Nameplate drawing,
- Electric control circuits drawing complete with related bill of material.
- Test certificates and oscillographs
- Guaranteed technical particulars

13.2.15. Installation

Contractor shall install and commission the 33 kV circuit breakers in accordance with the requirements of this Specification and as required by the Engineer in charge at site. Tools as required for erection and maintenance, including any special tool for complete maintenance shall be supplied alongwith suitable racks for holding them. Testing instruments as required for erection and commissioning of VCB shall be the responsibility of the contractor.

13.3. 33 KV DISCONNECTOR SWITCH (ISOLATOR)

13.3.1. Scope

Contractor shall perform all necessary work for the supply, installation, commissioning and connection of the 33kV disconnect switches with or without earth switch as shown in Single Line Diagram or as required by the Purchaser and as specified hereafter. All the required accessories, documents &

equipment whether specified herein or not shall be in the scope of the bidder.

13.3.2. Supply

The technical specifications of the 33 kV disconnect switches supplied and installed by Contractor are defined hereafter.

13.3.3. Description

Contractor shall design, build, guarantee, deliver, perform the factory and commissioning tests, install and connect 33 kV disconnect switch as per single line diagram. All disconnect switches shall be triple pole, horizontal double break, center post rotating, three phase and outdoor type. All disconnect switches shall be hand operated type with arrangements to padlock the manual operating handle both in open and closed condition. The disconnect switches shall be complete with, supporting structures, operating mechanism and all other accessories required with isolator. These shall comply with the requirements of the IS: 9921.

13.3.4. Electrical Characteristics

The isolators 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 Isolators shall be mechanically interlocked with the main blade and shall be manually operated type. The isolator with earthing switch shall have the following ratings:

S.No	**Parameter**	**Description**
1.	Type	Outdoor, horizontal double break type.
2.	Rated Frequency	50 Hz.
3.	System neutral earthing	effectively grounded
4.	Number of poles	3
5.	Normal system voltage	33 kV_{rms}
6.	Highest System Voltage	36 kV_{rms}
7.	Basic Insulation Level	
a)	Lightning impulse withstand voltage: i) between line terminal and ground ii) between terminals with isolator open	 +/-170 kV_p +/-195 kV_p
b)	Power frequency dry and wet withstand voltage	

	-between line terminal and ground -between terminal with isolator open	70 kVrms 80 kVrms
10.	Rated normal current (for isolator only)	1250 A
11.	Rated short time withstand current of isolator and earth switch	25kArms for 1 sec.
12.	Rated peak withstand current of isolator and earth switch	62.5 kVp
13.	Temperature rise over design ambient temperature	As per IS:9921 Part-2
15.	Operating mechanism of isolator and earth switch	Manually operated
16.	Control voltage	220V DC
17.	Auxiliary contacts:	
a)	Continuous theramal rating	10A at 220 V DC
b)	Breaking capacity	2A DC with circuit time constant not less than 20ms.
18.	No. of auxiliary contacts on each isolator	10 NO + 10 NC contacts wired to terminal block for Purchaser use in future.
19.	No. of auxiliary contacts on each earthing switch	5 NO + 5 NC contacts wired to terminal block for Purchaser use in future.
20.	Number of terminals in control cabinet	All contacts and control circuits are to be wired upto control cabinet plus 20% spare terminals evenly distributed.
21.	Creepage distance of insulators	31mm/kV
22.	Design and Construction Details	
a)	Material of Blades	Hard drawn electrolytic Copper
b)	Silver plating of contacts	> 15 microns
c)	Manual operating handle	Shall be provided both for main

		isolator and earthing switch, suitably interlocked
d)	Marshalling Box	Weather proof having enclosure protection of IP: 55, made from heavy gauge galvanized sheet steel, with adequate no. of terminals for interlocking control cables and cable glands shall be provided for each switchyard Bay
e)	Mounting structure	Galvanized steel structure for Isolator, terminal box and marshaling box to be provided.
f)	Grounding terminals	2 Nos. to be provided for connection to station earth mat.

13.3.5. Control Mechanisms

1. A suitable diameter hand-wheel shall be supplied to ensure the three-pole operation.
2. The disconnect switches shall be of horizontal double break rotating (HDBR) type. Other mechanism of the isolator may also be proposed by the bidder if it is considered to be better than HDBR type.
3. Ten (10) adjustable auxiliary contacts shall be supplied to indicate the disconnect switch control position. These auxiliary contacts are to be located in an easily accessible cubicle to permit contact adjustment.
4. The control compartment shall include auxiliary contacts for control, the thermostatic control for heating and terminal block.
5. The control cabinet shall have provision of a cubicle heater. A shield shall be provided to avoid accidental contact with the heating element.
6. All control and power wiring shall be made with PVC (1100 V rating) insulated stranded copper conductors having a minimum cross section of 2.5 Sq. mm.
7. To prevent incorrect operations of disconnect switches, earthing switches and breakers, both electrical as well as mechanical interlocks shall be provided.

13.3.6. Insulators

All the disconnect switch insulators shall be made of porcelain.

1. Rated Voltage ((kVrms): 33
2. Lightning Impulse withstand voltage (dry & wet) (kVp): ±170
3. Power frequency with stand voltage (dry and wet) (kVrms): 70
4. Creepage distance (mm/kV): 31

5. Minimum Cantilever strength (kg): 350

13.3.7. Conductive Parts

The disconnect switch conductive parts shall be made of Aluminum conductor.

13.3.8. Supporting Structures

All disconnecting switches shall be provided with hot dipped galvanized steel supporting structures, foundation material and fastener.

13.3.9. Terminals

1. All disconnect switch power terminals shall be a NEMA four hole aluminium pad.
2. Terminals shall be suitable for its connection with the “Panther” conductor & 33 KV XLPE cable
3. Two (2) earthing terminals shall be located at the bottom of each supporting structure to allow bolted connection to the switchyard earthing grid (50 x 6 mm conductor). The earthing terminals shall be made of two 14 mm diameter holes, 38 mm spacing.

13.3.10. Name Plates

All disconnect switches shall be provided with a nameplate giving the following information:

- Marking “Disconnect Switch”
- Manufacturer’s name,
- Disconnect switch type and serial number,
- Year of manufacture,
- Frequency (Hz),
- Rated Current (A),
- Rated Voltage (kV),
- Lightning impulse withstand voltage (kVp),
- Rated breaking capacity (kA),
- Purchase order number.

13.3.11. Tests

1. **Routine Tests:**
   Contractor shall perform the routine tests as per the requirements of IS: 9921 (Part IV). Following Routine tests as per IS: 9921(Part IV)/IEC: 129 shall be carried out on each isolator in the presence of purchaser’s representative. Minimum 50 nos mechanical operations will be carried out on one isolator assembled completely with all accessories, as acceptance test.

a. Power frequency voltage dry test on the main circuit
b. Voltage tests on auxiliary and control circuit
c. Measurement of resistance of main circuit

d. Mechanical operating test

2. Type Tests:

The contractor shall provide the purchaser the following type test reports:

a. Lightning impulse test
b. Power frequency voltage test as per IS: 2071 (Part-2)
c. Test on auxiliary and control circuits
d. Temperature rise test of main circuit
e. Temperature rise test of auxiliary circuits
f. Measurement of resistance of main circuit
g. Short time withstand and peak withstand current tests
h. Test for short circuit making performance of earth switch
i. Operating and mechanical endurance test
j. Test for satisfactory operation at minimum and maximum temperature (special type test)

13.3.12. Contractor's Drawings

Contractor shall supply the following drawings for comments:

- Outline dimensioned drawing showing disconnect switch, control cabinet and supporting structure,
- Sectional view and description of details of isolators/ disconnect
- Mechanical interlock between earth and isolating switch
- Control cabinet general arrangement drawing,
- Supporting structure installation details drawing along with foundation drawing /design,
- Drawing showing weights and loads location,
- Nameplate drawing,
- Electric control circuits drawing complete with related bill of material.
- Guaranteed Technical Particulars.

13.3.13. Installation

Contractor shall install the 33 kV disconnect switches in accordance with the requirements of article of this specification and as required by the Purchaser.

13.4. 33 KV CURRENT TRANSFORMERS

13.4.1. Scope

Contractor shall perform all necessary work for the supply, installation, commissioning and connection of the 33 kV current transformers as shown in single line diagram or as required by the Purchaser and as specified below. All the required accessories, documents & equipment whether specified herein or not shall be in the scope of the bidder.

13.4.2. Supply

The technical specifications of the 33 kV current transformers supplied and installed by Contractor are defined hereafter. These shall comply with the latest revision of IS:2705.

13.4.3. Description

Contractor shall design, build, guarantee, deliver, perform the factory and commissioning test, install and connect 33kV, single phase, current transformersas per enclosed Single line Diagram. All current transformers shall be single- phase, oil immersed, sealed and outdoor type. The current transformers shall be complete with their supporting structures, junction box and all other accessories required for the current transformers.

13.4.4. Electrical Characteristics

The current transformers shall be of outdoor type, single phase, 50 cycles, oil immersed, self-cooled and suitable for operation under climatic conditions prevailing at site without any protection from sun, rain and dust.

Technical parameters of current transformers shall be as under:

S.No	**Parameter**	**Specification**
1	Nominal Voltage	33 kV_{rms}
2	Highest system voltage	36 kV_{rms}
3	Rated frequency	50 Hz.
4	System neutral earthing	effectively earthed
5	Installation	Outdoor
6	Type	Single phase
7	Rated Insulation Levels	
8	a) 1.2/50 micro-sec impulse b) One min. power frequency withstands	$170kV_p$ 70 kV_{rms}
9	Rated fault current	25 kA for 1 Sec
10	Rated extended primary current	120% of rated primary
11	Rated continuous thermal current	120% of rated primary
12	Dynamic current rating	62.5 kAp

13	Rated Secondary current	1 Amp.
14	One minute power frequency withstand voltage between secondary and earth	3 kV_{rms}
15	Creepage distance	31 mm/kV
16	Phase to phase spacing	1500mm
17	Current Transformer Characteristics:	Relaying and metering drg
18	Max. temperature rise over design ambient temperature of 50^0 C	as per IS:2705/ IEC:185
19	No. of terminals in marshalling box	All terminals of control circuits wired upto marshalling box plus 20% spare terminals evenly distributed onall TBs.
20	Parameters of Insulating oil:	
A	Appearance	The oil shall be clear and transparent and free from suspended matter or sediments
B	Density at 29.5 °C (max.)	0.89 gm / cm^3
C	Kinematics viscosity at 27 °C (Max.)	27 CST
D	Interfacial tension at 27 °C (Max.)	0.04 N/m
E	Flash point (minimum)	140 °C
F	Pour point (Max.)	-6 °C
G	Neutralization value (Max.)	0.03 mg KOH/gm
H	Corrosive Sulphur	Non-Corrosive
I	Electric strength (breakdown voltage) (Min.)	
J	a) New unfiltered oil b) After filtration	30 kV (rms) 60 kV (rms)

K	Dielectric dissipation factor (tan delta)at 90 °C (Max.)	0.002
L	Water content (Max) (in untreated and unfiltered oil)	50 ppm
M	Specific Resistance (Min) (ohm cm)at 90 °C at 27 °C	35 x 1012 1500 x 1012
N	Oxidation stability - Neutralization value (Max) - Total sludge after oxidation (Max)	0.40 mg KOH/gm .10 % by weight
O	Ageing characteristic after 96 hrs. asper ASTM-D1934/IS: 12177 with catalyst (copper) a) Specific Resistance (Min) (ohm cm) at 90 °C at 27 °C b) Tan delta at 90 °C (Max.) c) Total acidity (Max.) d) Sludge content	 2.5 x 1012 0.2 x 1012 0.2 0.05 mg KOH/gm 05% Wt. (Max.)
P	Presence of oxidation inhibitor	Total oil shall not contain antioxidant additives
24	Details of neutral earthing	Neutral effectively earthed

13.4.5. Design And Constructional Details

S.No	Parameter	Specification
1	Material of Winding	Copper
2	Material of core	Silicon laminated steel of low hysterisis loss and high permeability
3	Sealing, breathing	hermetically sealed with Nitrogen above oil

4	Type of primary winding	Single bar
5	Method of obtaining requisite current ratio	By Secondary taps
6	Type of terminal box for secondary	Weatherproof with enclosure protection of IP:55 and provided with cable glands with stud type disconnecting terminal block.
7	Junction boxes	One no shall be provided for a set of three current transformer.
8	Primary terminals	Suitable to received ACSR "Panther" Conductor with bimetallic terminal connector
9	Insulator	As per IS: 5621
10	Mounting Structure	Galvanised Steel Structure
11	Grounding Terminals	2 Nos. to be provided for connection to station mat

13.4.6. Terminals

1. All current transformer power terminals shall be suitable for connection to ACSR 'Panther' conductor as per ANSI/ASME B1.1 Standard.
2. All current transformers shall be provided with an earthing terminal. The earthing terminal shall be made of a two 14 mm diameter holes, 38 mm spacing, mild steel plate.

Two (2) earthing terminals shall be located at the bottom of each supporting structure to allow bolted connection to the switchyard earthing grid conductor(50 x 6 mm). The earthing terminals shall be made of two 14 mm diameterholes, 38 mm spacing.

13.4.7. Terminal Box

Each current transformer shall be provided with a terminal box. This connection box shall include a mild steel earthing bar. A removable cover shall be supplied on the front of the connection box to enable easy access to the secondary winding connections.

13.4.8. Three-Pole Junction Box

A three-pole junction box shall be supplied and installed on the centre-phase supporting structure of current transformers. This junction box shall be made of aluminium, weatherproof, 400 mm H x 360 mm W x 250 mm D, complete with cover, gasket, mild steel earthing bar and cover clamping hardware and should have terminals to be used for CTs for 6 mm² copper cable.

13.4.9. Supporting Structure

Each current transformer shall be provided with their hot dipped galvanized steel supporting structures, foundation material and foundation bolts.

13.4.10. Insulators

All the current transformer insulators shall be made of porcelain.

13.4.11. Accessories

All current transformers shall include at least the following accessories:

- Expansion equalizer,
- Oil level indicator,
- Filling and draining plugs,
- Oil sampling valve.

13.4.12. Name Plates

All current transformers shall be provided with a nameplate giving the following information:

- Marking “Current Transformer”
- Manufacturer’s name,
- Current transformer type designation and serial number,
- Year of manufacture,
- Frequency (Hz),
- Rated primary and secondary current,
- Rated output and the corresponding accuracy class,
- Rated voltage (kV),
- Lightning impulse withstand voltage (kV),
- Purchase order number.

13.4.13. Tests

1. **Routine tests:**

   Contractor shall perform the routine tests as per the requirements of IS:2705.

2. **Type tests:**
   Contractor shall provide to the Purchaser the following type test reports:

- Short-time current test

- Temperature-rise test
- Impulse test on primary winding,
- Wet power frequency test,

13.4.14. Contractor's Drawings

- Outline dimensioned drawing showing current transformer,
- Magnetising characteristics, ratio and phase angle and composite error curve
- connection and junction box general arrangement drawings,
- Connections diagram showing polarities,
- Nameplate drawing,
- Wiring diagrams complete with related bill of material.
- Supporting structure drawings
- Guaranteed technical Particulars

13.4.15. Installation

Contractor shall install the 33 kV current transformers in accordance with the requirements of this Specification and as required by the Purchaser.

13.5. 33kV POTENTIAL TRANSFORMERS

13.5.1. Scope

Contractor shall perform all necessary work for the supply, installation, commissioning and connection of the 33 kV class potential transformers as shown on single line diagram or as required by the Purchaser and as specified below. All the required accessories, documents & equipment whether specified herein or not shall be in the scope of the bidder.

13.5.2. Supply

The technical specifications of the 33 kV potential transformers supplied and installed by Contractor are defined hereafter.

13.5.3. Description

Contractor shall design, build, guarantee, deliver the factory and commissioning tests, install and connect 33 kV single phase potential transformers as per Single Line Diagram. All potential transformers shall be single-phase, oil insulated and outdoor type. These shall be mounted in a separate bay and connected between phase and ground and shall be used for metering, protection and synchronization. The voltage transformers shall also be provided with their supporting structures and all other accessories required with voltage transformers.

13.5.4. Electrical Characteristics

The voltage transformers shall have the following ratings:

Parameter	**Description**
Type of construction	Oil filled, outdoor, Electromagnetictype
Nominal system voltage	33 KV
Highest system voltage	36 KV
Rated Frequency	50 Hz
No. of secondary winding	3
Transformation Ratio	33 KV /√3/ 110 V/√3 / 110 /√3 /110V
Connection	Star/ Star/ Star, Delta
Rated Burden per phase & Accuracy Class of secondary	To be co-ordinated with protection system supplier
a. Protection	3P
b. Metering	0.2, 0.5
Rated voltage factor	1.2 continuous & 1.9 for 30 seconds
Creepage distance of Insulators	31 mm/kV
One minute power frequency withstand voltage between line terminal and ground	70 kVrms
Lightning withstand voltage between line terminal and ground	170 kVp
One minute power frequency withstand voltage for PT secondary	3 kVrms
Maximum temp rise over ambient	As per IS: 3156

temperature	
System Fault level	25 kA for 1 sec

13.5.5. Design And Constructional Details

(i)	Material of winding	Copper
(ii)	Material of core	Silicon laminated steel of low hysteresis loss
(iii)	Sealing breathing	Hermetically sealed, with nitrogen above oil
(iv)	Type of terminal box	Weather proof with enclosure protection of IP-55 and Provided with cable glands & stud type non disconnecting terminal block.
(v)	Junction box	Shall be provided for a set of three voltage transformers
(vi)	Primary terminals	Suitable to receive ACSR "Panther" conductor with bi-metallic terminal connector
(vii)	Insulating Oil	As per IS: 335
(viii)	Insulator	As per IS: 5621
(ix)	Mounting structure	Galvanized steel structure
(x)	Grounding terminals Station mat.	2 Nos. to be provided for connection to

13.5.6. Terminals

1. All the voltage transformer terminals shall be suitable for connection with ACSR Panther conductor as per ANSI/ASME B1.1 Standard
2. Terminals shall be suitable for its connection with the “Panther” conductor.
3. All voltage transformers shall be provided with an earthing terminal. The earthing terminal shall be made of a two 14 mm diameter holes, 38 mm spacing, mild steel plate.
4. The neutral side of the voltage transformer high voltage winding shall be brought out for earthing.

Two (2) earthing terminals shall be located at the bottom of each supporting structure to allow bolted connection to the switchyard earthing grid conductor(50 x 6 mm). The earthing terminals shall be made of two 14 mm diameterholes, 38 mm spacing.

13.5.7. Connection Box

Voltage transformers shall be provided with a weatherproof connection box. This connection box shall include a mild steel earthing bar. A removable cover shall be supplied of the front of the connection box to enable easy access to the secondary connections.

13.5.8. Three-Pole Junction Box

A three-pole junction box shall be supplied and installed on the centre-phase supporting structure of voltage transformers. This junction box shall be made of aluminium, weatherproof, 400 mm H x 360 mm W x 250 mm D, complete with cover, gasket, mild steel earthing bar and door clamping hardware.

13.5.9. Supporting Structures

All voltage transformers shall comprise their hot dipped galvanized steel supporting structures.

13.5.10. Insulators

All voltage transformers insulator shall be made of porcelain.

13.5.11. Accessories

All voltage transformers shall include at least the following accessories:

- Expansion equalizer,
- Oil level indicator,
- Filling and draining plugs,
- Oil sampling valve.
- Lifting lugs

13.5.12. Name Plates

All voltage transformers shall be provided with a nameplate giving the following information:

- Marking “Voltage Transformer”
- Manufacturer’s name,
- Voltage transformer type designation and serial number,
- Year of manufacture,
- Rated primary and secondary voltage (kV),
- Rated frequency (Hz),
- Rated output and the corresponding accuracy class,
- Highest system voltage (kV),
- Rated insulation level (kV),
- Rated voltage factor and corresponding rated time,
- Use of each winding and its corresponding terminals,
- Purchase order number.

13.5.13. Tests

1. **Routine tests:**
   Contractor shall perform the routine tests as per the requirements of IS: 3156.
2. **Type tests:**
   Contractor shall provide to the Purchaser the following type test reports:

- Temperature-rise,
- Impulse voltage,
- Ferro-resonance,
- Test for accuracy,

13.5.14. Contractor's Drawings

Contractor shall supply the following drawings for comments:

- General arrangement of VT showing dimensional details
- Mounting detail drawings,
- High voltage terminals drawing,
- Connection and junction box general arrangement drawings,
- Connection diagrams drawings,
- Nameplate drawing,
- Wiring diagrams complete with related bill of material.
- Graph between accuracy and percent rated voltage,
- Supporting structure drawing,
- Guaranteed Technical Particulars.

13.5.15. Installation

Contractor shall install the 33 kV voltage transformers in accordance with the requirements of this Specification and as required by the Purchaser

13.6. 30 KV LIGHTNING ARRESTER

13.6.1. Scope

Contractor shall perform all necessary work for the supply, installation and connection of the 30 kV lightning arresters as shown on single line diagram or as required by the Purchaser and as specified below.

13.6.2. Supply

The technical specification of the 30 kV lightning arresters supplied and installed by Contractor are defined hereafter. These shall be outdoor type, heavy duty, single pole, non-linear ZNO gapless station type, suitable for connection between line and earth, confirming to the provisions as laid out in the latest edition of IS:3070 and shall be suitable for satisfactory operations under the specified climatic conditions.

13.6.3. Description

Contractor shall design, build, guarantee, deliver, perform the factory and commissioning tests, install and connect eighteen (18) nos of 30 kV lightning arresters as per Single Line Diagram. The arrestors are to be used for protection of transformers, circuit breakers, isolators, PT, CT and the station insulation against lightning and switching surges and their construction shall be such as to offer full protection and insulation co-ordination of various equipment and the transmission line. The lightning arresters shall also comprise their supporting structures. All the required accessories, documents & equipment whether specified herein or not shall be in the scope of the bidder.

13.6.4. Electrical Characteristics

S.No	Parameter	Value
1	Rated Arrester Voltage	30 kV rms
2	Nominal System Voltage	33 kV rms
3	Highest System Voltage	36 kV rms
4	BIL of equipment to be protected	125 kV rms
5	System neutral earthing	Effectively earthed.
6	Frequency	50Hz
7	Nominal discharge current	10 kA
8	Maximum residual voltage at - Nominal discharge current of lighting impulse wave	100 kVp
9	Power frequency withstand voltage of housing	70 KVrms
10	Power frequency spark over voltage	70kVrms
11	Lightning impulse withstand voltage of housing	170 kVp
12	Long duration discharge class	Class II
13	Pressure relief class	Class A
14	Cross section of connecting leads	ACSR “Panther”/ 33 kV
		XLPE cable

15	Phase to phase spacing	1500 mm
16	Creepage distance	31 mm/kV
17	Continuous operating voltage	33 KVrms

13.6.5. Design And Construction Details

Construction details	Surge Arresters shall be suitable for outdoor duty and shall made from metal oxide discs connected in series without any spark gaps.
Type of monitoring device for	
Mounting structure for surge arresters and surge monitoring device	Galvanised steel structure
Insulators	As per IS 5621, Cantilever strength shall not be less than 350 kg

13.6.6. Terminals

1. All lightning arrester power terminals shall be a four-hole Aluminium NEMA pad.
2. Terminals shall be suitable for its connection with the “Panther” conductor & 33 KV XLPE cable.
3. All lightning arresters shall be provided with an earthing terminal. The earthing terminal shall be made of two 14 mm diameter holes, 38 mm spacing, steel pad.
4. Two (2) earthing terminals shall be located at the bottom of each supporting structure to allow bolted connection to the switchyard earthing grid conductor (50 x 6 mm). The earthing terminals shall be made of two 14 mm diameter holes, 38 mm spacing.

13.6.7. Supporting Structures

All lightning arresters shall comprise their hot dipped galvanized steel supporting structures. The lightning arrester supporting structures shall comply with the latest issue of the Standard.

13.6.8. Insulators

All the lightning arrester insulators shall be made of porcelain.

13.6.9. Insulating Base

All lightning arresters shall be provided with an insulating base between the lightning arrester base and the supporting structure. This insulating base shall sustain at least a continuous voltage of 1 kV.

13.6.10. Tests

1. **Routine Tests:**
   Contractor shall perform the routine tests as per the requirements of IS: 3070.
2. **Type Tests:**
   Contractor shall provide to the Purchaser the following type test reports:

- Insulation withstands test
- Residual voltage,
- Long duration current impulse withstands test
- Operating duty,

13.6.11. Contractor's Drawings

Contractor shall supply the following drawings for comments,

- Outline drawing showing lightning arrester shape, dimensions, mass, accessories and all necessary details for installation,
- Nameplate drawing,
- Insulation base drawing,
- Terminals drawing.
- Descriptive literature of the arrestor offered.
- Guaranteed Technical Particulars.

13.6.12. Installation

The lightning arrestors are required for installation near the generator transformers and on the outgoing feeder. The outgoing 33 KV transmission line shall be constructed on steel tubular poles and will be provided with an earth wire running below the conductors. In addition, the outdoor yard shall be protected against direct strokes by installing overhead ground wire on the switch yard structures. The ground wires shall be connected to the station ground at locations depending on design and the ground mat resistance. The installation work therefore would include steps to improve resistance. The earthing resistance of the common sub-station ground mat to which the ground wire leads will be connected should be of the order of one (1) ohm. The bidder may quote accordingly. The bid shall state the safe coverage distance of the LA offered, offering complete protection. The bid shall also clearly specify if installation of additional arrestors is required for the station transformer in the yard.

13.7. SWITCHYARD STRUCTURE

13.7.1. Scope

Contractor shall perform all necessary work for the supply, installation of the 33 kV switchyard structure as required by the Purchaser for both generating bays and line bays of switchyard.

13.7.2. Design Criteria

The structure shall be designed to take into account following loads as per IS: 802.

1. Wind load 2. Wire tension 3. Vertical load 4. Short circuit forces
5. Seismic forces

Wind load:

Wind pressure on towers and beams, on insulator strings, on conductor & ground wire, maximum tension in conductor and earth wire shall be calculated and submitted with the bid

Vertical loads :

These loads shall comprise the following

- Weight of conductor and steel wire
- Weight of insulator and hardware
- Self weight of tower & beams
- Weight of man with tool at mid point

Short circuit forces:

Bus supporting structure shall be designed to withstand lateral forces produced due to 3 phase short circuit of 25 kA for one second.

Seismic forces:

The structure shall be designed to withstand seismic forces as may be expected at this location.

Factor of safety for designing members of columns & beams shall be 2.0 in normal condition and 1.5 in abnormal condition.

Stresses in various members multiplied by factor of safety should not exceed the permissible stresses given by strut formulae as per IS: 802.

The maximum net working stresses considered for design for normal conditions shall be stated in the bid along with calculations and detailed stress diagram and loading tree.

The minimum thickness of leg members, ground wire peak & lower members of cross arm shall be 5 mm and minimum thickness of bracing and other members shall be 4 mm. Bolts less than 12mm diameter shall not be used. Not more than two sizes of bolts shall be used in one tower.

Structure shall be of bolted construction. Field welding shall not be permitted.

Various members, bolts, nuts and fittings shall be hot dip galvanized after fabrication.

Galvanizing shall meet all the requirements when tested in accordance with IS: 2633, IS: 2629 & IS: 4759.

Galvanizing of each member shall be carried out at in one complete immersion double dipping shall not be permissible.

13.8. ACSR CONDUCTOR

Steel reinforced aluminium conductor shall be used for 33 kV switchyard and shall have following ratings.

S.No	Particular	Details
1	Code name of conductors	ACSR “Panther”
2	Copper equivalent Area (mm2)	130
3	Number of aluminum strands & dia of each strand (mm)	30/3.00
4	Number of aluminum strands & dia of each strand (mm)	7/3.00
5	Total sectional area (mm2)	262
6	Overall dia (mm)	21
7	Approx. Mass of conductor kg/km	976
8	Calculated d.c. resistance at 20 deg C (ohm/km)	0.1375
9	Minimum UTS (KN)	89.67
10	Modulus of elasticity (GN/ m2)	80
11	Coefficient of linear expansion per degree C	17.80×10^{-6}

The conductor accessories shall be free from inequalities, spills, splits, or other defects and shall be smooth, close grounded and have true forms and adequate dimensions.

The design and construction of conductor accessories shall be such that they can be easily fitted and are free from unsightly projections, sharp edges etc., Bolts nuts, washers check nuts etc, used in the parallel groove clamps, connectors etc. shall be made of stainless steel.

All parts of fittings shall be either inherently resistant to atmospheric corrosion or suitably protected against corrosion both during service and storage.

All current carrying parts shall be so designed and manufactured so that minimizes the contact resistance.

13.9. EARTH WIRE

Galvanized earthwire shall be used for earth wire in 33kV switchyard and shall have following ratings.

S.No	Parameter	Description
a)	Material of earthwire	Galvanized Steel
b)	Stranding/wire diameter(mm)	7/3.15
c)	Total sectional area (mm2	54.55
d)	Over all diameter(mm)	9.45
e)	Approximate weight	428 kg/km
f)	Calculated de resistance at 20 deg C (ohms/km)	3.375
g)	Minimum UTS (kg)	5710
h)	Coefficient of linear expansion/deg C	11.5x10 -6

GSS earth wire shall be complete with all accessories such as mid span compression joints, suspension clamp, tension clamp, earth bonds, vibration dampers etc.

13.9.1. Workmanship:

1. All steel strands of earth wire shall be smooth, uniform and free from all imperfections such as spills and splits, die marks, scratches, abrasions and kinds after drawing and also after stranding. The earth wire shall be free from grease, metal particles dirt etc.
2. The finished steel strands shall have minimum brittleness, as it will be subjected to appreciable vibrations while in use.

3. The steel strands shall be dip galvanized and shall have a minimum zinc coating of 274 gm/sq.m. The zinc coating shall be smooth, continuous of uniforms thickness, free from imperfections.

13.10. INSULATOR STRINGS

Insulator strings shall have following ratings.

S.No	Description	Suspension	Tension
1	Size of disc (dia x spacing mm)	255x145	255x145
2	No of standard discs	2	2
3	Electromechanical strength (KN)	45	45
4	Mechanical strength of complete string (KN)	45	45
5	Creepage distance	31mm/kV	31mm/kV
6	Lightning impulse with stand voltage of string	170 kVp	170 kVp
7	Power frequency withstand voltage of string	70 kV(rms)	70 kV(rms)

Insulator strings shall be complete with hardware fitting including appropriate clamps and other hardware.

13.11. POST INSULATORS

S.No	Parameter	Value
1	Type	Solid Core
2	Nominal system voltage	33Vrms
3	Highest system voltage	36kVrms
4	Rated frequency (Hz)	50 + 3%
5	Rated short time withstand current of	25

	insulator (KA rms)	
6	Rated duration of short time current	1 sec
7	Rated dynamic short circuit withstand current of insulator	62.5 kAp
8	Dry lightning impulse withstand Voltage	170kVp.
9	Dry & wet one minute power frequency withstand voltage	70 kV (rms)
10	Minimum cantilever strength	350kg
11	Minimum creepage distance	31 mm/kV
12	Mounting structure	Galvanized steel structure

13.12. SPARE PARTS AND TOOLS

The spare parts mentioned hereunder are meant for use by the Employer for 5 years trouble free operation & shall not be used as erection / commissioning spares required during installation. All the spare parts shall be interchangeable & shall be of the same material and workman ship as corresponding parts of the main equipment.

If any additional spare parts required for a 5 years trouble free operation period are recommended by contractor, these shall be listed and the unit price shall be quoted in the price schedule. The Employer reserves the right to order any or all of such spares.

All spare parts shall be protected against corrosion suitably packed and shall be marked with identification labels in the English Language. The identification shall be in accordance with the agreed Works Identification System.

All spare parts, tools and materials shall be delivered in marked boxes of sufficient sturdy construction to withstand long term storage. Material that is subjected to long term storage shall be stored in a dry, ventilated room with low humidity.

Acceptance of any spare parts will not take place before the Contractor has submitted the complete final list of all spare parts and tools. They shall be replaceable without cutting or destruction of adjacent components. Before issue of the Completion Certificate, the spare parts shall be checked at the Site by the Contractor in presence of the Engineer / Employer.

Mandatory Spare Parts

Sl.No	Description	Qty
1.	Trip coils of CB	1 No for each CB supplied
2.	Closing coils of CB	1 No for each CB supplied
3.	Spring charging Motors	2 Nos.
4.	Operating mechanism box of Isolator	1 No.
5.	Isolator with earth switch	1 No.
6.	Current Transformers	1 No. of each type
7.	Voltage transformers	1 No. of each type
8.	Insulators string Suspension Tension	 3 Nos. 3 Nos.
9.	All types of clamps (for main conductor of earth wire)	2 Nos. each
10.	ACSR conductor	50 m.
11.	Lightning arrestor along with Surge counter, insulating base and connecting copper braids	2 Nos.
12.	Post Insulator	3 nos.

If any additional spare-parts required for trouble free operation are recommended by bidder, these shall be listed and the unit price shall be quoted in the price schedule. The Employer reserves the right to order any or all of such spares.

Tools and Instruments

The Supplier shall supply all necessary tools, devices, testing Instruments / equipment etc. for installation, repair and maintenance at site. These shall remain the property of the Supplier unless otherwise agreed to be taken over by Employer any / all of these at mutually agreed conditions.

Commissioning of Switchyard

The Bidder shall obtain necessary permission for commissioning 33 kV Switchyard from Electrical Inspector by submitting required documents in advance as to avoid delay in commissioning of switchyard.

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14. ELECTRICAL WORKSHOP

14.1. Scope of Work

Scope of work under this section covers the provision of labour, tools, plants, materials and performance of work necessary for the design, manufacture, quality assurance, quality control, shop assembly, shop testing, delivery at site, site storage and preservation, installation, commissioning, performance testing, acceptance testing, training of Employer's personnel, handing over to Employer and guarantee of electrical workshop equipment as per the specifications hereunder, each complete with all auxiliaries, accessories, spare parts and warranting a trouble free safe operation of the installation.

The scope of work shall be a comprehensive functional system complete in every respect including but not be limited to following:

14.2. Electrical Workshop

1. Measuring devices:
   Measuring devices as defined in later clauses "Measuring devices" of this section.
2. Testing devices:
   Testing devices as defined in later clauses "Testing devices" of this section.
3. Transformer oil testing devices:
   Transformer oil testing devices as defined in later clauses "Transformer oil testing devices" of this section.
4. Tools and devices:
   Tools and devices as defined in later clauses "Tools and Devices" of this section.
5. Lockers:
   Lockers as defined in later clauses "Workbenches, lockers and instruments" of this section.

14.3. Specific Parameters and Layout Conditions

An electrical workshop is to be located in the powerhouse to meet the requirements of powerhouse O&M works. This workshop shall be equipped with all general, measuring, testing, calibrating tools and devices as elaborated below. However, this list is indicative only and final list shall be approved during detailed engineering.

14.4. Rating and Functional Characteristics

14.4.1. Rating

Measuring devices

The following items shall be supplied with all accessories, carrying cases, connecting leads, power supply unit / cells etc. necessary for operation.

1. One (1) DC motorised insulation testers (Make- Meggar) with:
    - Accuracy: ±2%,
    - Range 100 KΩ to 100 GΩ at Steps of 500 V, 1 kV, 2.5 kV and 5 kV with locking and non-locking test buttons;
    - Battery.

2. One (1) DC manual insulation testers (Make- Meggar) with:
    - Accuracy: ±2%,
    - Range 1 MΩ to 100 GΩ at 500 V and 1000 V; III. One (1) portable universal bridge with:
    - Accuracy class: 1,
    - Built in capability for storing, printing and downloading test results, Ranges,
        - Resistance: 100 m Ω...10 MΩ,
        - Inductivity: 1...100 H,
        - Capacity. 10 pF...1 µF,
        - tanδ: 0...1 in several steps,
        - Frequency range: 15...1000 Hz.

3. Two (2) digital multimeters for AC and DC with:
    - Accuracy,
    - DC: ±1%,
    - AC: ±1.5%,
    - Ohm: ±1%.
    - Ranges,
        - voltage: 60 mV... 1000 V in several steps,
        - current :1.5 mA...30 A in several steps,
        - Resistance: 0...50 k Ohm.
    - Continuity audible test,
    - Diode test, capacitance measurement, frequency measurement,
    - Hold display features,
    - Overload protection.

4. Two (2) analog multimeters for AC and DC with:
    - Accuracy,
        - DC: ±1%,
        - AC: ±1.5%,
        - Ohm: ±1%.
    - Ranges,
        - voltage: 60 mV... 1000 V in several steps,
        - current: 1.5 mA...30 A In several steps,
        - Resistance: 0...50 kohm.

5. Laboratory connection leads, suitable for all specified instruments, with vulcanized banana plugs on ends, 1.5 mm2 copper, high-flexible, insulated voltage class 1000 V with:
    - Twenty (20) leads of each colour namely yellow, black, green, red, blue length 0.5 m,
    - Ten (10) leads of each colour namely yellow, black, green, red, blue length.
    - 1.5 m,
    - One (1) ring (100 m) laboratory cable,
    - Fifty (50) banana plugs,
    - Fifty (50) test clips fitting to banana plugs.

6. Two (2) single phase toroidal transformers with:
    - Primary voltage: 230 V,
    - Secondary voltage: 0 ... 230 V stepless adjustable,
    - Rated power: 2500 VA.

7. Two (2) phase-sequence indicators with:
    - Voltage :100...500 V,
    - Terminals marked with L1, L2, L3,
    - Frequency 15...1000 Hz.

8. One (1) portable digital frequency meter with:
    - Accuracy class:0.5,
    - Rated voltages:5 V...550 V,
    - Ranges: 40...60 Hz.

9. One (1) contact type portable temperature measuring instrument with sensor and batteries:
    - Accuracy: ± 0.5 % reading,
    - Range: -50°C to +21O°C in several steps,
    - Setting time: maximum 3 seconds.

10. One (1) digital mechanical revolution counter with:
    - Range: 0... 15000 rpm in several steps.

11. One (1) stop-watches with:
    - Three (3) separate scales.

12. Two (2) Clamp-on voltammeters with:
    - Accuracy class: 1.5,
    - Ranges: 1.2...60 A and 60...600 V in several steps,
    - For round conductors up to 30 mm diameter,
    - For flat conductors up to 30 x 45 mm,
    - All accessories.

13. One {1) portable earth resistance measuring device with:
    - Accuracy class: 1,
    - Digital indication,

- Measuring ranges: 0.... 20 Ω in steps of .01 Ω

  0 .. 200 Ω in steps of .1 Ω

  0....2000 Ω in steps of 1.0 Ω

14. One (1) micro ohm-meter of the portable type, suitable for measuring contact resistance of high voltage equipment, with:

    - 230 V AC power supply,
    - Measuring range: 0 -1999 μΩ,
    - Accuracy: 1%,
    - Output current: 0 - 400 A DC,
    - All accessories.

15. Thermal Imaging Camera

14.5. Testing devices

Automatic turns ratio tester [single & three phase]

The equipment offered shall be used for measurement of turns ratio of various transformers and bushing current transformers automatically displaying the ratio without requiring any manual balancing of scales.

Technical Requirement

- Operation Voltage 230 volts: 50Hz, single phase A.C,
- Test Voltage 230 volts AC,
- Accuracy ±0.5%ofFSD.

The kit shall be capable of operating at a temperature of 50°C and at humidity up to 85%. It should have the facility to store 100 results and upload to PC.

Calibration certificate for each testing instrument covering entire range should be supplied with the test kit at the time of supply.

14.5.1. Transformer oil testing devices

1. One (1) no. high voltage insulation oil testing device, which shall be an automatic testing device, freely programmable, for execution of test specifications according to 1EC / VOE or other international test standards, complete with all accessories, suitable for:
   - Test voltage: 0 100 kV AC,
   - Connection voltage: 230 V, 50 Hz.
2. One (1) resistivity measurement kit,
3. One (1) set. Karl Fischer type moisture measurement kit.

14.6. Tools and devices

1. One (1) hydraulic crimping machine for crimping all sizes of power cables,
2. Crimping tool kit, consisting of pliers and dies for insulated cable lugs 0.55 - 2.5 mm2, bare tube cable lugs 0.5 - 6 mm2 and ferrules 0.25 - 10 mm2 (Typical make Phoenix),
3. Crimping pliers, for non-insulated cable lugs 4 - 10 mm2, double indent crimp (Typical make Phoenix),
4. Stripping tools for conductor and cables (For PVC insulated conductor 0.02 - 10 mm2) (Typical make Phoenix),
5. Basics pliers to accommodate crimping inserts (Typical make Phoenix);
6. Tool set for stripping, crimping and screwing consisting of:
    - Stripper for 0.02 - 10 mm2 (AWG 34-8) with cable cutters up to 10 mm2 (AWG 8),
    - Crimping pliers for ferrules 0.5 - 6 mm2 (AWG 20-10),
    - Screwdriver for slotted-head screws, blade 0.6 x 3.5 x 100 mm,
    - Ferrules, 50 pcs. each 0.5 mm2 (AWG 20), 2.5 mm2 (AWG 14),
    - Ferrules, 100 pcs. each 0.75 mm2 (AWG 18), 1.5 mm2 (AWG 16). (Typical make Phoenix Tool - SET ALLROUND 3))
7. Battery powered screwdriver, inclusive battery pack, charger, user manual, case, for 230 V AC (Typical make Phoenix),
8. Four (4) short, filled nylon headed mallets,
9. One (1) silica gel drying oven of stainless steel, with" minimum clear size of 500 mm x 500 mm x 500 mm, temperature range 60...240°C,
10. One (1) motor winding drying oven for drying the windings of the motors having ratings upto 100 kW,
11. One (1) vacuum cleaners of 1000 W,
12. Two (2) sets of electric nut tighteners;
13. Two (2) hot air blowers having:
    - Power input: 1500 W
    - Temperature control :150 / 560°C,
    - Airflow: 400 / 450 litre/min.

14.6.1. Lockers

Three (3) tool lockers of appropriate size.

14.7. Performance Guarantee

The electrical workshop equipment along with all auxiliaries and accessories shall be capable of performing intended duties under specified conditions. The Bidder shall guarantee the reliability and performance of the individual equipment as well as of the complete system.

14.8. Design and Construction

14.8.1. Standards

The system and equipment shall be designed, built, tested and installed to the latest revisions of the following applicable standards. In the event of other standards being applicable they will be compared for specific requirement and specifically approved during detailed engineering for the purpose:

The equipment of the electrical workshop shall be designed and constructed to suit the requirement of the powerhouse.

14.8.2. Drawings, Documents and Design Calculations

The list of drawings / documents which are to be submitted to the Employer shall be discussed and finalized by the Employer at the time of award.

The Bidder shall submit all the drawings / documents unless anything is waived. The Bidder shall also supply calculations, studies, bills of material, Input and Output lists, operating sequences, setting reports, cable schedule, wiring and connection schematics and pre commissioning test procedures and reports.

The Bidder shall submit six (6) sets of drawings / design documents / test reports as may be required for the approval of the Employer.

All drawings submitted by the Bidder including those submitted at the time of bid shall show enough details to indicate the type, size, arrangement, material description, Bill of Materials, weight of each component, break-up for packing and shipment, the external connections, fixing arrangement required, the dimensions required for installation and interconnections with other equipment and materials, clearances and spaces required for installation and interconnections between various portions of equipment and any other information specifically requested in the specifications.