UJVN LIMITED

4X39 MW UJVNL, CHILLA HEP, PAURI, GARHWAL, RMU HYDRO ELECTRIC PROJECT

TECHNICAL SPECIFICATION

FOR

HVAC SYSTEM

SPECIFICATION NO.: - PE-TS-464-571-11000-A001 (REV00)
(MAY-2025)

BHARAT HEAVY ELECTRICALS LIMITED
POWER SECTOR
PROJECT ENGINEERING MANAGEMENT
BHEL SADAN, PLOT NO.-25,
SECTOR-16A, NOIDA, INDIA

	TITLE: 4X39 MW UJVNL, CHILLA HEP, RMU HYDRO ELECTRIC PROJECT TECHNICAL SPECIFICATION FOR HVAC SYSTEM	SPECIFICATION No: PE-TS-464-571-11000-A001	
		SECTION	
		REV. 00	DATE: MAY 2025
		SHEET: 1 OF 2	

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This Technical specification consists of two sections:

SECTION - I

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SECTION - I

SECTION-I

SUB-SECTION-A

INTENT OF SPECIFICATION

1.0 INTENT OF SPECIFICATION

1.1 The specification covers design (i.e. Preparation and submission of drawing /documents including "As Built" drawings and O&M manuals), engineering, manufacture, fabrication, assembly, supply / procurement, inspection and testing at vendor's / sub vendor's / manufacturer's works, painting, maintenance tools & tackles (as applicable), fill of lubricants & consumables till handing over, mandatory spares along with spares for erection, start-up and commissioning as required, forwarding, proper packing and shipment till storage area and delivery from storage area to site, unloading, handling & on-site transportation, storage, preservation , security / safety at site , Erection & Commissioning, final painting at site, minor civil work, trial run at site and carrying out Performance guarantee / Functional / Demonstration tests at site (As applicable), training of customer / client O&M staff, and handover in flawless condition of the package to the end customer complete with all accessories for the total scope defined as per BHEL NIT & tender technical specification as specified above, amendment & agreements till placement of order for **4X39 MW UJVNL, CHILLA HEP, RMU (Renovation, Modernization & Upgradation), HYDRO ELECTRIC PROJECT (HEP) PAURI, GARHWAL-HVAC SYSTEM**.

1.2 The contractor shall be responsible for providing all material, equipment & services, which are required to fulfil the intent of ensuring operability, maintainability, reliability and complete safety of the complete work covered under this specification, irrespective of whether it has been specifically listed herein or not. Omission of specific reference to any component / accessory necessary for proper performance of the equipment shall not relieve the contractor of the responsibility of providing such facilities to complete the supply, erection and commissioning, performance and guarantee/ demonstration testing of **HVAC SYSTEM.**

1.3 It is not the intent to specify herein all the details of design and manufacture. However, the equipment shall conform in all respects to highest standards of design, engineering and workmanship and shall be capable of performing the required duties in a manner acceptable to purchaser who will interpret the meaning of drawings and specifications and shall be entitled to reject any work or material which in his judgement is not in full accordance herewith.

1.4 The extent of supply under the contract includes all items shown in the drawings, notwithstanding the fact that such items may have been omitted from the specification or schedules. Similarly, the extent of supply also includes all items mentioned in the specification and /or schedules, notwithstanding the fact that such items may have been omitted in the drawing. Similarly, the extent of supply also includes all terms required for completion of the system and not withstanding that they may have been omitted in drawings / specifications or schedules.

1.5 The general term and conditions, instructions to tenderers and other attachment referred to elsewhere are made part of the tender specification. The equipment materials and works covered by this specification is subject to compliance to all attachments referred to in the specification. The bidder shall be responsible for and governed by all requirements stipulated herein.

1.6 While all efforts have been made to make the specification requirement complete & unambiguous, it shall be bidders' responsibility to ask for missing information, ensure completeness of specification, to bring out any contradictory / conflicting requirement in different sections of the specification and within a section itself to the notice of BHEL and to seek any clarification on specification requirement in the format enclosed under Vol-III of the specification **within 10 days of receipt of tender documents.** In absence of any such clarifications, in case of any contradictory requirement, the more stringent requirement as per interpretation of Purchaser / Customer shall prevail and shall be complied by the bidder without any commercial implication on account of the same. Further in case of any missing information in the specification not brought out by the prospective bidders as part of pre-bid clarification, the same shall be furnished by Purchaser/ Customer as and when brought to their notice either by the bidder or by purchaser/ customer themselves. However, such requirements shall be binding on the successful bidder without any commercial & delivery implication.

1.7 The bidder's offer shall not carry any sections like clarification, interpretations and /or assumptions.

1.8 Deviations, if any, should be very clearly brought out clause by clause along with cost of withdrawal in the enclosed schedule (in Vol – III); otherwise, it will be presumed that the vendor's offer is strictly in line with NIT specification. If no cost of withdrawal is given against the deviation, it will be presumed that deviation can be withdrawn without any cost to BHEL/its customer.

1.9 In the event of any conflict between the requirements of two clauses of this specification documents or requirements of different codes and standards specified, Section – C1 shall prevail over section – D, however more stringent requirement as per the interpretation of the owner shall apply.

Further, In case of any discrepancy in section 'C1' and section 'C2', Section-C2 shall prevail (customer specification).

1.10 In case all above requirements are not complied with, the offer may be considered as incomplete and would become liable for rejection.

1.11 For definition of word like Contractor, bidder, supplier, vendor, Customer/ Purchaser Employer, consultant, please refer relevant clause of NIT.

SECTION: I

SUB-SECTION: B

PROJECT INFORMATION WITH WIND AND SEISMIC DESIGN CRITERIA

(PLS REFER SUB-SECTION: C2-A CUSTOMER SPECIFICATION-GENERAL TECHNICAL REQUIREMENT CHILLA HEP)

SECTION: I

SUB SECTION: C1

TECHNICAL SPECIFICATION

SECTION: I

SUB-SECTION: C-1

SPECIFIC TECHNICAL REQUIREMENT

1 FUNCTION

The purpose of the system is to provide Air-Conditioning & Ventilation for different areas of CHILLA RMU (4 x 36 MW) under the scope of BHEL. To achieve proper working conditions inside the power house complex, HVAC system is provided to serve the following purpose:

a. To prevent temperature stratification

b. To remove contaminated air

c. To remove waste heat from equipment

d. To provide outside fresh air necessary for human comfort

2 SYSTEM DESCRIPTION

Conditioned and dehumidified air shall be supplied to different zones of the powerhouse in accordance with heat generated in each zone. The power station shall be divided into two zones as below:

(A) Air Conditioning Zone

(B) Ventilation zone

2.1 AC SYSTEM ZONE CONSIST OF THE FOLLOWING AREAS.

2.1.1 2x100% Air-cooled DX type condensing units along with D-X type AHU type air conditioning plant shall be provided to cater to the air conditioning requirements of the following areas of power house.

2.1.1.1 Control room

2.1.1.2 LT room

2.1.1.3 Carrier / PLCC room

2.1.1.4 Existing battery room & Battery charger room

2.1.1.5 Test room

2.1.1.6 Committee room, offices and other facilities

2.1.2 Air cooled split air conditioners shall be provided for other area if required.

2.2 VENTILATION SYSTEM ZONE CONSIST OF THE FOLLOWING AREAS

DRY TYPE VENTILATION SYSTEM

2.2.1 Ventilation system by adopting 4 Nos. (W) fresh air blowers shall be provided. Supply air from fresh air blowers shall be fed to various areas of power house as detailed below through duct.

2.2.1.1 Strainer / Gallery / Draft tube floor at RL 284.6M.

2.2.1.2 Turbine floor at RL 292.4M.

2.2.1.3 Generator Floor at RL 295.3M.

2.2.1.4 Erection / Service Bay / Machine floor at RL 299.6M.

2.2.1.5 Unloading Bay area RL 303M.

2.2.2 Axial fans for Toilets and Battery Room for power house.

2.2.3 Axial fans for AC Plant room of power house

2.2.4 Axial fans for Store and Workshop of power house (Floor mounted ducted fan)

2.2.5 Axial fans for sub-station building at switchyard area.

2.3 REFERENCE DOCUMENT / DRAWINGS

The following drawings shall be referred while designing the HVAC System:

2.3.1 12000020751_Rev 01: TRANSVERSE SECTION THROUGH CENTER LINE OF POWER HOUSE

2.3.2 12000020752_Rev 01: PLAN AT RL. 299.6M (MACHINE HALL FLOOR)

2.3.3 12000020753_Rev 01: PLAN AT RL 295.1M (TURBINE HALL FLOOR)

2.3.4 12000020754_Rev 01: PLAN AT RL 292.4

2.3.5 12000020755_Rev 01: PLAN AT RL. 284.60 (GALLERY FLOOR)

2.4 Complete Structural work for erection of mechanical, electrical and C & I equipment, support, inserts for duct / fans / pipes / cable tray etc. is in bidder's scope. Following may please be noted.

a. Duct support structure outside and inside power house for routing supply / exhaust duct / cable trays etc. from AHU room shall be in bidder's scope. Necessary supports may be taken from nearest structure / walls / roofs / floors etc. by bidder subject to customer / BHEL acceptance during detail engineering.

b. Fixing frame works for diffusers and grilles in the scope of Vendor.

c. Anchor fastener / HILTI fasteners shall be used by vendor for fixing duct/ pipes etc. wherever applicable.

d. Duct supporting and accessories material such that hangers, tie rods, nut, bolts, lock nut, washer, HILTI fastener, gasket, bracing, adhesive, sealant, rivets, angles, channels, bracket support etc. for completeness of duct installation in all aspects shall be in bidder scope.

e. Any other type of structural work for complete HVAC system is deemed to be in bidder's scope even though specifically not mentioned above.

3 DESIGN CRITERIA

3.1 SYSTEM DESIGN CRITERIA – AMBIENT CONDITIONS

3.1.1 The outside design conditions considered shall be under: -

	Summer	Monsoon	Winter
DBT (°C)	40.5	32.2	5.5
WBT (°C)	23.8	26.6	3.3
RH (%)	25	65	70

3.1.2 Maximum ambient temperature of air in summer: 46.9°C

3.1.3 Minimum ambient temperature of air in winter: 2°C

3.1.4 Maximum Relative humidity: 86%

3.1.5 Minimum Relative humidity: 46%

3.1.6 Ambience temperature of water river: 35 °C

3.2 SYSTEM DESIGN CRITERIA - AIR CONDITIONING SYSTEM

3.2.1 The inside design conditions to be maintained shall be as under: -

- 24°C ± 1^0C & RH 50% ± 5% for control room etc.

3.2.2 Fresh air requirement shall be minimum 1.0 air change per hour for control room areas or 16 CFM per person whichever is higher. For other areas like office, Fresh air shall be considered as per ISHRAE.

3.2.3 A design margin of 10% on total sensible heat, 12.5% on total latent heat and 10% on overall machine capacity shall be considered while designing the AC System of each area.

3.2.4 Necessary Heater and Humidifier shall be provided (if required). However, no humidity control shall be provided where wall mounted split AC / cassette type AC shall be used.

3.2.5 The maximum air velocity through Air conditioning duct shall be 7.6 m/sec in main duct and 6.0 m/sec in branch duct.

3.3 SYSTEM DESIGN CRITERIA - VENTILATION SYSTEM

3.3.1 Inside Temperature shall be maximum 5 deg. C above the design ambient temperature during summer for mechanically ventilated areas

3.3.2 Ventilation provision for various location is envisaged as follows

S.No.	Name of premises	Type of Ventilation	ACPH	Occupancy
1.	Battery room	Wall mounted exhaust fans (spark proof with flame proof motor)	8	0
2.	Machine Hall	Fresh Air supply Blower	2	10
3.	Erection bay	Fresh Air supply Blower	2	
4.	Unloading bay	Exhaust by means of wall mounted axial flow exhaust fans.	2	2
5.	Store and Mechanical workshop	Exhaust by means of wall/floor mounted axial flow exhaust fans.	4	4
6.	Generator floor	Fresh Air supply Blower	2	4
7.	Switchgear room in power house	Fresh Air supply Blower	4	0
8.	Compressor room	Fresh Air supply Blower	4	2
9.	AC Plant Room	Exhaust by means of wall mounted axial flow exhaust fans.	4	2

10.	Turbine floor	Fresh Air supply Blower	2	4
11	Staircase area	Fresh Air supply Blower	2	0
12	MIV Floor	Fresh Air supply Blower	2	4
13.	DG set Room	Exhaust by means of wall mounted axial flow exhaust fans. Fresh air supply through of intake Louvers	10	0
14.	Toilets & pantries for Power House and other areas	Exhaust by means of propeller type exhaust fan. Supply through door undercuts / door louvers	8	0
15.	Switchgear room for outside power house	Fresh air supply through axial supply air fan. Exhaust through gravity damper.	4	0
16.	Store room for outside power house	Exhaust by means of wall mounted axial flow exhaust fans.	4	0

3.3.3 Air quantities shall be calculated based on heat load basis based on heat dissipation values from the various equipment, other heat source in various areas and the air quantity calculated based on air changes per hour and adopting higher of the two values.

3.3.4 The maximum air velocity through ventilation duct shall be 10 m/sec.

3.3.5 Ventilation system shall operate on 100% fresh air.

3.4 CODES AND STANDARDS

The following standards, codes and technical documents are used for the design of HVAC system.

3.4.1 ASHRAE / ISHRAE Guide and data book, American Society of Heating, Refrigerating and Air Conditioning Engineers.

3.4.2 IS: 655/ IS 277 for Sheet Metal Air ducts.

3.4.3 IS: 4720 (Latest), Indian Standard Code of Practice for Ventilation of Surface Hydel Power Stations.

3.4.4 IS: 3103- Code of practice for industrial ventilation

3.4.5 ANSI/ Standard 62- Ventilation for acceptable indoor air quality

3.4.6 IS 659- Safety code for Air-conditioning.

3.5 GENERAL PRINCIPLES

3.5.1 Fresh air shall be supplied generally at low points of the powerhouse and exhaust air shall be at high points.

3.5.2 Areas such as battery room, toilet and pantry which are exposed to harmful gases or odors shall be maintained at negative pressure and these harmful gases / odors shall be exhausted outside the power building with the help of separate exhaust air fans.

3.5.3 Lighting load considered shall be 1 Watts/sq. feet or actual whichever is higher.

3.5.4 The Occupancy considered shall be 1 person in 25SQM or (actual) whichever is higher.

3.5.5 All the equipment for HVAC system shall be designed for continuous duty.

3.5.6 The heat dissipation values from various equipment / Occupants shall be taken into consideration while designing the HVAC system.

3.5.7 For winter Load calculations, only the lighting load shall be considered and equipment load shall be considered as Zero (0).

3.5.8 Design noise level shall be of NC 35-45 within control room, control equipment room, instruments and electronic room and offices.

3.5.9 Velocity through face area (max.) of different system equipment shall be as under.

a) intake louvers: 2.5 m/s.
b) Exhaust louvers: 2.5 M/s.
c) Volume control dampers: 10 m/s.
d) Back Draft dampers: 6 m/s
e) Supply Air grills/ Diffusers for Ventilation area: 5m/s.
f) Supply air grills / diffusers for AC area: 2.5 m/s.
g) Pre-filters: 2.5 m/s.
h) Fine filters: 1.5 m/s (150mm thick) and 2.5 m/s (300mm thick).

3.5.10 Motor design ambient temp

a) Roof Exhausters and wall mounted Exhaust Fans: 55-degree C ambient.
b) supply air fans: 50-degree C ambient.

4. GENERAL DESCRIPTION OF VENTILATION AND AIR CONDITIONING SCHEME

4.1 VENTILATION SYSTEM

4.1.1 POWER HOUSE AREA

4.1.1.1 Dry type Ventilation by mean of fresh air blowers shall be provided.

4.1.1.2 The supply air quantity requirement will be worked out based on heat load calculation from first principle as well as for maintaining minimum no. of air changes as per IS:4720. The higher value of the two shall be adopted for supplying air to various areas of power house.

4.1.1.3 In order to meet the above requirements, 4 nos. Fresh Air Blower shall be provided.

4.1.1.4 Each Fresh Air Blowers of required capacity shall be placed outside Power House at transformer area at RL 303M. These units shall be in floor mounted horizontal design, comprising of VCD, Pre-filters and fan section having supply air centrifugal fan with driving/ installation accessories. Fresh air from these blowers shall be supplied to the various areas of the power house building with the help of air conveyance ducting and grilles.

4.1.1.5 In summer, 60% of fresh air supplied to Power House area except Battery rooms & toilets, shall be exhausted with the help of exhaust fans. These fans shall be mounted at a higher level in Machine hall all through the equally distributed on upstream & downstream wall.

These fans shall be complete with air inlet bird mesh, exhaust air cowl with gravity louver and bird mesh and supporting/ fixing frame.

4.1.1.6 The exhaust air from toilets and battery room in power house shall be evacuated by means of separate exhaust fans.

4.1.1.7 For Exhaust of Stale air from Power House Complex, exhaust Air fans of suitable capacity shall be provided on the wall of power house. These fans shall be placed on the two longitudinal sides of the Machine Hall and erection bay near roof top.

4.1.1.8 One (1) lot of rooftop passive type turbines ventilators shall be provided at the roof of Power House.

4.2 AIR-CONDITIONING SYSTEM

4.2.1 POWER HOUSE AREA

4.2.1.1 Air cooled D-X type condensing unit type air conditioners shall be provided for power house as per details given below.

Sr. No.	Area to be Air-Conditioned	No. of D-X type Condensing Unit and D-X type AHU	Remarks
1.	Control room, LT room, Carrier / PLCC room, Existing battery room, Battery charger room, Test room, Committee room, offices and other facilities	2 x 100 %	Each DX unit shall have a dedicated D-X type AHU. The AHU shall be double skin type having sand-witched insulation in between.

4.2.1.2 As per heat load calculation, the load / capacity of the air conditioning system for above areas shall be worked out during detailed engineering stage.

4.2.1.3 Winter heating section shall consist the strip heater along with control system of suitable capacity.

4.2.1.4 For control of humidity, pan type humidifiers of suitable capacity shall be provided for above D-X type air conditioners.

5. LAYOUT CONSIDERATIONS:

5.1 AIR CONDITIONING SYSTEM

5.1.1 Air Cooled D-X type condensing unit shall be housed at various locations, as under:

Sr. No.	Area to be Air-Conditioned	Space Requirement for AC Equipment	Location of equipment
1.	Control room, LT room, Carrier / PLCC room, Existing battery room, Battery charger room, Test room, Committee room, offices and other facilities	AC Plant at RL 295.3: 9.9M x 4.6M	As per existing layout drg
		AHU Room at RL 295.3: 7.5M x 4.6M	As per existing layout drg
		D-X Type Condensing Unit at RL 307.00: 12M x 6M	At RL 307.00 near existing cooling tower, 12M x 6M space is provided to locate air cooled D-X type condensing Unit.

locations and space requirement of the AC equipment given above may change during detail engineering

5.2 VENTILATION SYSTEM

5.2.1 Four nos (4) Fresh Air Blower (all working) located at floor RL. 303.0M level outside the power House (open space, expose to atmosphere).

5.2.2 Exhaust Air Fan for Power House: Power House Walls, Approx. at El. 316.0 M. Tentative opening available for Exhaust air fan is given at the end of the specification. Axial fan selected should fit in above opening.

5.3 Since, it is RMU project, Bidder are advised to visit site to have better assessment of the space requirement/ layout consideration of the HVAC equipment.

6. EQUIPMENTS TO BE PROVIDED

6.1 Two (2) Nos DX condensing unit (1 Working + 1 Standby) complete with all accessories.

6.2 Air Handling Units (AHUs).

- Two (2) Nos, cabinet type (double Skin) Air Handling Units (1 W + 1S) of sectionalized construction each complete with all accessories including NRD as described hereinafter to match the AC load of Power House control room at RL. 299.6M.

6.3 One (1) Pan type humidifier in AHU room.

6.4 Four nos (4) Fresh Air Centrifugal Blowers for Ventilation Supply Air requirements.

6.5 For exhaust air of Power House, Axial exhaust fans to be provided

6.6 For other areas like battery room, toilets etc. separate exhaust fans to be provided.

6.7 1 lot strip type duct heaters at common discharge plenum of AC duct.

6.8 Lot – Pre-filters having efficiency of 85% down to 10-micron particle size (inside the pre-filter section of the AHUs

Pressure drop:

Initial pressure drops: Not to exceed 5.0 mm WC at rated flow

Final pressure drops: Up to 7.5 mm WC

6.9 Lot - Fine filters having efficiency of 95% down to 5-micron particle size (shall be provided in Common discharge of AHUs).
Pressure drop:
Initial pressure drops: Not to exceed 10.0 mm WC at rated flow
Final pressure drops: Up to 25 mm WC

6.10 Fresh air arrangement complete with louvers, filters shall be provided for AHU room.

6.11 Lot- Refrigerant piping with insulation interconnecting condensing unit and fittings such as elbows, tees, reducers, flanges etc.

6.12 Lot-Drain water piping out of MS pipes conforming to IS-1239, Part I, medium grade from various equipment like AHU etc. up to the nearest drain point (within the room).

6.13 The supply air and return air duct shall be provided with motor operated fire damper at locations where duct pass through walls & floors for ease of isolation, maintenance and as well as for emergency operation. The operation of these automatic dampers shall be interlocked with the fire alarm system. Fire dampers shall be of rating 90 minutes.

6.14 Lot – GSS Ducting (as per IS-277) with 180 g/sq.m. of zinc coating sheet metal work, complete with volume control dampers, extruded aluminium supply air (with VCD) and return air differs and grills, hangers, supports, flexible connections, including thermal insulation on complete supply air duct & return air duct (as applicable for air conditioning system) and Ventilation duct, wherever they are exposed to outside the building.

6.12 ACOUSTIC INSULATION

6.12.1 Lot- Acoustic insulation 25 mm thick of fibre glass with 48kg/m3 of first 2 M of ducting after AHUs but limited to plenum.

7. AC EQUIPMENT

7.1 AIR COOLED CONDITIONING UNIT (DX TYPE)

Each air-cooled D-X type condensing Unit shall comprise of the following as per Manufacturer standard:

a. Type: Air cooled scroll type
b. Vibration isolators: Steel spring / Neoprene rubber cushy foot type with isolation efficiency not less than 85%.
c. Compressor
d. Type: The Compressor shall be scroll either hermetic type or semi-hermetic type with automatic capacity control.
e. Type of drive: Motor driven, direct or through V-belt.
f. Refrigerant (CFC free): The refrigerant shall be R-134a/ R-410A/R-407C or any other environment friendly refrigerant.
g. Accessories: High/Low pressure cutouts, oil pressure switches, relief valves, pressure gauges at each stage, lube oil and control oil pressure gauges, suction & discharge stop valves, Muffler, Crank case heaters, oil filters, magnetic oil separators, temperature indicators for

lube oil/heaters, oil level indicators, safety thermostat for crank case heater, vibration isolators, etc.

h. Motor rating: 10% more than the power required by the compressor at 50 deg C design ambient temperature.
i. Capacity: Minimum capacity shall be suitable for the identified/selected at evaporating temperature and condensing temperature and shall be indicated.
j. For other details please refer to other relevant clauses of Customer technical specification section C2-A.

7.2 AIR HANDLING UNIT (DOUBLE SKIN TYPE)

Each air-handling unit shall comprise of the following: -

a. The casing of AHU shall be of double skin construction. Double skin sandwich panels (inside and outside) shall be fabricated using minimum 0.63 mm (24G) galvanized steel, with 25 mm thick polyurethane insulation of minimum 38 kg/m3 density in between. 16G galvanized steel sheet channel shall be used as reinforcing to give structural strength.
b. Fan section complete with backward curved multi-bladed centrifugal fan (DWDI) mounted on a shaft with adjustable motor base.
c. One No adequately sized TEFC sq. cage induction motor suitable for 415 V, 3 phase, 50 Hz AC supply with drive package comprising fan pulley, motor pulley, V-belt and belt guard.
d. Cooling coil section (min. 4 row deep) with suitably sized DX cooling coil made of seamless copper tubes with aluminium fins firmly bonded to cooper tubes and shall be provided with suitable drains and vents connection.
e. Sloping condensate drain pan shall be made of minimum 1.2 mm thick Stainless Sheet Steel. It shall be isolated from bottom floor panel through 25mm thick heavy duty treated for Fire (TF) quality expanded polystyrene or polyurethane foam. Drain pan shall extend beyond the coil.
f. Flat filter (Pre & Fine filter) sections complete with 50 mm thick dry panel type filter (Average arrestance efficiency of 65-80% for Pre filter & 80-90% for fine filter) shall be provided for all other AC areas.
g. Drain piping from the AHUs up to nearest drain point.
h. Lot – Controls comprising
    - One No. Proportionating type thermostat / temperature & RH sensor.
i. Lot – Serrated rubber pads for vibration isolation having minimum 85% vibration dampening efficiency.
j. All unit sections shall be supplied with 12-gauge G90 galvanized steel structural support rails.
k. VCD and NRD at the outlet of each AHU.
l. For other details please refer to other relevant clauses of Customer technical specification section C2-A.

7.3 STRIP HEATING & HUMIDIFICATION PACKAGE

a. One common set of electrical strip heaters package of suitable capacity complete with contactor, airstat, humidistat (room or mounted on strip heater control box), safety thermostat, heater box with insulation etc. for winter heating and monsoon reheat, mounted inside the AC plenum/duct for each AHU Room.
b. One No. Pan humidification system comprising heater, humidistat, water tank, draining, make up connection, float valves etc. for AHU Room.

7.4. SPLIT AIR CONDITIONER

a. Split type air conditioners (air cooled) shall be provided to cater to the air conditioning requirements for auxiliary / local control room etc. For these areas multiple working split ACs shall be provided. (Only those aux. control rooms which are under scope of BHEL). Local isolator / MCB shall be provided with split units.
b. Hand operated remote and other accessories as specified. Local Distribution Boards containing Switch / MCB shall be provided for Split Air Conditioners. Each split unit shall also be provided with suitable rating stabilizer.
c. Redundancy of split type units shall be N+1 configuration where 'N' is the nos. of working units.
d. Split AC shall conform to latest available highest BEE rating (5 Star).

8. VENTILATION EQUIPMENT:

8.1 FRESH AIR BLOWER UNIT

Each Fresh Air Blower unit shall comprise of the following: -

a. Fan Casing (galvanized steel).
b. Filter section shall be separate.
c. Fan-motor set on a common base frame with all drive accessories shall be provided.
d. Fan section complete with backward curved multi-bladed centrifugal fan mounted on a shaft with adjustable motor base.
e. One No. adequately sized TEFC sq. cage induction motor suitable for 415 V, 3 phase, 50 Hz AC supply with drive package comprising fan pulley, motor pulley, V-belt, belt guard and slide rail etc.
f. Dampers and flexible connection with matching flanges.
g. Flat filter sections complete with 50 mm thick dry panel type filter having efficiency 85% down to 10 micron.
h. Lot – vibration isolation (Neoprene rubber cushy foot / neoprene serrated rubber pad type with isolation efficiency not less than 85 %.), foundation bolts and nuts.
i. MOC for Centrifugal fan:
    i. Fan Scroll: Heavy Gauge MS (IS−2062 Gr.B) with Galvanized.
    ii. Fan Casing (side plates & stiffeners): Mild Steel Sheets/plate to IS: 2062 Gr.B / IS: 1079 /Eq. The minimum thickness of casing shall be 3.15 mm galvanized steel.
    iii. Impeller: M.S. sheet/plate (IS−2062 Gr.B)
    iv. Impeller hub: Mild Steel

v. Impeller back plate blade & shroud: Mild Steel to IS: 2062 Gr.B.
vi. Shaft: EN − 8 or eqv.
vii. Fan Supports, frames and structure: Mild Steel (IS−2062 Gr.B).
viii. Flexible connection at outlet/inlet: Fire resistant type plastic impregnated canvas with M.S. flange and cleats (3 mm thick).
ix. V Belt (matched sets): ISI marked (Reinforced rubber section to (IS: 4776).
x. V Pulley: Cast Iron multi−groove to Gr−20 as per IS: 210.
xi. Slide rails: M.S. / C.I.
xii. Connection pieces: G.I. according to supplier's design.
xiii. Bolts & nuts: Galvanized / MS (Epoxy painted).
xiv. Accessories: Vibration isolating cushy foot mountings, foundation bolts and nuts etc.
xv. Dampers: Heavy Gauge MS (IS−2062 Gr. B).

j. For other details please refer to other relevant clauses of Customer technical specification section C2-A.

8.2 WALL MOUNTED AXIAL FLOW FAN:

Each wall mounted axial flow fan is complete with

a. Fan impeller with aerofoil section of cast aluminium alloy & casing / short duct as required.
b. Electric drive motor with coupling if any, including motor brackets.
c. Inlet cone and grouting framework, if any.
d. Rain protection cowl with bird-screen, adjustable damper, vibration isolator, back draft damper etc shall be provided.
e. Axial fans will be of propeller type, for fans with 5 mm of wc fan static pressure and Tube Axial type for fans with static pressure above 5 mm of wc.
f. All supply air axial flow fans shall be provided with pre-filters (and also fine filters for MCC/ switchgear room).
g. Efficiency of pre-filter shall be 85% down to 10 microns and for fine filter shall be 95% down to 5 microns.
h. Each Axial fan comprises of fan, fan motor, inlet and outlet cone (for Tube axial), Louvered shutter (exhaust fans), bird screen and supporting arrangement.
i. These fans shall cater to the areas as indicated in the fan schedule of ventilation system during detailed engineering.
j. MOC for Axial fan:
    i. Casing: M.S. sheet – 3 mm thk for fan dia upto 750 mm, 5mm thick for fan dia of 750 mm and above as per IS:1079 / IS:2062 Gr.B.
    ii. Impeller: Cast Aluminium. (Alloy A−6M, IS−617).
    iii. Hub: As per manufacturer std. (AL− LM6).
    iv. Support frame and structure: M.S. of adequate thickness (Galvanized / painted) IS−2062 Gr.B.
    v. Neoprene rubber pads: Required.
    vi. Protective screen at inlet: Yes (Min 14 SWG Galvanized wire knitted in 1" square mesh).

vii. Rain Protection Cowl: Aluminium or hot dip galvanised after fabrication from MS.
viii. Mounting flange on casing: At inlet and outlet.
ix. Painting / protecting coating: All the MS parts shall be galvanised or protected with three coats of epoxy paint.

k. For other details please refer to other relevant clauses of Customer technical specification section C2-A.

8.3 WIND DRIVEN TURBINE ROOF TOP VENTILATOR:

Each Turbine Roof Ventilator comprises of:

a. Aerodynamically profiled curved vanes of rigid anodized Aluminium.
b. Opaque Venturi Dome.
c. Rain proof rugged spider design.
d. The top plate and the bottom ring shall be of Stainless steel.
e. The bearings shall be zero maintenance permanently lubricated type.

8.4 AIR FILETRS:

8.4.1 Pre-Filters:

a. Filter Media: Fibrous material (extruded polyethylene) or felt filter: Dry types with element of 5 ply construction for fabric type.
b. Efficiency: Shall be 90% down to 10 microns.
c. Allowable pressure drops: Initial pressure drop – Not to exceed 5.0 mm WC at rated flow. Final pressure drops− Up to 7.5 mm WC.
d. Frame Work: 18 G GSS. Filter mounting frame shall be GI angle iron frame of adequate thickness.
e. Size: 610 x 610 mm (Approx.)

8.4.2 Fine-Filters:

a. Filter Media: Synthetic non−woven for fresh air pressurization (MCC). The filter media shall be of High-Density Polyethylene (HDPE) or equivalent. The filter media shall be sandwiched in between two galvanized wire netting arrangement in a uniformly corrugated form to increase the surface area. The filter shall be fixed in GI angle iron frames of adequate thickness suitable for long use in an industrial plant.
b. Efficiency: shall have efficiency not less than 99.5% down to particle size of 5 microns.
c. Allowable pressure drops: For HDPE (SNW) −6 mm WG during clean condition & 12 mm WG during dirty condition.
d. Frame Work: 18 G GSS.
e. Size: 610 x 610 mm (Approx.)

8.5 VALVES:

a. Valves shall have full sizes port and suitable for horizontal and as well as vertical installation.
b. Valves for regulating duty shall be of globe type suitable for controlling throughout its lift.
c. Gate, Globe and stop check valves shall have bonnet back seat to facilitate easy replacement of packing with the valves in service.

d. All safety / relief valves shall be so constructed that the failure of any part does not obstruct the free discharge.
e. Manual gear operators be provided for valves of size 250 NB and above.
f. All valves shall be provided with locking arrangement.
g. All water line valves shall be of cast iron body for sizes 65 NB and above conforming to IS: 780 and Gun metal construction for sizes less than 65 NB conforming to IS: 778. Cast iron parts shall conform to IS: 210 Gr. FG 220.

9. SHEET METAL WORK

a. Lot – GSS (Galvanised Steel Sheet) supply and return air Ducting (as per IS-277) with 180 g/sq.m. of zinc coating complete with vanes, damper, hangers / supports etc.
b. The maximum air velocity through duct shall be 10m/sec in main duct, 8m/sec in branch duct and 2 m/s in Ducts in the occupied rooms. However, the air velocity may increase up to 15 m/s, in some zone due to layout constraint.
c. Lot- Supply air diffusers / grilles (Frame and Louvres of Diffuser/Grilles shall be of extruded aluminium of 1.2 mm thick section, duly powder coated) with volume control dampers. Return air Diffusers will have no Volume Control Damper.
d. Rectangular ducts of size upto 750mm and above shall be supported by 15mm M.S. rods and 50 x 50 x 3 mm M.S. angles while ducts below 750mm shall be supported by 10 mm M.S. rods and 40 x 40 x 3mm M.S. angles. The M.S. rods and angles shall be given a coat of primer paint. The spacing of duct supports shall not be more than 1500 mm. Arrangement like drilling and placing anchor fasteners for duct support, auxiliary or special steel members, hooks coach screws and all other supporting material required shall be provided. Wherever the ducts are thermally insulated the M.S. angles and supports shall not be in direct contact with ducts.
e. Thickness of duct shall be as follows.

Rectangular duct Size (mm)- lager dimension	**Thickness of GI (mm)**	**Gauge**
150 to 500	0.63	24
501 to 750	0.80	22
751 to 1000	0.80	22
1001 to 1250	1.00	20
1251 above	1.25	18
Cylindrical spiral ducts- Diameter in mm	**Thickness of GI (mm)**	**Gauge**
Up to 300 mm	0.63	24
From 301 mm to 600 mm	0.63	24
From 601 mm to 750 mm	0.63	24
From 751mm to 1000 mm	0.80	22
From 1001 mm to 1500	0.80	22

From 1501 mm to 2250	1.00	20
Over 2250	1.25	18

F. Motorized fire dampers (spring return type) shall be provided in the supply & return air duct which shall close and stop the air flow in the event of fire. These dampers shall be operated with the help of a signal from smoke detectors/thermal sensors. The dampers shall operate on "De-energized to close "mode. In the event of fire, the dampers shall close automatically & PAC / Air washer fan shall also stop. Necessary interlocks shall be provided for this purpose in IO panel / PLC control system. Fire damper shall be of rating 90 minute (min.).
G. MS grills & diffuser.
H. Manually adjustable/ back draft type/ Gravity type exhaust air dampers, Volume control dampers, guide vane, splitter dampers.
I. For Battery room areas, where exhaust ducting is required for ventilation, MS ducting having epoxy coating shall be provided.
J. The diffuser / grills shall be of powder coated MS sheet (20 SWG) for ventilation system.
K. Supports and hangers including anchor bolts as required.

For other details please refer to other relevant clauses of Customer technical specification section C2-A.

10. INSULATION

Insulation shall be provided as under:

S.No	Surface	Insulation Material	Insulation Form	Thickness (mm)	Finish
i)	AC Duct	resin bonded fiber glass, (25 Kg/m3 density)	Roll / Slab	25	24-gauge Al cladding
ii	Ventilation duct (running outside the building) (if required)	resin bonded fiber glass, (25 Kg/m3 density)	Roll / Slab	25	Covered with 500 Gauge Polythene sheet, chicken wire mesh, 12mm thick sand cement plaster and an overall cladding of 24 G GI sheet.
iii)	Acoustic insulation of first 5M of ducting after AHUs but limited to plenum	Fibreglass (48 Kg density)	Roll / Slab	25	Perforated Al sheet

S.No	Surface	Insulation Material	Insulation Form	Thickness (mm)	Finish
iv)	Refrigerant Piping	Al foil faced Nitrile rubber / Eqvt	Roll / Slab	39	Al cladding
v)	AHU drain pipe	Al foil faced Nitrile rubber / Eqvt	Tube	19	As per manufacturer std.

For other details please refer to other relevant clauses of Customer technical specification section C2-A.

11. CONTROL PHILOSPHY

Operation of the AC plant for power house shall be controlled through PLC (Located at 299.6M EL). This PLC system shall perform all functions such as auto / manual operation of drives, status indication, annunciation, interlock and protection of drives, etc. Provision of necessary contacts and/ or ports for integration with plant SCADA system through HVAC PLC shall also be provided for monitoring purpose only.

11.1 DX condensing unit shall be provided with unit mounted control panel.

11.2 AHU CONTROL

11.2.1 Humidity sensor and gyserstat located in the return air duct shall actuate the PAN humidifier to obtain the desired degree of humidification.

11.2.2 Humidity & temperature sensor shall be provided and interlocked in steps with winter heater / re-heater / strip heaters for monsoon and winter re-heating or heating as the case may be.

11.2.3 Heater banks shall be interlocked with the running of AHU, temperature of return air, humidity of return air and safety thermostat (airstat-located in front of each heater in the supply air duct).

11.2.4 AHU shall be started either locally or from the main control room by means of Remote / Manual selection facility.

11.2.5 The closure of fire dampers, automatic tripping of AHU fans and fresh air fans shall be interlocked with fire Detection System.

11.3 Local MCB shall be provided for operating Hi wall / Split Air-Conditioners.

11.4 Fresh Air Blowers, Supply air fans, exhaust air fans of each area shall be provided with their local starter panel.

11.5 Emergency stop push button shall be provided for Fresh Air Blower.

11.6 All fire dampers shall be closed on getting signal from the respective fire panels. Necessary cabling required for the purpose shall be covered under HVAC bidder's scope. Further the respective AHU motor / Package AC Unit motor etc shall stop on closure of fire damper.

11.7 Detailed control philosophy shall be discussed and approved during detailed engineering stage.

11.8 For other details please refer to other relevant clauses of Customer technical specification section C2-A.

12. POWER SUPPLY ARRANGEMENT

The power supply (rated voltage, frequency, phase) of the equipments will be 415V +/- 10%, 3ph, 50 Hz +/- 5% or 240V+/- 10%, 1ph, 50 Hz +/- 5% as the case may be.

13. ACCEPTANCE TEST

a. **Air conditioning system:** Room condition test shall consist of taking the reading of dry bulb and wet bulb temp at different locations points to be mutually decided at site in the areas which are air-conditioned by the respective system/plant. Room condition test shall be done after stabilization of the system. The dry and wet bulb temp shall be measured by sling psychrometer which will have accuracy of +/-0.5% with aleast count of 0.5 degC. This will be carried out for 24 hrs continuously and readings will be taken every two hours. Standby equipment should be changed over during these 24 hours. This test shall be carried out during summer during month April to June when the dry bulb temp is generally high and during. The format for recording the readings shall be defined in PG / Demonstration test procedure during detailed engineering stage. Relative humidity shall be determined from psychometric chart.

b. **Ventilation system:** Temperature test at the out let of FFU/Blower and at different floors at mutually agreed locations. The dry bulb temp shall be measured by sling psychrometer which will have accuracy of +/-0.5% with a least count of 0.5 deg C. This will be carried out for 24 hrs continuously and readings will be taken every two hours. Standby equipment should be changed over during these 24 hours. This test shall be carried out during summer between months April to June. The format for recording the readings shall be defined in PG / Demonstration test procedure during detailed engineering stage.

c. All shop testing and test at site as specified shall be carried out.

d. The Noise level of the AC system shall not be exceeding 55dB (A) in rooms as in the Control Rooms, Offices & Reception Room.

e. The Noise level of the rotating derive shall not be exceed 85dB (A) at 1.5m from source.

f. Acceptance Test to be covered separately and should cover followings;

   i. Performance Testing (Air Quantity at various floors)
   ii. Air Balancing
   iii. Leakage
   iv. Noise level
   v. Vibration level
   vi. Fire Dampers working
   vii. Interlocking with SCADA
   viii. Motor Current
   ix. Temperature/Humidity at various location of different floors

x. All equipment (fans, blowers, motors, Compressors, Pumps, heater etc.) checking.

g. For other details please refer to other relevant clauses of Customer technical specification section C2-A.

14.0 GENERAL

1) Basis of design, all calculations including heat load calculations for summer seasons, equipment selection criterion, layout drawings/ schemes/G.A. dwg and documents like data sheet/ technical particulars etc are subject to Customer approval during detail engineering stage.
2) Vendor to furnish characteristic curves for all major equipment offered indicating duty point during detailed engineering.
3) All drawings and documents shall be computer based.
4) All commissioning spares & consumables for trouble free operation shall be provided by Vendor.
5) Quality Requirements in the Technical Specification are indicating minimum requirements for inspection and testing. Vendor shall note that quality plan is subject to Customer & BHEL-approval during detail engineering stage. Standard QP format is enclosed in the technical specification.
6) Indicative list of makes is enclosed elsewhere in the specifications; however, these equipments / items shall be subject to Customer & BHEL approval during detail engineering Stage.
7) Drain piping within room and up to the drain point to be provided by the Vendor.
8) Tools & tackles as required for regular maintenance shall be supplied by Vendor.
9) Instruments, consumables, lubricant required for performance testing of various equipment / system of the package shall be arranged by Vendor at site.
10) Only calibrated instruments shall be used by HVAC supplier for testing of various equipment.
11) Temperature gauges shall be provided with thermo wells and fixing arrangement.
12) Pressure gauges shall have provision for air venting. Three-way valves (if applicable) shall be used which shall have air venting provision.
13) Matching sockets / stubs (weld type) for flow switches and other instruments shall be supplied.
14) Bidders shall guarantee to maintain specified inside design conditions during summer, monsoon and winter and also even if the internal equipment load varies from 100% to 25%.
15) Besides the system performance as above, bidder shall guarantee major technical parameters of various equipments as per design basis / details furnished.
    a. The guarantee tests shall cover but not limited to the following rated parameters for smooth operation of HVAC system.
    b. Design dry bulb temperature and relative humidity of conditioned air, Vibration and noise level etc.

16) All calibrated instruments to be used for the tests at manufacturer's works/site shall be arranged by the bidder.
17) For motorized fire damper / 3 Way valve actuators / motorised valves, power supply shall be derived by vendor from respective control panels. BHEL shall not provide any feeder for them. Suitable transformer shall be provided by bidder (if required) to derive the power input. Further distribution through junction box / distribution board shall be in vendor scope and shall have provision for isolation of individual fire damper/ valves.
18) Tender drawings enclosed form the part of specification and the bidder shall check the space requirements for installing the equipment as per the specification and layout requirements given in the specifications.
19) Bidder should suitably group the signals coming from various instruments etc. & the same shall terminate in local JB, from Local JB common cable to PLC / panel / MCC shall be selected. Any Electrical / C&I items and accessories like junction box, glands etc. shall be included by vendor in his scope.
20) In the event of any conflict between the requirements of two clauses of this specification documents or requirements of different codes and standards specified, the more stringent requirement as per the interpretation of the owner shall apply.
21) Bidder to note that BHEL reserve the right for drg/doc submission through web-based Document Management System. Bidder would be provided access to the DMS for drg/doc approval and adequate training for the same. Bidder to ensure proper net connectivity at their end.
22) The drawings/ documents submitted by vendor shall be complete in all respects with revised drawing submitted incorporating all comments. Any incomplete drawing submitted shall be treated as non- submission with delays attributable to vendor's account. For any clarification/discussion required to complete the drawings, the bidder shall himself depute his personal to BHEL / Customer's place any number of times as per the requirement for across the table discussions/ finalizations/ submissions of drawings.
23) Flat, platform type RCC / PCC foundation shall be provided for installing PUMP, AHU and FAN etc. Vendor shall fix the equipment using anchor fasteners to secure the equipment obtain parameters related to vibration and noise.
24) Bidder to note that the P&ID shows only the bare minimum requirement of valves and instruments. Any instrumentation & valves as required for the completion of the system in line with technical specification shall be provided by bidder during detailed engineering without any commercial implication.
25) HVAC plant supplier to furnish drawings/ documents as per the dwg. / documents distribution as per project requirement.
26) All electrical equipment shall be suitable for the power supply fault levels and other climatic conditions indicated in project information / synopsis / specifications enclosed.
27) The bidder's proposal shall be for equipment in accordance with the tech. Specification.
28) The bidder shall furnish complete tech. Particulars in data sheet and schedules as specified elsewhere in the specification during detailed engineering.

29) The bidder shall arrange to provide training on complete HVAC system including operation & Maintenance for Employer Personnel.
30) The tools and machine required for erection of equipment shall be arranged by Vendor.
31) Construction of openings in brick-walls, as required, for routing the ventilation, Air conditioning ducts and installation of axial fans, shall be in bidder's scope of works. Floor openings, as available at site, for duct routing can be used by bidder during erection of duct.
32) Further, sealing of duct opening, grouting of foundation / foundation bolts including special type of grouting like GPX2 etc. are in the scope of HVAC system supplier.
33) Necessary duct mounted Booster fan (if required) to maintain the static pressure for Package AC / Precision AC / AC Duct / Ventilation duct shall be provided without any implication.
34) Minor civil work like chipping of foundation, grouting below base plate for all structures, equipment, grouting of anchor bolts wherever these are not placed in the foundation during casting of foundation itself including special type of grouting like GPX2 etc, making opening to suit / finishing of opening after completion of AC Equipment erection, sealing of duct / pipe opening.

    Making Good / Repairing / replacement of and damaged done by bidder to adjacent structure, pipes etc. while erecting equipment's related to HVAC System.
35) Making Good / Repairing / replacement of and damaged done by bidder to adjacent structure, pipes etc. while erecting equipment's related to HVAC System.
36) Pre-Commissioning work such as flushing, hydraulic testing etc. Necessary consumables and instrumentation like refrigerant, grease, lubricants, anemometer, tachometer, ammeter, voltmeter etc. for inspection and testing at works as well as at site including pre-commissioning activities shall be arranged by the successful bidder at their own cost.
37) Training of plant Owner's personnel (Min 2 days), O&M operators' personnel on plant operation and maintenance.

15.0 EXCLUSIONS

Items of works listed below are excluded from scope of the HVAC supplier.

a) Construction of AC plant room, air handling unit room, foundations for AC equipment's i.e. D-x type condensing Unit, AHU, Fresh air blowers, roof/wall openings for ducts, dampers/louvres.

b) False ceiling, drop ceiling.

c) Slab cut out for running ducts, pipes, cables, grilles/dampers. Underground masonry trenches and masonry risers.

d) For Electrical scope, refer Electrical scope matrix sheet.

16.0 Terminal Point

Make Up Water for HVAC system: One No. Tapping shall be provided at EL. 303.0m, outside power house near service bay (A-1-row). Further routing of the water to HVAC System shall be in Bidder scope.

16.0 Codes and Standards

Design, manufacture, inspection and testing of the equipment covered by the specification shall conform to the latest edition of the standards and codes of HVAC system.

SECTION: I

SUB-SECTION: C2-A

CUSTOMER SPECIFICATION

(TECHNICAL REQUIREMENT)

CHAPTER 18 -AIR CONDITIONING & VENTILATION SYSTEM

Table of Contents

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M&U-Ganga Valley
UJVN Limited,
Ganga Bhawan, Dehradun

18.1. SCOPE OF WORK

18.1.1. Scope of work under this chapter covers the provision of all labour, supervision, tools, material, material handling equipments for dismantling of existing "Heating Ventilation & Air Conditioning System" along with other appurtenant", transportation used items/scraps to store and storage at Employer's store.

18.1.2. Scope of work under this chapter covers the Provide labour , tools , plants, material and performance of work necessary for design and engineering, manufacture, quality assurance, quality control, shop assembly, shop testing, transportation, delivery at site, site storage and preservation, erection, testing and commissioning, performance testing, field acceptance testing, training of the Employers personnel, handing over to the Employer and guarantee for Twenty Four (24) months, of "Heating Ventilation & Air Conditioning (HVAC) System" complete with all accessories and necessary components for making the equipment and the system complete and for warranting a trouble-free and safe operation.

18.1.3. The specification shall be read and construed in conjunction with other chapters of volume-III of bidding document. In the event of any discrepancy with listed documents, the stipulation of this specification shall govern.

18.1.4. The scope of work shall be a comprehensive functional system covering all supplies and services including but not limited to the following:

i. Two (2) Air-Handling Units AHU-1 and AHU-2 (one main & one standby) for each of 100% of required capacity for air-conditioned control block area at Chilla Powerhouse comprising control room, LT room, carrier/ PLCC room, battery charger room, test room, committee room, offices and other facilities. At a time one of the unit shall operate with the second one as the standby. Each AHU shall be complete with compressors, condensers, evaporators, cooling coils, expansion nozzles, interconnecting piping, controls, indicating instruments, necessary devices, safety devices, valves, thermostats, refrigerating pipes and duct heaters etc.

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ii. Suitable No. of Air-Handling Units (AHU) without any cooling coil shall be provided for ventilation of erection/ service bay floor, generator floor, turbine floor, draft tube floor etc. and other indoor area.
iii. Two (2), exhaust air fans for exhaust of air from battery and battery charger room each of 100% of required capacity.
iv. Four (4) Nos. fresh air blowers AHUs of capacity 216 m3/min. complete with motor and motor control panel and wiring;
v. One (1) lot of rooftop passive type turbines ventilators.
vi. Twenty (20) Nos. wall mounted blower fans of capacity 60m3/min complete with motor, starter panel and wiring;
vii. Required number of exhaust air fans for exhaust of air from non- air-conditioned areas such as powerhouse floors, toilets, etc., at different floors. The rating shall be such that 100% of required capacity is achieved with 50% fans under operation.
viii. Insulation for the complete Air-condition ducting and lagging of pipe lines and fittings;
ix. Minimum Two (2) exhaust air fans for exhaust of air from DG set room each of 100% of required capacity.
x. Two (2), exhaust air fans for exhaust of air from unloading bay area each of 100% of required capacity.
xi. Air duct distribution system for supply and return air of entire air handling and ventilation systems, with necessary galvanized sheet metal ducts (for battery room exhaust air system, complete plastic ducts, grills etc.), elbows, tees, supports, fixations, including all necessary grills, filters, louvers, outside air louvers, adjusting duct dampers, motorized air dampers, heating and cooling insulations, etc.

xii. The centralized control system of the HVAC system shall be based on microprocessor and shall be programmable, meaning the direct digital control program code may be customized for the intended use. The program features shall include time schedules, set points, controllers, logic, timers, trend logs,and alarms. The unit controllers shall typically have analog and digital inputs that allow measurement of the variable (temperature, humidity, or pressure). Digital inputs shall be typically (dry) contacts from a control device, and analog inputs are typically a voltage or current measurement

from a variable (temperature, humidity, velocity, or pressure) sensing device. Digital outputs shall be typically relay contacts used to start and stop equipment, and analog outputs are typically voltage or current signals to control the movement of the medium (air/water/steam)control .devices such as valves, dampers, and motors.

xiii. Either CFC free refrigerant compressors or chilling tower of adequate capacity or Air cooled DX-type condensing unit having CFC free refrigerant compressor for air conditioning system in which there is no requirement for chilling tower/Cooling Tower.

xiv. Local control panels for air handling units, water cooled chilling units, circulation/ cooling water pumps, strainer, exhaust fans etc.

xv. Necessary pressure, temperature, flow/ humidity, sensing devices/ instruments, meters etc.

xvi. Provision of necessary contacts and/ or ports for integration with plant SCADA system through local control board of common services.

xvii. Dismantling of existing HVAC system and Transportation, tagging & stacking of dismantled equipment at UJVNL stores.

xviii. Items not specified above, but are necessary for satisfactory operation of air conditioning and ventilation systems.

xix. All specified devices, tools maintenance equipment etc. required for installation, testing, commissioning and maintenance of the air conditioning and ventilation systems.

xx. Spares

The quantities of equipment / units mentioned in above clause are tentative only. The actual quantities may need to be examined and reviewed and shall have to be got approved from the Employer during detailed engineering.

18.2. SPECIAL DESIGN AND LAYOUT CONDITIONS

The contractor shall utilize the cut-outs and block-outs in the powerhouse structure being utilized by the existing HVAC system for successful erection, testing and commissioning the new HVAC system.

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UJVN Limited,
Ganga Bhawan, Dehradun

18.2.1. Basic Dimensions and Ratings

The system design shall be based on criteria, factors, and details recommended or indicated in the latest ASHRAE handbook.

18.2.2. Indoor Air Conditioners

Rooms as control room and office room etc. shall be maintained at temperature of 24°C±1°C at relative humidity of 50±5%. The room occupants shall be able set temperature & humidity of their choice or shut off the AC end handling unit in their room when leaving. During the winter season when the ambient temperature is below 24°C, heating requirement in the control rooms and offices shall be met with the combination of duct heaters and base board heaters. The use of Class I ozone-depleting chemicals including all chlorofluorocarbons, halons, or their mixtures are prohibited.

The HVAC systems shall be designed and erected to guarantee the room conditions according to the design requirements. The internal heat production from electrical and mechanical equipments shall be calculated and submitted by the Contractor. Final calculation depends on the design data of individual manufacturer's equipment.

18.2.3. Air Changes per Hour

For all ventilated rooms / areas, the air changes shall be as per relevant ASHRAE / IEC / IS to provide the desired heat relief and maintain a minimum level of fresh air in the powerhouse. All ventilated and air conditioned area shall be designed to maintain a positive pressure within the powerhouse.

18.2.4. Noise Levels

The noise levels caused by operation of the ventilation shall not exceed 55 dB (A) in rooms as in the control rooms, offices, & reception room. Silencer, as required, shall be provided to guarantee the above sound levels

18.2.5. Maximum Air Velocities

In main ducts	Maximum 10m/sec
In branch ducts	Maximum 8m/sec
Ducts in the occupied room zones	Maximum 2m/sec

18.3. STANDARDS AND CODES

All works shall be performed in accordance with the most advanced practice in engineering for each class of equipment and completed in a workmanlike manner following the best modern practice in the manufacture of high-grade equipment. The standards under which the equipment is to be designed, constructed, erected and tested shall be the following:

S.No.	Standard	Description
1	ISO	International Standard Organization (for machine work tolerances)
2	DIN	Deutsche Industries-Norm
3	ASTM	American Society for Testing and Material for material
4	IEC	International Electro technical Commission (for electric installation)
5	ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
6	AMCA	Air Moving and Conditioning Association
7	ASRE	American Society of Refrigerating Engineers
8	IS	Indian Standard

18.4. PERFORMANCE CRITERIA AND GUARANTEE

The ventilation and air conditioning system along with all its accessories shall be capable of performing all intended duties and it is the responsibility of the Contractor to supply the equipment as per guaranteed technical particulars.

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Ganga Bhawan

18.5. SPECIFIC TECHNICAL REQUIREMENT

18.5.1. Air Handling Units

18.5.1.1. General Description

Unit shall be central station air handler. It shall consist of a fan with the following factory-installed components as indicated on the equipment schedule:

i. Heating coil section with Electric coil
ii. Access and Plenum Section.
iii. Filter Section
iv. Mixing box section
v. Face and bypass damper sections for
vi. Exhaust section.
vii. Multi zone damper section
viii. Air mixer section
ix. Return fan section

Units shall be shipped in the number of sections necessary to meet project requirements. All sections shall be flanged and gasketed to allow easy assembly and disassembly.

18.5.1.2. Casing

I. Construction

All unit sections shall be supplied with 12-gauge G90 galvanized steel structural support rails. Perimeter 10-gauge lifting lugs for overhead rigging shall be provided on each section. Slinging of units in lieu of lifting lugs is not acceptable. Exterior panels (top, sides, and bottom) shall be constructed of G90 galvanized steel, with pre-painted, baked enamel finish. These panels shall be capable of withstanding a 500-hour salt spray test per ASTM Standard B-117.

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Interior panels (double wall option) shall be 20-gauge G90 galvanized steel. Casing panels shall be removable for easy access to unit. All panels shall be gasketed to ensure a tight seal.

Fan supports, structural members, panels, or flooring shall not be welded, unless aluminium, stainless steel, or other corrosion-resistant material is used. Painted welds on unit exterior steel or galvanized steel are not acceptable.

Each component section shall have mating flanges for assembly. The flange shall extend around the complete perimeter of each section. Fasteners shall be located no further than 12 inches on centre. The manufacturer shall install closed cell gasket for full perimeter coverage.

The fan section shall have a G90 galvanized steel floor of sufficient size to enable field personnel to service or adjust the motor and drive without damaging the insulation. A double-wall hinged access door shall be provided on both sides of the fan section.

All coil sections shall be constructed of insulated, double-wall, galvanized steel panels. Coil sections shall have coil tracks to facilitate coil removal. Blow-thru coil sections shall have a diffuser plate as an integral part of the coil section if used immediately downstream of the fan section.

Filter sections shall be designed and constructed to house the specific type of filter approved during detail engineering. A double-walled hinged access door shall be provided on both sides of the section.

All mixing boxes and filter-mixing boxes shall have a double-wall hinged access door as specified. Filter-mixing boxes shall have doors on both sides of component. Mixing boxes shall have floors of G90 galvanized steel to protect insulation.

Access sections shall have a double-wall hinged access door on both sides of component. Sections shall have floors of G90 galvanized steel to protect insulation.

II. Insulation

Each section shall be factory insulated. Insulation shall have full coverage waterproof adhesive to firmly secure the material to the

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unit casing. Insulation shall meet the erosion requirements of UL 181. Insulation and insulation adhesive shall comply with NFPA 90A requirements for flame spread and smoke generation.

III. Access Doors:

Access doors shall be of double wall construction. Hinge pins shall be non-removable to avoid loss. Use of "drop-in" hinge pins is not acceptable. Sufficient handles shall be provided to assure positive closure. Doors shall be gasketed and shall open outward for negative pressure sections and inward for positive pressure sections. Doors shall be provided on both sides of all access, fan and filter sections. All fan and access sections must have handles on inside and outside of door in compliance with OSHA requirements for confined space access.

IV. Drain Pans

Drain pans shall be constructed of insulated double wall stainless steel. The pan shall be sloped toward the drain fitting. Drain pan shall have a recessed bottom drain design with integral FPT elbow for side discharge and trapping. One drain outlet shall be supplied for each cooling coil section. Drain pan shall allow no standing water and comply with ASHRAE Standard 62-R. Where two or more coils are installed in a coil bank, intermediate drain pans shall be provided that extend a minimum of 6 in. from the downstream side of the upper coil face and the condensate shall be piped to the bottom drain pan. The bottom coil shall not serve as a drain path for the upper coil.

18.5.1.3. Fans

I. General

a) Forward-curved fans

It shall have one double width double inlet (DWDI) fan wheel and scroll. They shall be constructed of heavy gauge galvanized steel. They shall be designed for continuous operation at the maximum rated fan speed and motor horsepower. Fans shall have a minimum AMCA Class II rating.

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b) Airfoil fan sections

These sections shall have one DWDI airfoil fan wheel and scroll. Airfoil blades shall be double thickness design. They shall be painted with zinc chromate primer and enamel paint. Fans shall have a minimum AMCA Class II rating.

c) Plenum fan sections

These sections shall have one single width single inlet (SWSI) airfoil fan wheel. Airfoil blades shall be double thickness design. Wheels shall be painted with zinc chromate primer and enamel paint. They shall be designed for continuous operation at the maximum rated fan speed and motor horsepower. Fans shall have a minimum AMCA Class II rating.

d) Fan wheels

Fan wheels shall be keyed to the shaft and shall be designed for continuous operation at maximum rated fan speed and motor horsepower. Fan wheels and shafts shall be selected with a maximum operating speed 25% below the first critical, and shall be statically and dynamically balanced as an assembly.

e) Fan shafts

Fan shafts shall be solid steel, turned, ground, polished and coated with rust preventative oil.

f) Fan motor

Fan motor shall be mounted within the fan section casing on slide rails equipped with two adjusting screws. Motor shall be of high efficiency, open drip-proof or totally enclosed fan cooled NEMA Design B with size and electrical characteristics as shown on the equipment schedule. Premium efficiency motors shall be available. Motor shall be mounted on a horizontal flat surface and shall not be supported by the fan or its structural members. All motors shall have a ±10% voltage utilization range and a 1.15 minimum service factor. Motor shall be compliant with EPACT where applicable.

II. Performance Ratings

Fan performance shall be rated and certified in accordance with ARI Standard 430.

III. Sound Ratings

Manufacturer shall furnish first through eighth octave sound power for fan discharge and casing radiated sound.

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IV. Mounting

Fan scroll, wheel, shaft, bearings, 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 fan discharge seal. The isolation system shall be designed to conform to seismic zone 5 requirements.

V. Fan Accessories

I. Forward curved fans — Inlet guide vanes (IGV) shall be available for variable volume control, as required.
II. Airfoil fans —Inlet guide vanes (IGV) shall be available for variable volume control, as required.
III. Plenum fans: Inlet guide vanes (IGV) shall be available for variable volume control, as required.
IV. Rotor/Fan guard package shall be available as required.

18.5.1.4. Coils

General Fabrication:

All water and refrigerant coils shall have 15 mm OD seamless copper tubes mechanically expanded into fins to ensure high thermal performance with lower total flow and pumping requirements. Minimum tube wall thickness shall be 0.025 inches. Copper plate fin type with belled collars. Copper-finned coils shall be supplied with stainless steel casing and tube sheets

Water Cooling Coils:

Headers shall be non-ferrous with steel MPT connections. Headers shall have threaded drain and vent connections accessible from outside the unit casing. Coils shall be drainable, with non-trapping circuits. Working pressure shall be 300 psig at 200 F.

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Refrigerant Coils:

Headers shall be seamless copper tubes with brazed joints. Coils shall be provided with a minimum of two brass liquid distributors with solder type connections. Distributors shall have removable brass venturi (nozzles). Distributor to coil capillary feeder tubes shall be seamless copper.

Coils for full face-active or face-split operation shall have intertwined circuits for equal loading on each circuit. Suction and liquid connections shall be on the same end.

Electric Heating Section:

Electric heating sections shall be constructed of pre painted galvanized steel and shall provide mounting of the heater control box access door on the side of the unit.

Coils shall be open-wire type, 80% nickel, 20% chromium resistance coils, insulated by floating ceramic bushings and supported in a galvanized steel frame. Bushings shall be recessed into embossed openings and stacked into supporting brackets, spaced no more than 4-inch centres. Thermal cut-outs for over-temperature protection shall be provided to meet UL and NEC requirements. Maximum element heating density shall be 55-watts/sq inch.

The manufacturer shall furnish an integral control box. It shall contain thermal cut-outs, primary and secondary control, sub-circuit fusing, airflow switch, and fused control transformer.

Units with electric heat sections shall be listed under UL1995 Standard for Safety.

18.5.1.5. Filter Sections

Flat filter sections shall accept 1-inch, 2-inch, or 4-inch width filters in any combination that totals 1,2,3, or 4 inches. Sections shall include side access slide rails. Rails shall be constructed of extruded aluminium for increased rigidity.

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Angle filter sections shall accept 2-inch filters of standard sizes, arranged in a horizontal V formation. Filter tracks shall be constructed of extruded aluminium for increased rigidity.

Draw thru bag cartridge filter sections shall be capable of accepting standard size 12-in. deep rigid media or bag filters. For bag filters with lengths longer than 12 in., additional access section(s) shall be available.

Blow thru bag cartridge filter sections shall contain a face loading Farr type 8-filter frame.

18.5.1.6. Dampers

Mixing boxes, filter-mixing boxes, and exhaust boxes shall have parallel blades and interconnecting outside-air and return-air dampers. Exhaust ducts in the room containing a fire hazard shall have dampers with automatic and manual mode of operation during fire.

Damper blades shall be constructed of galvanized steel with a double-skin airfoil design. They shall have silicone blade seals and stainless steel jamb seals. Blades shall be mechanically fastened to hex axle rod rotating in stainless steel bearings. To eliminate blade warping, dampers shall be sectionalized to limit blade length to 48 inches maximum. Maximum leakage rate shall be 5 cfm/ft^2 at 1-inch wg (0.25 kPa) differential pressure.

Face and Bypass Dampers:

Shall be factory mounted in galvanized steel frame. Damper blades shall be constructed of galvanized steel, with silicone blade seals and stainless steel edge seals. Blades shall be mechanically fastened to hex axle rod rotating in self-lubricating synthetic bearings. To eliminate blade warping, dampers shall be sectionalized to limit blade length to 48 inches maximum. Dampers shall be opposed-acting and arranged to match coil face with top bypass, and external linkage.

Multi-Zone Dampers:

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Shall be factory mounted in galvanized steel frame. Damper blades shall be constructed of galvanized steel, with blade seals and stainless steel edge seals. Axles shall have self-lubricating nylon bearings. Linkage shall have external connections. Number of zones shall vary by size of section.

18.5.1.7. Air Mixer

Air Mixer shall be constructed of welded aluminium framing and turbulence. The mixer shall have no moving parts. It shall contain a primary set of direction-changing vanes, a secondary set of turbulence vanes, and a cone design for mixing of air streams. Unit shall mix two or more air streams of different temperatures (at nominal flow) to within a range of 6°F standard deviation of theoretical mixed-air temperature. It will provide a uniform velocity contour entering a downstream filter or oil bank.

18.5.1.8. Humidifier

Required AHU shall be provided with Humidifier, Pan type steam boiler to raise and maintain specified level of indoor Relative Humidity (RH). The Humidifier will consist of insulted Pan, electric heater, water connection and wiring.

The pan will be fabricated from 22G stainless steel (SS) sheet with welded nozzle and open able top fastened with SS nuts/ bolts. Steam will be generated by heating water with electrical resistance immersion type tubular heating sheet with welded nozzle and open able top fastened with SS nuts/ bolts. Steam will be generated by heating water with electrical resistance immersion type tubular heating element. It will have 12 mm/ 15 mm GI pipes nipple for connection to water line header. Accessories will include float switch for low water level cut-out, float valve with SS Ball thermostat, sight glass and humidistat for sensing/ controlling Humidity.

It will be duly factory wired (control as well as power) with copper bus bar connection and terminal box. The pan will be thermally

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insulated with 25 mm thick fibreglass slab (150 crown) and properly cladded with 22G GI sheet. In addition to providing heating element of required rating the humidifier will be provided with 0.5 KW heater with thermostat to maintain water temperature.

18.5.1.9. Air Cooled Chillier (ACC)

The packaged air cooled liquid chiller will consist of accessible hermetic/ semi – hermetic, direct driven screw compressor with independent circuits evaporator, condenser, microprocessor based control and a unit-mounted motor starter, refrigerant charged, factory run-tested and rated in accordance with ARI 550-90 and ready for operation.

I. Screw Compressor

The compressor will be screw (helical Rotary) type design for positive displacement for use with ozone friendly refrigerant R-134a. Compressor will essentially consist if two inter meshing helical grooved rotors, a male rotor (the drive) and a female rotor enclosed in a stationary housing with suction and discharge ports. During operation, it will be pure rotary motion providing uniform gas flow, even torque and positive displacement to ensure vibration free operation over a wide range of operating conditions. The compressor will generally have only three major moving parts: two rotor assemblies and the capacity controlling valve. Intake and discharge cycle will overlap effectively to produce a smooth and continuous flow of gas. The rotor tip clearance will be optimized to reduce leakage between high and low pressure cavities during compression and also to achieve high energy-efficiency to ensure that lKW/ TR at part load is always less than lKW/ TR at full load. The capacity controlling device shall be arranged for unloaded start. Power consummation shall proportionally reduce with the stepping down of compressor capacity to as low as 25% of full load in direct response to refrigeration load charges.

II. Compressor motor Assembly

The screw compressor will have, accessible hermetic direct drive motor with 2950 rpm (or as per manufacturer's design speed),

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working on 415V + 10%, 3 phase, 50 Hz power supply, as normally available in India. The motor will be squirrel-cage two pole induction type and will be suction-gas-cooled. Due consideration will be given while deciding the protection devices to take care of probable voltage fluctuations prevailing at site.

Rolling element bearing groups will be provided at each end of both rotors, separately housed, and pressure lubricated. The system will be provided with oil separator and filtration devices.

III. Condenser

Condenser coil shall be air cooled with integral sub-cooler constructed of aluminium fins mechanically bonded to seamless copper tubes, which shall be then cleaned, dehydrated and sealed. Condenser fans shall be direct driven propeller/ axial type, with totally enclosed air over motor, having class 'F' insulation and IP 55 protection, discharging air vertically upwards and shall be equipped with the following features.

a) Permanently lubricated bearings.
b) Steel wire safety guards duly coated with PVC.
c) Statically and dynamically balanced fan blades.

Air-cooled condenser coil shall be teak at 150 psig (1034kPa) and pressure tested at 450 psig (3103 kPa).

IV. Chiller (Cooler)

Chillers shall be direct-expansion/ flooded type comprising mild steel shell, integrally finned copper tubes rolled into tube sheets cast iron water headers, liquid line connection, suction header, drain plug and purge valves.

Shell and tube type chillers shall have the following components:

a) Shell and Water Boxes

The chiller shell shall be formed of carbon steel, provided with cast iron water boxes having standard flange type connections suitable for 10 kg/cm^2 (150 psig) working and 21 kg/cm^2 (300 PSIG) test pressure. Necessary test certificate

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shall be submitted. Water boxes shall be provided with drain connections and shall be easily openable for tube cleaning. Suitable tapping shall be provided in the water boxes/ water lines for temperature control bulb and gages.

b) Tube Sheets

A thick steel tube sheet shall be welded to each end of the shell and shall be drilled and reamed to accommodate tubes. Annular grooves in the tube sheets shall prevent leakage at the tube sheet bond. Tube support sheets shall be placed along the length of the shell to avoid relative motion between the tubes.

c) Tubes

12.5 to 19 mm diameter seamless copper tubing, not less than 24G wall thickness, shall be used for evaporator surface. Tubes shall be rolled into the tube sheets and shall pass through intermediate supports so that the refrigerant side of the evaporator shall be leak free and there shall be no relative motion between tubes and tube supports. Each tube shall be individually replaceable.

d) Insulation

The chiller shell shall be covered with expanded polystyrene in multiple layer of thermal insulation with vapour barrier as per the section "Insulation". Suction line of refrigerant circuit piping shall also be provided with thermal insulation. Salient features of the Chiller will be as briefed below:

i. It will be shell-and tube type with removable heads.
ii. Tubes shall be internally enhanced seamless-cooper type rolled into tube sheets.
iii. It will be equipped with victaulic type fluid connections.
iv. Shell shall be insulated with PVC foam (closed-cell) with a maximum K factor of 0.28.
v. Design shall incorporate two (2) independent direct expansion refrigerant circuits.
vi. Cooler (chiller) shall be tested and stamped in accordance with ASME Code for a refrigerant working side pressure of 278 psig (1916 kPa). Cooler shall

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have a maximum fluid-side pressure of 300 psig (2068 kPa)

e) Refrigerant Piping and Components

Refrigerant piping and fittings inter connecting compressor, condenser and chiller shall be all copper and valves shall be brass/gunmetal construction.

Refrigerant circuit components shall include hot gas muffler, high side pressure switch, liquid line shut off valves, filter drier moisture indicting sight glass, stepper motor actuated electronic expansion valve or thermostatic expansion valve, and complete operating charge of refrigerant and compressor oil.

18.5.1.10. Unit Cabinet

Salient features of the Cabinet will be:

i. Frame shall be of heavy-gage galvanized steel members.
ii. Cabinet shall be galvanized steel casing with a pre-painted finish.
iii. Cabinet shall be capable of withstanding 500-hour salt spray test in accordance with the ASTM B-117 standard.

18.5.1.11. Unit Control Module

The unit shall be provided with microprocessor control system for air-cooled Rotary chiller with latest chiller control technology. It shall have control logic with the Clear Language Display panel will have sufficient keys. The read-out screen shall be a two-line, 40 character liquid crystal with a backlight. The backlight shall allow the operator to read the display in low-light conditions.

18.5.1.12. Unit Control Module Features

a) Equal Compressor Sequencing

The control system shall maximize both compressor and motor life by equalizing the number of starts and the operating hours. The UCM will start the compressor with the least number of starts and

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tum off the compressor with the most operating hours, equalizing starts and running hours. This will provide equal compressor wear to various units.

b) Chiller Flow Protection
The in-built protection will automatically detect a no water flow condition.

18.5.1.13. Chiller System Logging

The UCM will display data required to log the chiller system. The following information will be available as standard feature with the Air-Cooled rotary Chiller Microprocessor.

- Entering and leaving chilled water temperatures.
- Ambient air temperature
- Evaporate and condenser refrigerant temperatures and pressures.
- Percent RLA for each compressor
- Percent line voltage
- Compressor starts and running hours.
- Active set points.
  - Chilled water set point
  - Current limit set point
  - Low ambient lockout set point
- Over 90 diagnostic and operating conditions
- Part failures diagnostics:
  - Water temperature sensors
  - Refrigerant temperature sensor
  - Compressor contactors

18.5.1.14. Remote Display Panel

The system shall be provided with a twisted pair connection to an optional remote display panel. With this provision it will be possible to control chiller operation from the remote panel similar to the control interface on the chiller itself, and it will be possible to tum "On" and "Off", change the chilled water set point, and display all operating and diagnostic conditions from this panel. The remote

display panel shall be mounted indoors so that it can be accessed without the need to go to the chillers plant room/ item.
Remote clear language display will have the ability to control multiple units. In the multiple unit configuration, the Remote Clear language Display Panel will have the capability to communicate with up to four units. Each unit will require a separate communication link with the Remote Display Panel.

18.5.1.15. Interface to the Station DAC System

The system should have provisions and facility for interfacing the chiller with Station DAC System:

- Chiller inputs will include:
  - Chiller enable/ disable
  - Circuit enable/ disable
  - Chilled water set point
  - Current limit set point
- Chiller outputs will include:
  - Compressor running indication
  - Alarm indication (for each circuit)
  - Maximum capacity

18.5.2. Ducts

All ducts for the ventilating system shall be fabricated from galvanized steel sheet metal in accordance with IS 655. The supply and exhaust air ducts of the battery room shall be of acid resistant plastic (PVC). Flexible connections should be provided between fan and ductwork to prevent the noise of fan vibration being transmitted directly to the sheet-metal ducts. The size of the air ducts shall be worked out from the permissible air velocities recommended in the relevant standards/codes in practice.

The sheet thickness shall not be below the thickness indicated in the following table, the thickness depending on the length of the longer side of the duct:

From 150 mm to 500 mm	0.63 mm

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From 501 mm to 750 mm	0.80 mm
From 751 mm to 1000 mm	0.80 mm
From 1001 mm to 1250 mm	1.00 mm
Over 1251 mm	1.25 mm

The cylindrical spiral ducts shall have the following thickness:

Up to 300 mm	0.63 mm
From 301 mm to 600 mm	0.63mm
From 601 mm to 750 mm	0.63 mm
From 751mm to 1000 mm	0.80 mm
From 1001 mm to 1500	0.80 mm
From 1501 mm to 2250	1.0 mm
Over 2250	1.25 mm

All ducts shall be airtight with opening at suitable locations.

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 by directing a regulated amount of air for supply outlets from the main duct.

The ducts shall be supported by straps attached directly to the sides of the duct if the duct size is not more than 400 mm, but larger ducts shall be carried by structural angles, hanging in rods with adjustable nuts, anchored to the ceiling of walls by concrete fastener bolts or anchors. Maximum allowable distance between duct supports is 1500 mm.

18.5.3. Insulations

The fresh air supply to the air ducts shall be insulated to prevent condensation on the duct surfaces.

The insulation material (thickness to be as per detail design) shall be non-hygroscopic, rot-proof, preferably of mineral raw material such as rock wool. The insulation mats or plates shall be fastened

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on the duct and wrapped with aluminium foils. The insulation material shall be also sufficient to obtain the acoustical guarantee.

18.5.4. Grills

The supply air grills shall be used for correct air distribution by horizontal and vertical adjustable bars of sidewall installations. The return air grills shall be suitable for adjustment from outside and shall be equipped with 45° horizontal fixed fins.
The design has to fit the architectural false ceiling and lighting schemes and the grills be made of aluminium powder coated with high surface finish and the sizes have to correspond to the fixed noise criteria.
Grills for the battery room shall be of acid resistant PVC.

18.5.5. Outside Air Louvers

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 and pressed out of one piece of aluminium sheet of at least 2 mm thickness. The frames shall also be made of aluminium.

18.5.6. Louver Dampers

Double acting louvers shall be fabricated with a welded frame of rolled section.

Bearings shall be of the oil retaining porous bronze type and shall be fixed into the frame.

The louver dampers as well as the steel frames shall be hot-dip galvanized after fabrication.

Louvers and dampers shall be equipped with related limit switches to be used in control and interlocking system.

18.5.7. Air Filters

The filter banks shall be composed of panels not bigger than 500 x 500 mm, which can be easily removed by hand. They shall be designed taking care of the recommended velocity of the air passing through an area as per relevant standards/codes in practice. The filters shall be of the viscous impingement type, cleanable, aluminium wire mesh coated with viscous substance such as filter oil or grease. Separation degree may be similar to EU4 (rough air filter), according to EUROVENT or DIN 24185 standards.

The frame structure of the panel cells shall be made of aluminium sections.

A properly positioned pressure gauge of the inclined tube type shall give an indication of the degree of dust loading on the filters for establishing the periods between services.

18.5.8. Fans

Exhaust air fans shall be adjustable axial flow fans. Axial air fans shall be of the multi blade vane type. The vanes shall be adjustable individually at standstill. 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 and dynamically balanced.

All bearings shall be pre-lubricated, self-aligning and selected for a minimum of 40000 hour's average life at the maximum design rating. If, however, frequent lubrication is required this should be possible from the outside of the fan casing without disturbing the fan duct assembly. Bearing supports shall be specially designed for trouble-free bearing service. All fan shafts and wheels shall be designed to operate at their maximum rated speed, which is below the first critical speed.

All motor bases shall be adjustable and V-belt drives selected for 115 percent of motor power.

The steel casing of the air fans shall be made of hot-dip galvanized steel or aluminium.

Where the impeller is accessible in operation, guards shall prevent injuries to maintenance personnel.

Anti-vibration mountings shall be provided for each fan.

18.5.9. Piping Systems

The necessary piping installation for condense water discharge from all above-mentioned air coolers shall be included in the supply. The supply shall also include the necessary fittings, valves (manually and motor operated valves, return valves etc.), flow control meters, pressure gauges, thermostats, insulations and fixations. All pipes shall be galvanized and insulated.

For chilled water circuits, water pumps shall be provided. The speed of pumps shall be 1450/ 1500 rpm. Pump bearings shall be water lubricated.

18.5.10. Rooftop turbine ventilators

The rooftop turbine ventilator shall be installed through-out the roof of the Chilla Powerhouse building. The quantity of the said rooftop turbine ventilator shall be decided during the detailed engineering by the employer. It shall be passive type running on wind energy thus attracting zero operating cost. It shall operate by utilising the velocity energy of the wind to induce air flow by centrifugal action The centrifugal force caused by the spinning vanes shall create a region of low pressure area which draws air out through the turbine. Air drawn out by the turbine shall be continuously replaced by fresh air from the outside (windows and gates). Slightest breeze will cause the turbine to spin and even after the breeze has stopped, the fly wheel effect of the rotor cage will use its stored energy to continuously remove air giving rise to ventilation. Suction is maintained even at low wind velocities. Hot air becomes lighter and accumulates at the centre apex of the shed/ roof.

Each ventilation turbine shall be of rain proof rugged spider design. The top plate and the bottom ring shall be of Stainless steel while the curved vanes shall be fabricated from rigid anodized

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Aluminium. The bearings shall be zero maintenance permanently lubricated type.

18.5.11. Bolts, Nuts and Washers

All bolts, screws and nuts shall be of metric thread standards and have hexagonal heads. The material shall be of stainless steel.

18.5.12. Controls and Electrical Equipment

The HVAC system shall be equipped with operation on fully automatic mode and manual mode.

Automatic Control and Regulation:

The HVAC system shall be equipped with a fully independent computerized and automatic control system for efficient operation, which shall be included in the supply. It should automatically shutdown all fans immediately in case of fire detection.

All sensors and instruments (temperature, pressure, humidity, etc.), limit switches, etc. required for automatic regulation and monitoring of proper service of the systems shall be included in the supply.

Manual mode

Individual starting and stopping of equipments by push buttons.

All the necessary cabling between the control panels and the field HVAC components (as fans, sensors, pumps, valves, air dampers, etc.) shall be included in the supply and shall be in accordance with relevant standards/codes in recent practice.

Each of the control systems shall be equipped with the necessary control, interlocking and security devices. Any failure or breakdown in the control system shall be indicated by a signal on the respective control panel, as well as remotely in the main control room. Potential free contacts and terminals for remote indication of the alarms shall be provided in the panels. All necessary protection viz single phasing, IDMT and Instantaneous over current relays, Under voltage relays etc. shall be provided.

18.6. QUALITY CONTROL AND ASSURANCE

The contractor shall follow the quality assurance and testing requirements specified separately in Volume-III –D: Quality Assurance and Testing Specification/MQAP.

18.7. DRAWINGS, DOCUMENTS AND DESIGN CALCULATIONS

18.7.1. Drawings and Documents

The Contractor shall submit all the drawings and documents as per clause no. 2 of Section VIII.

18.7.2. Design Calculation

The Contractor is required to submit the design calculation for following to the Engineer for approval during detail engineering.

a) Sizing of ducts for air distribution

b) Calculation for selecting the AHU and other fans capacity

c) Cooling loads, air flow rate and temperature & humidity conditions at all locations/areas

18.8. SHOP TESTS

The HVAC system shall be type and routine tested as per relevant IEC / IS / Standards. The contractor is required to carry out all type tests on air cooled chiller units and other equipment of one-unit and routine tests on all units and submit the reports to the Employer. At the discretion of the Employer, type test certificates can be accepted in place of type tests.

18.9. INSTALLATION AND COMMISSIONING

The contractor shall furnish all labour, supervision, tools, supplies, bracing, spiders, shims and supports and all other provisions or materials necessary to assemble, erect, install, test and commission of the equipment in a thorough workman like manner following the best modern practices.

The equipment and all 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.

All necessary materials and labour for performing all the above tests shall be provided by the contractor. All test equipment and instruments shall be furnished by the contractor and will remain the contractor's property after the fulfilment of all field tests

All civil work required for foundation shall be carried by contractor. The contractor is required to submit all foundation drawings and supporting steels well in advance for approval.

18.10. FIELD TESTS

After installation, the HVAC system shall be field tested for operational tests, visual inspection of complete installations, main air flow rates, performance of heaters, electrical consumption of electrical components, room conditions in all rooms, control system, hydrostatical tests of whole piping systems, air tightness, vibration and noise due to turbulence in the duct assembly etc. The contractor shall prepare and hand over to Employer details of all test results in a report in a mutually agreed format.

18.11. SPARE PARTS

18.12. GENERAL SPARE PARTS

The Contractor shall supply the general spare parts as per relevant clauses of the tender specifications. The supply of this spares shall be as per the approved list of spares for each component / equipment / item during detail engineering. The following specified spare parts, which shall comprise the total requirement for HVAC system under this Contract, shall be supplied.

S. No.	Description	Unit & Quantity
1	Filter bank of each type and size	4 sets

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2	V- belts of each type and size	2 sets
	Relays of all type	2 sets
3	Circulation chilled water pump motor set	1 No.
4	Control system cards	1 set
5	All type of fuses and indicators	sets

A set is defined as the total number required for one unit.

18.13. SPECIAL TOOLS

The Contractor shall provide one set of all necessary special tools and maintenance equipment for repair and maintenance of the Air conditioning and Ventilation system as recommended by the manufacturer. A list of such tools shall be approved during detail engineering.

Reply of UJVNL on bidding form no 6 "Deviations from conditions of contract" filled by bidder.

Sl. No.	Referral Tender Clause/Addendum and its page number	Deviation	UJVN Limited Clarification	BHEL's Reply (16.07.2019)
1.	GCC Clause no 13.3 ,	BHEL has quoted price considering concessional customs duty for import of raw materials and components. Since tender does not provide any format for declaration of CIF content, therefore the same shall be furnished during pre-award stage. In case UJVNL desire the declaration of CIF content, the same can be submitted during post bid stage on intimation from UJVNL during post bid clarifications. We request to kindly issue "project Essentiality Certificate" for the imported components. During execution, the successful bidder shall submit a comprehensive list of all the goods to be imported into India under the contact to enable UJVNL to issue necessary declaration/letter for availing concessional rate custom and import duties.	Noted	Ok
2.	As per ITB, the bidder shall submit a sheet detailing rates of various applicable taxes and duties as considered in the price bid.	Since there is no separate format for declaring Taxes and duties, we have furnished the taxes and duties herein. **Supplies:-** GST@18% has been considered by BHEL for complete scope except Ventilation & Air Conditioning. For Ventilation & Air Conditioning GST@28% has been considered. **Services:** GST@18% has been considered. **Civil works:** -GST@18% has been considered. -An amount of 1% is considered at sl no 25 of price schedule(BOQ-1)-Any other Taxes and duties towards labour welfare fund of Government of Uttarakhand	Noted	Ok

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		carry out the Turbine model test at International laboratory in place of BHEL, Bhopal as per UJVNL tender requirement at van additional price mentioned herein. Note:- 1.Thus the total amount of conducting the Turbine Model testing in independent international laboratory in place of BHEL, Bhopal shall be the amount indicated at sl no. "b" above i.e. Rs***** PLUS GST@18%(which is included in the price appearing at sl. No.1.05 under "Turbine and associated auxiliaries" in price schedule(Price BOQ-1) Plus the additional price appearing herein under "Total amount with taxes" in this deviation sheet(price BOQ-2). 2. For price please refer price bid.	

Reply of UJVNL on bidding form no 6 "Deviations from conditions of contract" filled by bidder.

Sl. No.	Referral Tender Clause/Addendum and its page number	Deviation	UJVN Limited Clarification
1.	GCC Clause no 13.3 ,	BHEL has quoted price considering concessional customs duty for import of raw materials and components. Since tender does not provide any format for declaration of CIF content, therefore the same shall be furnished during pre-award stage. In case UJVNL desire the declaration of CIF content, the same can be submitted during post bid stage on intimation from UJVNL during post bid clarifications. We request to kindly issue "project Essentiality Certificate" for the imported components. During execution, the successful bidder shall submit a comprehensive list of all the goods to be imported into India under the contact to enable UJVNL to issue necessary declaration/letter for availing concessional rate custom and import duties.	Noted
2.	As per ITB, the bidder shall submit a sheet detailing rates of various applicable taxes and duties as considered in the price bid.	Since there is no separate format for declaring Taxes and duties, we have furnished the taxes and duties herein. **Supplies:-** GST@18% has been considered by BHEL for complete scope except Ventilation & Air Conditioning.	Noted

		For Ventilation & Air Conditioning GST@28% has been considered. **Services:** GST@18% has been considered. **Civil works:** -GST@18% has been considered. -An amount of 1% is considered at sl no 25 of price schedule(BOQ-1)-Any other Taxes and duties towards labour welfare fund of Government of Uttarakhand	

UJVNL observations on submitted bid

Sl. No.	Referral Tender Clause/Addendum and its page number	Deviation	UJVN Limited Clarification
1.	Bus Duct	Additional length of bus duct shall be charged extra	Being turnkey project, any length of bus duct/Power cable required to complete the works in totality shall be in the scope of the contractor. Please confirm
2.	Manufacture/vendors of items in tender Documents	In the offered bid, BHEL has not specified the manufacturing brand/vendors of many items/components/Testing equipment/Tools and tackles. Also in technical data sheet, BHEL mentioned BHEL approved make instead of manufacturing brad mentioned in tender document and subsequent addendums. Also some of the catalogue provided is not from the brand specified in tender document.	In case some specific equipment manufacturing brand is specified in the tender specifications, the contractor must adhere to it only. Please confirm
3.	Power House earthing & lightening protection system for Power House Chapter 1 clause no 1.5(C) & Chapter 8 Cl No 8.6.12.4(I) & Cl No 8.6.12.5	Equipment earthing shall be provided for BHEL supplied equipment only. Note: Underground network/Earthing grid/electrodes/riser/ring main etc shall be in customer's scope.	Please abide by the tender specifications and Being turnkey project, earthing, Underground network/ Earthing grid/electrodes/riser/ring main etc shall be required to complete the works in totality shall be in the scope of the contractor. Please confirm
	Bird repelling system for Power House	1.Arrangement of user licenses & clearance regarding Indian wild life	Please abide by the tender

					black start.	
72	Auxiliary Equipment	Clause 17.7.5.j)	1153	The size of the main oil tank shall be sufficient for continuous running at full power for at least 100 hours for new DG sets	Please clarify that the continuous running for 100 hrs. to be applicable for Single DG set or for both	For both DG sets.
73	INSTALLATIO N AND COMMISSIONI NG	Clause 17.11	1157	All civil work required for modification of foundation shall be carried by the Contractor	Civil work for modification of foundation shall not be in BHEL scope	Scope of Contractor
74	-	-	-	Station layout and foundation details for DG sets.	Please provide the soil report/bearing capacity& founding level considered for existing foundations for sizing of new required foundations.	All available data are provided with tender document .For more intricate details kindly visit the site before bidding for accessing the requirement.
Volume-IIIB: Chapter 18 of PTS– Heating Ventilation and Air Conditioning System						
75				Scope of Work	We propose to go ahead with refurbishment of existing HVAC system installed in power house as the same is in good working condition along with ongoing AMC with existing vendors Further we propose below scope with need to be changes during refurbishment . 4 no Fresh air Supply Blowers installed outside All wall mounted exhaust fans Kindly accept the same	The scope of work has been cleared defined in the tender document, and its subsequent addendums. Please abide by the tender specification.
Volume-IIIB: Chapter 19 of PTS: Cooling Water System						
76	-	-	-	-	Kindly arrange to provide the following information of existing Raw Water Filtration	All available data are provided with tender document .For more intricate details kindly visit the site before bidding for accessing the requirement.

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Addendum-1

				the load being fed through SAB.	
Volume-IIIB: Chapter 18 of PTS– Heating Ventilation and Air Conditioning System					
26	Basic Dimensions and Ratings	Clause no. 18.2.1	1164	18.2.1. Basic Dimensions and Ratings The system design shall be based on criteria, factors, and details recommended or indicated in the latest ASHRAE handbook	. 18.2.1. Basic Dimensions and Ratings The system design shall be based on criteria, factors, and details recommended or indicated in the latest ASHRAE handbook/ ISHRAE handbook
Volume-IIIB: Chapter 23 of PTS: Potable Drinking Water Purification System					
27	Comprehensive Services	Clause 23.9	1272	23.9 COMPREHENSIVE SERVICES CONTRACT FOR FIVE YEARS	23.9 COMPREHENSIVE SERVICES CONTRACT
28	Comprehensive Services	Clause 23.9(i,ii)	1273	The drinking water RO plant shall be guaranteed for trouble free operation for two year from the date of commissioning of plant. Thereafter, three year comprehensive service contract shall follow. Any faulty component such as pumps, filters, membrane etc. during comprehensive services contract shall be replaced by the contractor free of cost during the guarantee period plus three following years.	The drinking water RO plant shall be guaranteed for trouble free operation for two year from the date of commissioning of plant. Any faulty component such as pumps, filters, membrane etc. during comprehensive services contract shall be replaced by the contractor free of cost during the guarantee period
Volume-IIIC: TDS					
29	TURBINE AND ASSOCIATED AUXILIARIES(GUARANTEED TECHNICAL PARTICULARS)	Table 1.1 (S.No 2.3)	1325	2.3 Critical sigma over complete head range, output range, discharge and number of Units under operation	Deleted
30	TURBINE AND ASSOCIATED AUXILIARIES	Table 1.1 (S.No 2.4)	1325	2.4 Plant sigma at rated head, maximum discharge & maximum output when all Units are under operation.	Deleted
Volume-V - Bidding Forms					
31	5 MVA Station Transformer	Form 11(EII)		ii Minimum Rated Efficiency of Station Transformer at rated voltage, ratedfrequency rated continuous output and power factor of 0.9 % 98.5	ii Minimum Rated Efficiency of Station Transformer at rated voltage, rated frequency rated continuous output and power factor of 0.9 % 99.5

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				transmission rate, of at least 1Gbps shall be provided. Central control Room network shall be redundant Optical Fiber cables, based on the TCP/ IP Ethernet Standards at 1 GBPS data transfer rate.		
204	Redundancy	Clause No.-7.3.6	766	The GPS synchronization master clocks shall be redundant.	Master Clock shall be redundant with non-redundant receiver & antenna. Please confirm.	Please abide by the tender specifications.
205	System configuration	Clause No.-7.6.3	775	iv. Generation control based on reservoir level restrictions, Availability based tariff based restrictions, downstream release considerations and time based schedules.	Required data to be furnished by UJVNL. Please confirm.	Necessary data to the extent possible shall be provided by UJVN Limited.
206	Operator workstations	Clause No.-7.6.4.5	786	VII. Multimedia key board with all functions and provision of shortcuts for alarms,	All control and monitoring shall be carried out through OWS using mouse and ASCII keyboard. Membrane type Multimedia key board is not applicable. Please confirm.	The clause is self-explanatory. Please abide.
207	Unit Control Boards (UCB)	Clause No.-7.6.5	790	X. Brake dust & carbon dust collection system, XVI. Heat Ventilation & Air Conditioning (HVAC) System.	These standalone systems are having their dedicated control & monitoring system. It is not recommended to control these systems from other system due to control overlapping. However, monitoing shall be provided from DCS. Please confirm.	Accepted and confirmed

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					shutdown of 132kV switchyard shall be arranged as and when required during execution of project.	shutdown of the unit, however feeder and other remaining work shall is required to be completed by the contractor during the 3 months common shut down period.
225	Civil Work	Cl.8.2.5.1	822	The contractor shall carry out all type of civil work required for refurbishment, modification & strengthening of the existing equipment foundations, trenches with cable racks trays & trench covers, pathways etc. in the 4 Nos. unit bays, 1 No. bus–coupler bay, 3 Nos. feeder bays etc.	It was observed that all the existing cable trenches, which are made of brick, are not in good conditions. BHEL understands that all the existing trenches shall be completely dismantled, removed and new RCC cable trenches shall be cast in site as per new requirement. BHEL also understands that soil testing for soil parameters is in the scope of UJVNL. Please confirm.	Please abide by the tender specification All the existing trenches shall be completely dismantled, removed and new RCC cable trenches shall be cast in site as per requirement.
226	Civil Work	Cl. 8.2.5,	822	Civil Work	It was observed that all Switchyard cables are going to power house through a cable tunnel. It is assumed that any civil work for this tunnel is not in scope. Please confirm. Also we have not found any details of ventilation system for this tunnel; therefore we assume that any ventilation system is also not required in this tunnel. Please confirm.	Any civil work for cable tunnel is not in bidder's scope. Confirmed.
227	Civil Work	Cl. 8.2.5	822	Civil Work:	Please clarify following wrt switchyard civil work. i). It was observed that natural drainage is available for draining switchyard rain water. Hence is is understood that there is no	The natural drainage system available for draining switchyard rain water; shall be repaired and refurbished to ensure its proper working. The existing roads inside the switchyard are not to be dismantled and recast.

					requirement of design and execution of internal drainage. Ii) It was observed that the existing roads inside the switchyard are in good conditions. Hence it is understood that the existing roads are not to be dismantled and recast.	
228	General				Air Compressor room and ACDB room are loacted in Switchyard area. We understand that that existing compressor system located in existing compressor room located in 132kV Switchyard shall be dismantled. And this room and its adjacent room shall be used for placing ACDB & MLDB of 132kV Switchyard. Any civil work for these room is not envisaged. Only cleaning and painting work has been envisaged for these room. Ventilation system shall be provided through wall mounted axial fan for these rooms. LED type fixtures shall be used for illumination of this room. Please confirm.	Confirmed and accepted The existing compressor system located in existing compressor room located in 132kV Switchyard shall be dismantled and this room and its adjacent room shall be used for placing ACDB & MLDB of 132kV Switchyard. Any civil work necessary for installation of the systems shall be in bidder's scope along with cleaning and painting work. Necessary ventilation system through wall mounted axial fan and illumination by LED type fixtures is accepted for this room.
229	SUPPLY, ERECTION, TESTING AND COMMISIONI	Cl.8.2.1	819	The scope of work shall be a comprehensive functional system complete in every respect including but not be limited to design, manufacture,	As per specification all main equipment of switchyard shall be replaced with new. However, During our earlier site visit it was found that	Please abide by tender specification.

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					i) Route length and width of tunnel ii) Drawing of tunnel and its route iii) Lux level required in tunnel	visit the site and generate the drawings.
244	SCOPE OF WORK	clause no. 17.2.1.	1144	The scope of work including supply, erection, testing & commissioning of shall be a comprehensive functional system complete in every respect including but not be limited to following: Diesel Generating Unit (DG Unit), rated for 500kVA output (under site conditions), 415V, 0.8p.f., 1500rpm; complete with fuel system, lubrication system, exciter, automatic voltage regulator cooling system, radiators, exhaust silencers, base frame with anti-vibration dampers etc. enclosed in a sound proof enclosure along with air intake and exhaust system, battery and battery charger, instruments and protection system, annunciations, coupling arrangements etc.- 2 sets	During earlier site visit, we found that, there was One (1) Set of new DG set was found installed at site. Hence, please clarify, whether we have to supply two (2) nos. or single DG Set.	Tender specification is self-explanatory Please go with quantities specified in tender document
245	Auxiliary equipment,	clause no. 17.7.5 (S. No. j)		The size of the main oil tank shall be sufficient for continuous running at full power for at least 100 hours for new DG sets and that of day tank as 500 L.	Please specify the location where main oil tank will be located in the power plant.	The tank shall be placed at El. 303 m.
Volume-IIIB: Chapter 18 of PTS– Heating Ventilation and Air Conditioning System						

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246	Scope of work	Clause no. 18.1.4 i. & xiii	1161	i) Two (2) Air-Handling Units AHU-1 and AHU-2 (one main & one standby) for each of 100% of required capacity for airconditioned control block area at Chilla Powerhouse comprising control room, LT room, carrier/ PLCC room, battery charger room, test room, committee room, offices and other facilities. At a time one of the unit shall operate with the second one as the standby. Each AHU shall be complete with compressors, condensers, evaporators, cooling coils, expansion nozzles, interconnecting piping, controls, indicating instruments, necessary devices, safety devices, valves, thermostats, refrigerating pipes and duct heaters etc. ii) Either CFC free referigerant compressor or chilling tower of adequate capacity or air cooled DX-type condensing unit having CFC free refrigerant compressor for air conditioning system in which there is no requirement for chilling tower/ cooling tower.	We understand that evaporators, cooling coils, expansion nozzles, interconnecting piping, controls, indicating instruments, necessary devices, safety devices, valves, thermostats, refrigerating pipes and duct heaters etc. mentioned under clause 18.1.4 i. are applicable for Chiller unit (mentioned against clause no. 18.1.4 xiii) Pl clarify	There are certain specific areas in the powerhouse which are to be air conditioned & ventilated and there are areas which require just ventilation of normal air. The choice of the AHUs with chilling coils & heating elements as well as the AHUs without chilling coils & heating elements shall be done as per the HVAC system requirement & design.
247	Scope of work	clause no. 18.1.4 (ii) & 18.1.4 (iv)	1162	i) Suitable no. of Air-handling Units (AHU) without any cooling coil shall be provided for ventilation of erection/service bay floor, generator floor, turbine floor, draft tube floor etc and other	We understand that the equipment required against both these clauses is same. Accordingly, four (4) nos. fresh air blowers of required capacity shall be provided for ventilation system.	Suitable no. of Air-handling Units (AHU) without any cooling coil (minimum 4 number of fresh air blower AHU having capacity not less than 216 m3/min) shall be provided for ventilation of erection/service bay floor, generator floor, turbine floor, draft tube floor etc. and other area.

				area. ii) Four (4) nos, fresh air blower AHUs of capacity 216 m3/min. complete with motor and motor control panel and wiring.	Please confirm.	
248	Scope of work	Clause no. 18.1.4 (v)	1162	One (1) lot of rooftop passive type turbines ventilators.	Since required number of exhaust fans for exhaust of air from non air conditioned areas are being provided in line with specification requirement, separate rooftop passive type turbine ventilators have not been envisaged. Please confirm acceptance.	Please abide by the tender specification.
249	Scope of work/ Insulations	Clause no. 18.1.4. viii) & 18.5.3	1162,1180	viii) Insulation for the complete air conditioning ducting and lagging of pipe lines and fittings; 18.5.3 The fresh air supply to air ducts shall be insulated to prevent condensation on the duct surfaces.	We understand that insulation shall be provided for AC ducts and fresh air ducts for supply to air conditioning system, as required. Insulation has not been envisaged for ventilation ducts. Please confirm	Accepted and confirmed.
250	SPECIAL DESIGN AND LAYOUT CONDITIONS	Clause no. 18.2	1163	SPECIAL DESIGN AND LAYOUT CONDITIONS The contractor shall utilize the cut-outs and block-outs in the powerhouse structure being utilized by the existing HVAC system for successful erection, testing and commissioning the new HVAC system.	Kindly provide all layout drawings for existing HVAC system for estimation of BOQ for duct of AC and Ventilation system.	All available drawings have been enclosed in the tender for bidder reference. For more intricate details kindly visit the site before bidding for accessing the requirement.
251	Basic Dimensions and Ratings	Clause no. 18.2.1	1164	The system design shall be based on criteria, factors and details recommended or	Criteria, factors and details as indicated in ISHRAE handbook may also be	Accepted

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				indicated in the latest ASHRAE handbook.	allowed in addition to ASHRAE handbook, for design of HVAC system.	
252	Noise Levels	Clause no. 18.2.4	1164	The noise level caused by operation of the ventilation shall not exceed 55 dB (A) in rooms as in control rooms, offices & reception room	We understand the requirement of noise level limit as 55dB (A) is applicable for air conditioning system and not ventilation system. Please confirm.	Confirmed
253	Construction	Clause no. 18.5.1.2 I	1166	For AHU Casing construction - All unit sections shall be supplied with 12-gauge G90 galvanized steel structural support rails.	Since double skinned casing is being considered for AHU, it is requested to allow use of 24G galvanized steel panel for both inner and outer casing with 25mm thick PU insulation in-between. Please confirm acceptance.	Accepted.
254	Construction	Clause no. 18.5.1.2 I	1166	Fan supports, structural members, panels, or flooring shall not be welded.	Welding being a very standard process, is widely prevalent in the industry. Accordingly use of welding may please be allowed.	The same may be considered at the stage of detailed engineering.
255	Fan motor	Clause no. 18.5.1.3 I f)	1169	Motor shall be high efficiency, open drip-proof or totally enclosed fan cooled NEMA Design B with size and electrical characterstics as shown on the equipment schedule	Design of motors as per IS 12615 may please be allowed in addition to NEMA standard.	The alternate standard can only be accepted by UJVN Limited if the properties of the offered material as per the alternate standard is same or better as per the standard specified in the tender.
256	Mounting	Clause no. 18.5.1.3 IV	1170	The isolation system shall be designed to conform to seismic zone 5 requirements	Fans are provided with anti-vibration pads underneath to prevent transfer of vibrations. In view of this, design requirement of conformance to seismic zone 5 has not been considered.	Accepted

257	Coil	Clause no. 18.5.1.4	1170	All water & refrigerant coils shall have 15mm OD seamless copper tubes...	Internal details of AHUs are specific to individual supplier's design, as required to meet overall performance parameters of AHU. In view of this, internal details of AHU shall be manufacturer design specific.	All water and refrigerant coils shall have seamless copper tubes copper tubes. Please abide by the tender specification.
258	Remote Display Panel	Clause no. 18.5.1.14	1178	...it will be possible to control chiller operation from the remote panel similar to the control interface on the chiller itself and it will be possible to turn on & off, change the chilled water set point...	Microprocessor of chiller shall be hooked up with HVAC system PLC for 'ON' and 'OFF' operation. However, control of chiller shall be available through chiller microprocessor panel only. Accordingly, separate remote panel for control of chiller has not been envisaged. Please confirm acceptance.	It may be considered at the time of approval during detail engineering stage.
259	Outside Air Louvers	Clause no. 18.5.5	1181	Outside air louvers - they shall be stamped and pressed out of one piece of aluminium sheet of atleast 2mm thickness	Air louvers of maximum 1.2mm thickness are available in the market. The same are being considered for this proposal. Please confirm acceptance .	Please abide by tender specifications.
260	Air Filters	Clause no. 18.5.11	1181	The material (for bolts, nuts, washers) shall be of stainless steel.	Hot dip galvanized steel fastners are widely used in the industry. The same are being envisaged for this proposal. Please confirm acceptance.	The bidder is expected to abide by the tender specifications. However, if the Contractor submits enough supporting documents during detail engineering, request for same may be considered.
Volume-IIIB: Chapter 19 of PTS: Cooling Water System						

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VOLUME-III-C: TECHNICAL DATA SHEET

Table of contents

-interlocking features
-description of the control and measuring equipment as provided

2 Information on energy meters installed.

9. LT SWITCHGEARS SYSTEM

9.1. GUARANTEED TECHNICAL PARTICULARS

Item	Parameter	Units	Bidder's Data
	415 V Switchgear		
1	415V Switchgear		
1.1	Highest voltage for equipment Um	V	
1.2	Power frequency withstand voltage, 1 minute		
	- main circuits	V	
	- control circuits	V	
2	**UAB / SSB**		
2.1	Rated current of busbar and board	A	
2.2	Nominal voltage	V	
2.3	Material of bus bar		
2.4	Protection class		
3	**Circuit breaker (incoming circuit)**		
3.1	Rated current (at 40°C)	A	
3.2	Rated short circuit breaking current		
	symmetrical	kArms	
	asymmetrical	kArms	
3.3	Rated short circuit making current	kApeak	
3.4	Permissible short time current for 1 s	kArms	
3.5	Dynamic short time current	kApeak	
4	**Moulded case circuit breaker (outgoing circuits)**		
4.1	Short-circuit current limiting characteristic	yes/no	
4.2	Symmetrical short-circuit breaking current	kArms	
4.3	Short-circuit making current	kApeak	
5	**Current transformers (incoming circuits)**		

5.1	Number of CT's		
5.2	Rated current primary / secondary side	A	
5.3	Number of measuring/protection cores		
5.4	Accuracy class		
	-measuring cores		
	-protection cores		

9.2. INFORMATIVE DATA

Item	Parameter	Units	Bidder's Data
1	**General**		
1.1	Manufacturer		
1.2	Place of manufacture		
1.3	Type designation		
1.4	Applicable standards		
2	**UAB / SSB**		
2.1	Unit Auxiliary Boards		
	Weight of complete board	Kg	
	Dimensions of complete board	mm x mm x mm	
2.2	Station Service Boards		
	Weight of complete board	Kg	
	Dimensions of complete board	mm x mm x mm	
2.3	Cubicle assemblies		
	- Make		
	-Type designation		
2.4	Circuit breaker (incoming circuit)		
	- Manufacturer		
	- Type		
	- Type of over-current relay		
2.5	Moulded case circuit breaker (outgoing circuits)		
	- Manufacturer / Type		
	- Number of poles		
	CB motor drive (for stored - Energy operating mechanism)		
	- normal voltage	V	
	- power consumption	W	

	CB closing & tripping coils		
	- normal voltage	V	
	- power consumption	W	
	CB motor drive (for stored - Energy operating mechanism)		
	- normal voltage	V	
	- power consumption	W	
	CB closing & tripping coils		
	- normal voltage	V	
	- power consumption	W	
2.6	Current transformers (incoming circuits)		
	Make / type designation		
	Rated burden		
	-measuring cores	VA	
	-protection cores	VA	
2.7	Other distribution board (Misc.board)		
	Manufacturer /type designation		
	Number of boards provided		
	Minimum rating of board	A	
	Number of outgoing feeders / board and rating of each	Nos.	
	Rated current of bus bar	A	
2.8	Accuracy class of Meters		
	Energy meters		
	Voltmeter		
	Ammeter		

9.3. SPARE PARTS

Recommended additional spare parts

List hereunder the spare parts which are recommended by the Bidder for purchase in addition to the specified spare parts as per specifications in Tender document". The purchase of any or all of the recommended spare parts will be at the option of UJVNL. The prices for recommended additional spare parts for five (5) years shall therefore not be included in the bid prices.

Item	Description	Make / Type	Quantity
1			
2			

3			
4			
5			

* Use additional sheets if required

9.4. INFORMATION TO BE SUPPLIED AFTER AWARD OF CONTRACT

At least the information listed hereunder shall be given by the bidders. The bidders may submit additional documents /descriptions to describe special technical features of offered equipments / system:

1 The catalogues, Drawings, technical data, etc. of 415 V switchgear, all auxiliary transformers and other equipment

2 Pamphlets of the proposed switchgear showing the following

principle of segregation of various compartments

air circuit breaker handling and control including interlocking features

basic functions and characteristics of CB protection relay

3 Illustration of the drawout type MCCB

4 Information on energy meters installed.

10. DC SYSTEM

10.1. GUARANTEED TECHNICAL PARTICULARS

Item	Parameter	Units	Bidder's Data
1	**220 V battery charger**		
1.1	Type / designation	-	
1.2	Capacity	A	
1.3	DC rated voltage U_N		
	- Boost charger	V	
	- Float charger	V	
1.4	DC rated current I_N		
	- Boost charger	A	
	- Float charger	A	
1.5	Maximum ripple of output voltage (peak to peak)		

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	- with the battery connected	% U_N	
	- without the battery connected	% U_N	
1.6	Protection class of cubicle		
2	**48 V battery charger**		
2.1	Type designation	-	
2.2	Capacity	A	
2.3	DC rated voltage U_N		
	- Boost charger	V	
	- Float charger	V	
2.4	DC rated current I_N		
	- Boost charger	A	
	- Float charger	A	
2.5	Maximum ripple of output voltage (peak to peak)		
	- with the battery connected	% U_N	
	- without the battery connected	% U_N	
2.6	Protection class of cubicle		
3	**220V DC battery**		
3.1	Type	-	
3.2	Battery capacity at 25°C at 10 hours	Ah	
3.3	Number of cells per battery bank	Nos.	
3.4	Type of cells		
3.5	Voltage per cell	V	
3.6	Rated voltage U_N	V	
3.7	Float charging voltage	V	
3.8	Normal charging current	A	
3.9	Boost Voltage	V	
3.10	Discharge end voltage	V	
4	**48 V DC battery**		
4.1	Type	-	
4.2	Battery capacity at 25°C at 10 hours	Ah	
4.3	Number of cells per battery bank	Nos.	
4.4	Type of cells		
4.5	Voltage per cell	V	
4.6	Rated voltage U_N	V	

4.7	Float charging voltage	V	
4.8	Normal charging current	A	
4.9	Boost Voltage	V	
4.10	Discharge end voltage	V	
5	**220 V DC main distribution board**		
5.1	Type designation	-	
5.2	Number of boards	Nos.	
5.3	Power frequencies withstand voltage, 1 min.	kV	
5.4	Rated current of incoming feeder and busbar	A	
5.5	Short-circuit withstand current (1 s)	kA	
5.6	Protection class of cubicle		
6	**48 V DC main distribution board**		
6.1	Type designation	-	
6.2	Number of boards	Nos.	
6.3	Power frequency withstand voltage, 1 min.	kV	
6.4	Short-circuit withstand current (1 s)	kA	
6.5	Protection class of cubicle		
7	**Inverter**		
7.1	Type designation/ capacity	-	
7.2	DC supply		
	- input voltage	V	
	- maximum admissible variation of input voltage	%	
7.3	AC output		
	- rated voltage UN	V	
	- rated current IN	A	
	- number of phases		
	- rated output	kVA	
7.4	Short time overload capability for 1 second	% I_N	
7.5	Maximum distortion factor of voltage wave form	%	
7.6	Protection class of cubicle		

10.2. INFORMATIVE DATA

Item	Parameter	Units	Bidder's Data
1	**General**		
1.1	Manufacturer		
1.2	Place of manufacture	-	
1.3	Applicable standards	-	
2	**220 V Battery charger**		
2.1	Make	-	
2.2	Applicable standards	-	
2.3	AC supply		
	- voltage	V	
	- number of phases	Nos.	
	- frequency	Hz	
	- maximum power consumption at rated output	kW	
2.4	Weight of complete charger cubicle	Kg	
2.5	Overall dimensions of complete charger cubicle (LXWXH)	mm Xmm X mm	
3	**48 V Battery charger**		
3.1	Make	-	
3.2	Applicable standards	-	
3.3	AC supply		
	- voltage	V	
	- number of phases	Nos.	
	- frequency	Hz	
	- maximum power consumption at rated output	kW	
3.4	Weight of complete charger cubicle	Kg	
3.5	Overall dimensions of complete charger cubicle (LXWXH)	mm Xmm X mm	
4	**220 V DC battery**		
4.1	Make	-	
4.2	Applicable standards	-	
4.3	Heat losses at rated output	kW	
4.4	Battery fuse rating	A	
4.5	Expected life	Years	

4.6	Internal resistance		
	- of one cell	Ohm	
	- of complete battery	Ohm	
4.7	Weights		
	- of one cell	Kg	
	- of complete battery including racks	Kg	
4.8	Overall dimensions of complete cubicle (LXWXH)	mm Xmm X mm	
5	**48 V DC battery**		
5.1	Make	-	
5.2	Applicable standards	-	
4.3	Heat losses at rated output	kW	
5.4	Battery fuse rating	A	
5.5	Expected life	Years	
5.6	Internal resistance		
	- of one cell	Ohm	
	- of complete battery	Ohm	
5.7	Weights		
	- of one cell	Kg	
	- of complete battery including racks	Kg	
5.8	Overall dimensions of complete cubicle (LXWXH)	mm Xmm X mm	
6	**220V DC distribution board**		
6.1	Make	-	
6.2	minimum number of outgoing feeders	Nos.	
6.3	Rated current of incoming feeder and busbar		
6.4	Rated current of outgoing feeders.		
6.5	Overall dimensions of complete cubicle (LXWXH)	mm Xmm X mm	
7	**48V DC distribution board**		
7.1	Make		
7.2	Minimum number of outgoing feeders	Nos.	
7.3	Rated current of incoming feeder and busbar		
7.4	Rated current of outgoing		

	feeders.		
7.5	Overall dimensions of complete cubicle (LXWXH)	mm Xmm X mm	
8	**Inverter**		
8.1	Make	-	

10.3. SPARE PARTS

Recommended additional spare parts

List hereunder the spare parts which are recommended by the Bidder for purchase in addition to the specified spare parts as per specifications in "Chapter 11". The purchase of any or all of the recommended spare parts will be at the option of UJVNL. The prices for recommended additional spare parts for five (5) years shall therefore not be included in the bid prices.

Item	Description	Make / Type	Quantity
1			
2			
3			
4			
5			

* Use additional sheets if required

10.4. INFORMATION TO BE SUPPLIED AFTER AWARD OF CONTRACT

At least the information listed hereunder shall be given by the bidders . The bidders may submit additional documents /descriptions to describe special technical features of offered equipments / system:

1 Functional description interlocking scheme of the proposed DC system.

2 Pamphlets/catalogues etc. of battery, battery charger, UPS, other standard products used.

11. FIRE FIGHTING SYSTEM

12. POWER, CONTROL, INSTRUMENTATION & COMMUNICATION CABLES

12.1. GUARANTEED TECHNICAL PARTICULARS

Item	Parameter	Units	Bidder's Data
1	11 KV POWER CABLES(TO BE FILLED IN FOR EVERY TYPE)		
1.1	Type / designation		
1.2	Rated voltage	kV	
1.3	Insulation		
1.3.1	Material of insulation		
1.3.2	Minimum thickness of insulation	mm	
1.4	Conductor		
1.4.1	Material of conductor		
1.4.2	Form of conductor (circular/shaped)		
1.4.3	Size of conductor	mm^2	
1.5	Screen		
1.5.1	Type of screen		
1.5.2	Material of screen		
1.5.3	Minimum thickness of screen	mm	

1.6	Armour, if applicable		
1.6.1	Type		
1.6.2	Material		
1.6.3	Size/diameter of strip/wire	mm	
1.7	Overall diameter of cable	mm	
1.8	Power frequency withstand voltage	kVrms	
1.9	Highest voltage for equipment Um	kV	
1.10	Max. conductor temperature in		
1.10.1	service condition	°C	
1.10.2	fault conditions	°C	
1.11	Current rating (coninous in air)	Amp	
1.12	Short circuit current rating for 1 sec	kA	
1.13	Test voltage at factory	kVrms	
1.13.1	Period of test voltage	minute	
2	**LOW VOLTAGE POWER CABLES (TO BE FILLED IN FOR EVERY TYPE)**		
2.1	Type / designation		
2.2	Rated voltage	kV	
2.3	Insulation		
2.3.1	Material of insulation		
2.3.2	Minimum thickness of insulation		
2.4	Conductor		
2.4.1	Material of conductor		
2.4.2	Form of conductor (circular/shaped)		
2.4.3	Size of conductor	mm^2	
2.5	Screen		
2.5.1	Type of screen		
2.5.2	Material of screen		
2.5.3	Minimum thickness of screen	mm	
2.6	Armour, if applicable		
2.6.1	Type		
2.6.2	Material		
2.6.3	Size/diameter of strip/wire	mm	
2.7	Overall diameter of cable	mm	

2.8	Max. conductor temperature in		
2.8.1	service condition	°C	
2.8.2	fault conditions	°C	
2.9	Current rating (cont. in air)	Amp	
2.10	Short circuit current rating for 1 sec	kA	
2.11	Test voltage at factory	kVrms	
2.12	Period of test voltage	minute	
3	**CONTROL AND INSTRUMENTATION CABLES (TO BE FILLED IN FOR EVERY TYPE)**		
3.1	Type designation		
3.2	Voltage rating	V	
3.3	Conductor		
3.3.1	Material of conductor		
3.3.2	Form of conductor (circular/shaped)		
3.3.3	Diameter of conductor	mm	
3.4	Insulation		
3.4.1	Material of insulation		
3.4.2	Minimum thickness of insulation	mm	
3.5	Screen		
3.5.1	Type of screen		
3.5.2	Material of screen		
3.5.3	Minimum thickness of screen		
3.6	Armour		
3.6.1	Type		
3.6.2	Material		
3.6.3	Size/diameter of strip/wire	mm	
3.7	Overall diameter of cable	mm	
3.8	Test voltage	kV	
3.9	Period of test voltage	minute	
4	**CABLE TRAYS (ALL TYPE)**		
4.1	Type/ designation		
4.2	Minimum spacing between tiers	mm	
4.3	Material		
4.4	Proposed Sizes (L x W x H) of cable trays	mm x mm x mm	

12.2. INFORMATIVE DATA

Item	Parameter	Units	Bidder's Data
1	**General(To be filled for each cable)**		
1.1	Manufacturer		
1.2	Place of manufacturing		
1.3	Applicable standards		
1.4	Test voltage at site after laying	kV	
1.5	Identification of conductors by Colour or Numerals		
1.6	Temperature coefficient of resistance at 20°C	/°C	
1.7	Maximum DC conductor Resistance at 20°C per Km	Ohm/km	
1.8	Maximum permissible conductor temperature		
1.8.1	Under continuous full load	°C	
1.8.2	Under Transient over loading conditions	°C	
1.9	Suitability with regard to moisture, ozone, acid, oil and Alkaline surroundings	Yes/no	
1.10	Weight of cable per Km	Kgf/km	
2	**Junction Box**		
2.1	Material		
2.2	Multi block terminal board rating		
2.2.1	Current	A	
2.2.2	Voltage	V	

12.3. SPARE PARTS

Recommended additional spare parts

List hereunder the spare parts which are recommended by the Bidder for purchase in addition to the specified spare parts as per specifications in "chapter-13". The purchase of any or all of the recommended spare parts will be at the option of UJVNL. The prices for recommended additional spare parts for five (5) years shall therefore not be included in the bid prices.

Item	Description	Make / Type	Quantity
1			
2			
3			
4			
5			

* Use additional sheets if required

12.4. INFORMATION TO BE SUPPLIED AFTER AWARD OF CONTRACT

At least the information listed hereunder shall be given by the bidder . The bidders may submit additional documents /descriptions to describe special technical features of offered equipments / system:

1 Documentation on each of the following categories of cables and accessories:
- 11 kV power cables
- Low voltage power cables
- Control cables
- Coaxial cables
- Cable trays
- Junction boxes/Terminal blocks

13. PROTECTION SYSTEM

13.1. GUARANTEED TECHNICAL PARTICULARS			
Item	**Parameter**	**Units**	**Bidder's Data**
1	**General**		

1.01	Protection class of Relay enclosure IP54	Yes/ No	-
1.02	Protection class of Protection panel IP52 minimum	Yes/ No	-
1.01	Type of Protection relays		-
1.01	Redundancy in Protection scheme as per SLD	Yes/ No	-
1.5	Conforming to IEC 60255	Yes/ No	-
1.6	Test blocks in panels provided	Yes/ No	-
1.7	Communication with plant control at IEC 60870-5-103	Yes/ No	-
1.8	Main-1 & Main-II protection on different DC sources	Yes/ No	-
1.9	Line Main-1 & Main-II protection through different principle/ type	Yes/ No	-
	All protections covered as per scope/specification mentioned	Yes/ No	-
2.1	Interoperability with plant SCADA	Yes/ No	-
2	**Characterstic Data**		
2.01	Protection cubicles		-
(i)	- type		-
(ii)	- protection class	IP	-
(iii)	Trip circuit supervision		
	1- type / designation		-
	2- auxiliary hand reset	Yes/ No	-
	3- max. trip circuit supervision current	mA	-
(iv)	Test device		
	1- type / designation		-
	2- provided for each assembly	Yes/ No	-
(v)	Power consumption per cubicle	W	-
2.02	Numerical Relays		

(i)	Event logger provided	Yes/ No	-
(ii)	DR provided	Yes/ No	-
(iii)	RS 232/ usb/ RS 485 ports privided	Yes/ No	-
(iv)	Time synchronisation feature provided	Yes/ No	-
(v)	Numerical relays with front panel display	Yes/ No	-
(vi)	Indication with light emmitting diodes	Yes/ No	-
(vii)	IEC 61850 compliant	Yes/ No	-
(viii)	Compliance of latest standards	Yes/ No	-
2.03	D.C. infeed		
(i)	- supply voltage	V	-
(ii)	- D.C./D.C. converter included	Yes/ No	-
(iii)	- tolerances of supply voltage	%	-
2.04	Differential relay used for generators		
(i)	Type / designation		-
(ii)	Current rating	A	-
(iii)	Current setting:		-
	- differential elements		-
	- differential current	%	-
	- bias	%	-
(iv)	High set overcurrent elements:		-
	- operating time:		-
	- less than 3 x IN	ms	-
(v)	Relay stability for through-fault	xIN	-
2.05	Under impedance relay		
(i)	Type / designation		-
(ii)	Setting ranges:		-
(iii)	- Impedance		-
(iv)	- ratio R/X		-
(v)	- time stage t1,t2	S	-
2.06	Stator 100 % earth fault relay		
(i)	Type / designation		-
(ii)	Voltage setting	%	-

(iii)	Time setting	S	-
(iv)	Split phase protection relay		-
(v)	Type / designation		-
(vi)	Voltage setting	%	-
(vii)	Time setting	S	-
2.07	Overcurrent relay		
(i)	Type / designation		-
(ii)	Setting range of time relay	S	-
(iii)	Setting range of instantaneous element	ms	-
(iv)	Setting range of overcurrent	%	-
(v)	Setting range of instantaneous element	%	-
2.08	Overvoltage relay		
(i)	Type / designation		-
(ii)	Setting range of the pick-up values:		
	- delayed trip	xUN	-
	- instantaneous trip	xUN	-
(iii)	Time setting range	S	-
(iv)	Reset ratio	S	-
2.09	Under voltage relay		
(i)	Type / designation		-
(ii)	Definite time	Yes/ No	-
(iii)	Inverse time	Yes/ No	-
(iv)	Two setting levels	Yes/ No	-
(v)	Voltage setting:		
	- setting range	% UN	-
	- start element reset at	% UN	-
	- continuously variable	Yes/ No	-
	- steps	Yes/ No	-
(vi)	Operating time:		
	- continuously variable	Yes/ No	-
	- steps	Yes/ No	-
	- setting range	S	-
2.1	Voltage per hertz relay		
(i)	Type / designation		-
(ii)	Setting range of the pick-up values:		-

(iii)	- delayed trip	xRN	-
(iv)	- instantaneous trip	xRN	-
(v)	Time setting range	S	-
(vi)	Reset ratio	S	-
2.11	Stator thermal overload relay		
(i)	Type / designation		-
(ii)	Pick-up setting	% IN	-
(iii)	Selectable time constant	Yes/ No	-
(iv)	Instantaneous limit trip	Yes/ No	-
2.12	Rotor earth fault relay		
(i)	Type / designation		-
(ii)	Impedance setting	k-Ohm	-
(iii)	Time setting	**S**	-
(iv)	Harmonics filter	Yes/ No	-
2.13	Negative phase sequence relay (46)		
(i)	Type / designation		-
(ii)	Adjustable pick-up value:		
	- first stage	% IN	-
	- second stage	% IN	-
	Tripping time-lag adjustable:		-
	- first stage	S	-
	- second stage	S	-
2.14	Loss of excitation and out of step relay		
(i)	Type / designation		
(ii)	Setting range of pick-up generator xd	%	-
(iii)	Time setting:		
	- first stage	S	-
	- second stage	S	-
(iv)	Time integrator setting:		-
	- pick-up	S	-
	- drop-out	S	-
2.15	Rotor excitation circuit overcurrent relay		
(i)	Type / designation		-
(ii)	Setting range of time relay	S	-
(iii)	Setting range of instantaneous element	ms	-
(iv)	Setting range of overcurrent	%	-

2.16	Setting range of instantaneous element	%	-
(i)	Under / Over frequency relay		
(ii)	Settings:		-
	- level 1	% fN	-
	- level 2	% fN	-
	- level 3	% fN	-
	- level 4	% fN	-
(iii)	Continuous/steps		-
(iv)	Time settings	S	-
(v)	Number of steps		-
2.17	Reverse power relay		
(i)	Type / designation		-
(ii)	Two setting ranges	Yes/ No	-
(iii)	Pick-up range	%PN	-
(iv)	Pick-up 2nd range	%	-
(vi)	Maximum torque angle	Grade	-
(vii)	Reset ratio	%	-
(viii)	Direction reversible during operation	yes/no	-
(ix)	Operating time:		
	- continuously variable	Yes/ No	-
	- step	Yes/ No	-
	- definitive	Yes/ No	-
(x)	1st time setting range	S	-
(xi)	2nd time setting range	S	-
2.18	High-speed distance relay		
(i)	Type / designation		-
(ii)	Setting ranges:		-
	- Zone-1		-
	- Zone-2		-
	- Zone-3		-
	- Zone-4		-
	- R/X		-
	-time stage(T1,T2,T3,T4)		-
(viii)	Distance error	%	-
(ix)	Timer error	%	-
2.19	Directional over current & earth fault relay		
(i)	Type / designation		-

(ii)	Time setting	S	-
(iii)	Fault locator (21 F)		-
2.2	Synchro-check relay (25)		-
(i)	Type / designation		-
2.21	Auto reclosing relay		
(i)	Type / designation		
2.22	Shaft current protection relay		-
(i)	Type / designation		-
(ii)	Setting range of current	%	-
(iii)	Setting range of time relay	S	-
(iv)	Ratio of current transformer	A	-
(vi)	Event & Disturbance recorder		-
2.23	Type / designation of Voltage transformer fuse monitoring relay		-
2.24	Type / designation of Generator transformer overall differential protection relay		-
2.25	Type / designation of CT wire supervision relay		-
2.26	Type / designation of Restricted E/F protection relay		-
2.27	Type / designation of 95% stator ground faults protection relay		-
2.28	Type / designation of Local breaker failure relay		-
2.29	Bus Bar Protection		
(i)	Type / designation		-
(ii)	Operating time	ms	-
(iii)	Principle of operation		-

13.2. INFORMATIVE DATA

Item	**Parameter**	**Units**	Bidder's Data	
1	Generators Protection (Main)			

1.01	Manufacturer		-
1.02	Place of manufacture		-
1.03	Type		-
1.04	Principle of operation		-
1.05	Conforming Standards		-
2	Generators Protection (Duplicate)		
2.01	Manufacturer		-
2.02	Place of manufacture		-
2.03	Type		-
2.04	Principle of operation		-
2.05	Conforming Standards		-
3	Generators Transformer Protection (Main)		
3.01	Manufacturer		-
3.02	Place of manufacture		-
3.03	Type		-
3.04	Principle of operation		-
3.05	Conforming Standards		-
4	Generators Transformer Protection (Duplicate)		
4.01	Manufacturer		-
4.02	Place of manufacture		-
4.03	Type		-
4.04	Principle of operation		-
4.05	Conforming Standards		-
5	Bus Bar Protection		
5.01	Manufacturer		-
5.02	Place of manufacture		-
5.03	Type		-
5.04	Principle of operation		-
5.05	Conforming Standards		-
6	Distance Protection (Main-I)		
6.1	Manufacturer		-
6.2	Place of manufacture		-
6.3	Type		-
6.4	Principle of operation		-
6.5	Conforming Standards		-
7	Distance Protection (Main-II)		
7.01	Manufacturer		-
7.02	Place of manufacture		-
7.03	Type		-
7.04	Principle of operation		-

7.05	Conforming Standards		-
8	B/C Protection		
8.01	Manufacturer		-
8.02	Place of manufacture		-
8.03	Type		-
8.04	Principle of operation		-
8.05	Conforming Standards		-
9	Unit Tap-off transformer Protection		
9.01	Manufacturer		-
9.02	Place of manufacture		-
9.03	Type		-
9.04	Principle of operation		-
9.05	Conforming Standards		-
10	Excitation Transformer Protection		-
10.01	Manufacturer		-
10.02	Place of manufacture		-
10.03	Type		-
10.04	Principle of operation		-
10.05	Conforming Standards		-
11	Generator & Generator transformer Protection cubicles		
11.01	Total nos. of cubicles per Unit		-
11.02	Dimension of each cubicles	mmxmmxmm	-
12	Line Protection cubicles		-
12.01	Total nos. of cubicles per line		-
12.02	Dimension of each cubicles	mmxmmxmm	-
13	Bus-bar Protection cubicles		
13.01	Total nos. of cubicles		-
13.02	Dimension of each cubicles	**mmxmmxmm**	-

13.3. SPARE PARTS

1 Recommended additional spare parts

List hereunder the spare parts which are recommended by the Bidder for purchase in addition to the specified spare parts as per specifications in "Chapter-14". The purchase of any or all of the recommended spare parts will be at the option of UJVNL. The prices for recommended additional spare parts for five (5) years shall therefore not be included in the bid prices.

Item	Description	Make / Type	Quantity	
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

*** Use additional sheets if required**

13.4. INFORMATION TO BE SUPPLIED AFTER AWARD OF CONTRACT

At least the information listed hereunder shall be given by the . The may submit additional documents /descriptions to describe special technical features of offered equipments / system:

1 Pamphlets of each type of the proposed protection relays as well as of cubicle assemblies for complete systems.

2 Description of the proposed power supply concept as well as of the trip function arrangement for the protection system to receive an adequate safety and some kind of redundancy or back-up protection.

3 Describe processing and indication of trip signals coming from protective devices or actuators outside of this section (e.g. transformer Buchholz relays etc.)

4 Detailed technical documentation on proposed equipment for fault locator and disturbance recorders.

17. HEATING VENTILATION AND AIR CONDITIONING SYSTEM

17.1. GUARANTEED TECHNICAL PARTICULARS

Item	Parameter	Units	Bidder's Data
1	**General**		
1.2	Type/ designation		
2	**Air handling units (AHU)**		
2.1	Type/ designation		
2.2	Cooling coil efficiency	%	
2.3	Heating coil efficiency	%	
2.4	Noise level	dB(A)	
2.5	Minimum air flow rate	CMM	
2.5.1	- AHU # 1,2 & 3,4		
2.6	Proportion of fresh air to recirculated air		
2.6.1	- AHU # 1,2 & 3,4		
2.7	Maximum delivery head pressure(acc to system pressure drop)	Pa	
2.8	Type of unit (Single / double skin)		
2.9	Fan section		
	- Type/ designation		
	- Number of fans	Nos.	
	- Fins per cm	Nos.	
	- Rated speed	rpm	

	- Drive arrangement		
	- Total air quantity	m^3/min	
	- Whether statically and dynamically balanced	Yes/No	
3	**Water cooled chiller (WCC) unit**		
3.1	Capacity of fully assembled chiller units at		
	- Rated load	TR	
	- 75% loading	TR	
	- 50% loading	TR	
3.2	Noise level with measuring distance	dB(A)/ m	
3.3	Type/ designation		
3.4	Number of units	Nos.	
3.5	Working side pressure in the cooler	Kg/cm^2	
3.6	Maximum fluid side pressure in the cooler	Kg/cm^2	
3.7	Refrigerant used		
3.8	Compressor		
	- Type/ designation		
3.9	Compressor motor		
	- Type/ designation		
	- Class of insulation		
	- Class of protection		
	- Duty class of the motor		
	- Minimum service factor		
	- Motor speed	rpm	
	- Type of start		
3.10	Cooling coil		
	- Type/ designation		
	- Flow rate of water	Lpm	
	- Pressure drop in coil	mm of water	
3.11	Condensor coil		
	- Working pressure of the coils	Kg/cm^2	
	- Design pressure of the coils	Kg/cm^2	
3.12	Chiller		
	- Inlet temperature of raw water	°C	
	- Outlet temperature of raw water	°C	
	- Inlet temperature of return water	°C	
	- Outlet temperature of return water	°C	
	- Coefficient of performance		
	- Working pressure of the coils	Kg/cm^2	

	- Design pressure of the coils	Kg/cm^2	
4	**Air ducts**		
4.1	Maximum air velocities in ducts		
	In main ducts	m/ min	
	In branch ducts	m/ min	
	In occupied room zones	m/ min	
4.2	Noise level of fans with measuring distance	dB(A)/ m	
4.3	Design noise level of the entire HVAC system	dB(A)	
4.4	Type/ designation		
5	**Motors**		
5.1	- Type/ designation		
5.2	- Class of insulation		
5.3	- Class of protection		
5.4	- Duty class of the motor		
5.5	- Minimum service factor		
5.6	- Motor speed	rpm	
5.7	- Type of start		
6	**Air Filters**		
6.1	- Type/ designation		
6.2	- Frame work thickness	mm	
6.3	- Filter medium		
6.4	- Rated flow	m^3/min	
6.5	- Face velocity	m/min	
6.6	- Size of filter		
7	**Humidification Package**		
7.1	- Type/ designation		
7.2	Centrifugal Pumps		
7.3	Type/ designation		
7.4	Number of pumps	Nos.	
7.5	Duty of pump motors		
7.6	Insulation class and protection class of pump-motors		
7.7	Method of Starting		
7.8	Air filters		
	Type/ designation		
	Number of filters	Nos.	
	Filtration capability	micron	
8	**Fans**		
8.1	Type/ designation		
8.2	Number of fans of each type	Nos.	

8.3	Air quantity of each type of fans	m^3/min	
8.4	Number of blades/ vanes of each type	Nos.	
9	**Electrical Controls**		
9.1	Type/ designation		
10	**Material/ Standard/Class/Grade/ Type for**		
10.1	Air handling unit (AHU)		
	- Casing		
	- Casing insulation		
	- Drain pan		
	- Fan wheel and blades		
	- Tube and fin of cooling tubes		
	- Frame work of the air filter		
	- Material of construction of humidifier		
	- AHU motor shaft		
	- Damper blades		
10.2	Water cooled chiller (WCC) unit		
	- Condensor coil		
	- Chiller tubes		
10.3	Centrifugal pumps/Cooling pumps		
	- Pump casing		
	- Pump and motor shaft		
	- Pump impeller		
10.4	Piping		
	- Embedded piping		
	- Exposed piping		
	- Pipe insulation / lagging		
10.5	General items		
	- Air ducts		
	- Air ducts of battery room		
	- Duct insulation		
	- Grills		
	- Louvers		
	- Sound absorbant		

17.2. INFORMATIVE DATA

Item	Parameter	Units	Bidder's Data
1	**General**		
	Manufacturer		

	Place of manufacturer		
	Applicable standards		
2	**Air handling units (AHU)**		
2.1	Dimension of the AHUs (LxBxH)	mm	
2.2	Thickness of fan blades	mm	
2.3	Type of bearing and vibration isolators of the fans		
2.4	Thickness of AHU drain pan	mm	
2.5	Static pressure at outlet		
	- AHU # 1	mm water gauge	
2.6	Power rating of the heater in the humidifier	kW	
2.7	Cooling coil		
2.7.1	Tube diameter and thickness	mm	
2.7.2	Method of bonding of tube and fins		
2.8	Air Filters		
2.8.1	Frame work thickness	mm	
2.9	Electrical characteristics of the motors (415± 10%V, 3P, 50Hz Cycles)		
3	**Water cooled chiller (WCC) unit**		
3.1	Leak test pressure of the condensor coils		
	- Condensor coils	Kg/cm^2	
	-Chiller coils	Kg/cm^2	
3.2	Pressure test of the coils at		
	- Condensor coils	Kg/cm^2	
	-Chiller coils	Kg/cm^2	
3.3	Overall dimension L x W x H	mm x mm x mm	
4	**Fans**		
	- Make		
	- Applicable standards		
5	**Motors**		
	- Make		
	- Applicable standards		
	- Rated power of the motor	kw	
6	**Cooling coil**		
	- Manufacturer		
	- Applicable standards		

7	**Air Filters**		
	- Make		
	- Applicable standards		
	- Particles size	micron	
	- Efficiency of filter	%	
	-Flange to flange	mm	
	-Cassette dimension	mm	
8	**Humidification package**		
	- Make		
	- Applicable standards		
9	**Water cooled chiller (WCC) unit**		
	Manufacturer		
	Place of manufacturer		
	Applicable standards		
10	**Compressor**		
	- Make		
	- Applicable standards		
10.1	**Compressor motor**		
	- Make		
	- Applicable standards		
	- Rated power of the motor	KW	
11	**Centrifugal pump**		
	Manufacturer		
	Applicable standards		
	Capacity of pump	lpm	
	Rated power of pump-motors	KW	
12	**Air Filters**		
	Manufacturer		
	Applicable standards		
13	**Fans**		
	Manufacturer		
	Applicable standards		
	Rated power of fans of each type	KW	
14	**Air ducts**		
	Manufacturer		
	Place of manufacturer		
	Applicable standards		
15	**Electrical controls**		
	Manufacturer		

	Place of manufacturer		
	Applicable standards		
16	Minimum life of the fan bearings	Hrs.	
17	Air filter overall dimension L x W x H	mm	
18	Rated power requirement of Control panels	kW	
19	Minimum system insulation thickness	mm	
20	Minimum system sound absorbant thickness corresponding to system design noise level	mm	
21	**Make of the following electrical accessories**		
	Main electrical panel		
	Air circuit breaker / MCCB		
	Rotary and Capacitor switches		
	Star delta Starter , CT		
	Ammeter, Voltmeter, Relays		
	Indicating lamps, cables, wires		

17.3. SPARE PARTS

Recommended additional spare parts

List hereunder the spare parts which are recommended by the Bidder for purchase in addition to the specified spare parts as per specifications. The purchase of any or all of the recommended spare parts will be at the option of UJVNL. The prices for recommended additional spare parts for five (5) years shall therefore not be included in the bid prices.

Item	Description	Make/ Type	Quantity
1			
2			
3			
4			
5			

* Use additional sheets if required

17.4. INFORMATION TO BE SUPPLIEDAFTER AWARD OF CONTRACT

At least the information listed hereunder shall be given by the Bidders . The bidders may submit additional documents /descriptions to describe special technical features of offered equipments / system:

1 Pamphlets of the proposed air handling units with detailed description and technical data of the following

a) Supply air fans.

b) Cooling and heating coils.

c) Electrical heating elements.

d) Air filters.

e) Air dampers.

f) Humidifiers

2 Pamphlets of the water cooled chiller unit with description of control and protective devices.

3 Pamphlets of the fire dampers with description of the operating mechanism for opening and closing.

4 Pamphlets/ literature containing technical details of system insulating materials, their thickness and criteria for selection.

5 Pamphlets/ literature containing technical details of required duct velocities corresponding to specific noise level area wise and the criteria for selection of duct material and thickness.

6 Pamphlets/ literature containing technical details of system sound absorbant materials, their thickness and criteria for selection.

Volume III D
Quality Assurance and Testing Specifications/Model Quality Assurance Plan

January, 2019

Quality Assurance and Testing Specifications /Model Quality Assurance Plan (QAP)

Table of contents

GENERAL INSTRUCTIONS: -

I. Contractors/Manufacturers/Sub-suppliers are advised to submit QAP for items, in process of inspection and final inspections as per their latest manufacturing practice and Indian/ International Standards (with latest amendments, if any).

II. Contractors/Manufacturers/Sub-suppliers are required to use properly calibrated instruments / equipments during testing/inspection, for which necessary calibration certificates are required to be provided/presented to the Inspecting Officer. The calibration procedure to be adopted for calibration should be as per Indian/ International Standards.

III. Contractors/ Manufacturers/ Sub-suppliers have to make on their own all arrangements for testing facilities at their works for testing of equipments/materials.

IV. One set of complete test certificates as per the requirement of QAP be made available to the Employer for acceptance.

V. All the records, as per the requirement of QAP may be made available for review by the Inspecting Officer during inspection.

Field tests are to be carried out as per the requirements of the contract/purchase order.
Place of Shop Tests or Field Tests may be reviewed and finalized at the time of approval of QAP.

Model quality assurance plans for different E&M equipment packages as described earlier are given in following sub-sections.

QUALITY ASSURANCE AND TESTING SPECIFICATIONS

1 INSPECTIONS AND TESTS

1.1 General

In addition to the provisions established in the Conditions of Contract regarding general procedure of inspections and tests, terms and definitions, and time schedules for inspections and tests the following stipulations shall apply:

Approval of assemblies, tests, inspections, related procedures etc. and acceptance of pertinent test and inspection certificates, or waiving of inspections or tests, shall in no way relieve the Contractor of his contractual obligations for finishing the Works in accordance with the provisions of the Specifications.

Three (3) sets of all test records, test certificates, performance curves, tables etc. of all inspections and tests, whether or not attended by the Engineer shall be supplied soonest after performance of each inspection or test. After completion of all testing two (2) sets of the above-mentioned documents shall be supplied properly bound in books.

All test certificates shall be endorsed with sufficient information for identification of the equipment and material to which the certificates refer.

In addition, the following references shall be entered in the top right-hand corner:

1. Employer's name
2. Project title
3. Plant's (stage's) name
4. Number of Contractor's drawing
5. Date

1.2 Manufacture and Supply

All material furnished shall be of tested quality and all work performed shall be subjected to rigid inspection as specified in relevant International or Indian Standards and no articles or material or supplies shall be dispatched until the dispatch instructions are issued by the Employer, which shall be issued only after all test's analysis and shop inspection have been completed or certified copies of reports or, results of tests and analysis have been accepted by the Employer. Duplicate copies of manufacturer tests

certificate shall be submitted to the engineer in charge as soon as the tests are completed. In case test certificates are not available for any of materials, the same shall be tested if requested by the employer and only those materials, which fulfill the requirements of the specifications, shall be used.

1.2.1 Steel Casting

Castings shall be sound and free from blowholes, porosities, shrinkage holes, cracks or any other defects, Surfaces of castings which do not undergo machining and which are exposed to view in the installation shall be dressed for good appearance and for painting. The location of existing defects shall be determined, and all defects, which impair the strength or utility of the casting, shall be removed to sound metal. The structure of the castings shall be homogeneous and free from excessive non-metallic inclusions. An excessive concentration of impurities or separation of alloying elements at critical points in a casting will be a cause for its rejection.

1.2.1 Welding

Members to be joined by welding may be cut to shape and size by mechanical means such as shearing, machining, grinding, or by gas or arc cutting, to suit the conditions. Edges shall be shaped according to DIN 8551. Design of welded joints and selection of weld filler metal shall be in accordance with approved standards and shall allow thorough penetration and good fusion of the weld with the base metal. The edges of surfaces to be welded shall be sound metal free of visible defects such as laminations or defects caused by cutting operation at least 30 mm back from the edge of the weld, and free from rust, oil, grease, and other foreign matter.

The qualification of welding procedures, welders, and welding operators for all welding, including weld repairs, shall conform to DIN 8560, DIN 8563, EN 287, or to the requirements of the ASME Boiler and Pressure Vessel Code Section VIII and IX. The Contractor shall perform qualification tests of his welders and welding operators and submit evidence of this to the Engineer in-charge.

Weld-fabricated pressure-containing parts shall be designed, fabricated, inspected and tested, unless otherwise specified, in accordance with approved standards and shall be stress relieved as a unit prior to final machining.

1.2.2 Workmanship

i) Electric Welding

All welds shall be made continuous and watertight. The minimum size of fillet welds shall be 6 mm measured on the leg. All butt welds shall be full penetration welds welded from both sides.

Welds shall in general be treated so that they will display good appearance and a surface suitable for painting. Structural welds shall be ground and blended to avoid stress raisers. All welds, which require non-destructive examination, shall be dressed by chipping and grinding as required for good interpretation by the selected weld examination method.

All butt welds in the flanges and webs of beams and girders shall be radio-graphically/UT inspected. The fillet welds between flanges and webs shall be tested by the magnetic particle method.

ii) Machine work

All tolerances, allowances, and gauges for metal fits between plain (non-threaded) cylindrical parts shall be indicated. Sufficient machining stock shall be allowed on parts to be machined to ensure true surfaces of solid material. Finished contact or bearing surfaces shall be true and exact to secure full contact. Journal and sliding surfaces shall be polished, and all surfaces shall be finished with sufficient smoothness and accuracy to ensure proper operation when assembled. No machining shall be done on working surfaces of self-lubricating bushings or washers.

iii) Finished Surfaces

All surfaces that are so indicated on the drawings or those that require machining for their intended function, or those that are usually machined according to good workshop practice shall be machined. Surface finish qualities shall follow the Indian/ International Standards and shall be indicated on the Contractor's Drawings. Suitable measuring device such as Scatterometer or other acceptable measuring device will be used to determine compliance with specified surface.

iv) Unfinished Surfaces

So far as practicable, all work shall be laid out to secure proper matching of adjoining unfinished surfaces. Where there is a large discrepancy between adjoining unfinished surfaces they shall be chipped and ground smooth, or machined, to secure proper alignment. If surfaces not designated as finished in the Contract

Documents require machining to obtain the tolerances or straightness specified or needed for correct function, such machining shall be performed by the Contractor.

1.2.3 Dimensional Checks and Visual Inspection

Dimensional checks shall be performed on all major parts, components and partial assemblies, especially when close tolerances and fits are involved (tolerance of shafts, between stationary and moving parts, connecting dimensions for the assembly with other supplies, etc.). If the dimensional checks show discrepancies in measurement, which may affect the fit, assembly or dismantling of the respective part or component, the same have to be corrected correspondingly. Such correction or modification shall, however, in no way lead to sacrifices with respect to reliability of operation or inter-changeability, and shall be performed only after the agreement of the Engineer in-charge has been obtained. If the correction or modification cannot be carried out in accordance with the terms mentioned above, the part or component concerned may be subject to rejection. Faulty machine parts or equipment shall by no means be delivered.
Castings shall be inspected visually at the foundry after they are cleaned and while defects are being removed. Castings shall also be inspected after repairs and after heat treatment. Radiographic or other non-destructive tests will be required as specified under non-destructive testing and as directed by Engineer in-charge when granting permission to repair major defects. The Engineer in-charge reserves the right to require conducting non-destructive tests at the Contractor's expense to determine: the full extent of defects; that area is properly prepared for welding that the repairs are satisfactory.

1.2.4 Impact and Bend Tests

Steel products for all principal turbine and shut-off valve parts shall be tested for impact resistance using the ISO V-notch specimen. Both longitudinal impact tests shall be performed on plate steel. Bend tests shall be performed on specimens of all major steel castings and forgings in accordance with the applicable DIN standards. The nil ductility transition temperature shall be the temperature at which the impact resistance is at the values specified above.

1.2.5 Non-Destructive Testing

1.2.5.1 Examination of Welds

Unless otherwise indicated in these Contract Documents, non-destructive tests shall be in accordance with approved standards. Radiographic examination of welds shall be in accordance with the technique and acceptance standards of IIW (International Institute of Welding). The Contractor's Drawings shall indicate the type and extent of non-destructive examination as it applies to each component or weld.

Weld examination shall be by the ultrasonic, dye penetrant, or magnetic particle methods, supplemented by radiographic examination. Supplemental radiographic examination shall include examination of critical high-stressed areas where interpretation of other methods is unclear, or where the integrity of the weld is doubtful. The Employer shall have the right to request the Contractor to make random spot-check examination of welds, including radiographic examination, as part of his inspection of the equipment. The Contractor's detailed program for non-destructive examination of welds shall be submitted for review.

1.2.5.2 Examination of Casting

The turbine runner casting shall be given complete non-destructive examination including radiographic examination of the most critical areas. The Contractor shall submit Quality Sheets (Specification for inspection of steel casting for hydraulic machines), with his recommendation and specify special precautions to be taken for the casting of the turbine runner and other important casting components. The Quality Sheets submitted shall define the area and extent of the various non-destructive examinations to be performed on castings.

1.2.5.3 Examination of Forging

Shafts, stems and coupling bolts made of forgings shall be given complete ultrasonic examination and other applicable non-destructive test, to determine that they are sound. Non-destructive examination of other forgings shall be in accordance with accepted good practice to assure their soundness. The structure of forgings shall be homogeneous and free from excessive non-metallic inclusions. An excessive concentration of impurities or separation of alloying elements at critical points in a forging will be a cause for its rejection.

1.2.6 Pressure Tests

Unless specifically mentioned otherwise in the Contract Documents, equipment, vessels and tanks under internal pressure during service shall be subject to hydrostatic pressure testing. The test pressure shall be 1.5 times the maximum design pressure of the respective equipment, vessel or tank.

Unless otherwise specified, the test pressure shall be applied for a period of 1/2 hour without showing leaks or drop in pressure.

1.3 Workshop Inspections and Shop Tests

As far as practicable, quality of materials, workmanship and performance of all items of the Works to be furnished under this Contract shall be inspected at the places of manufacture.

Free and unrestricted access to the Contractor's factory and shops (including those of his Subcontractors) shall be granted to the Engineer also and upon reasonable notice by the Engineer if deemed necessary by the same for additional witnessing of assembly work or inspections and tests.

Should an agreed inspection not be carried out as proposed because of lack of preparation, obvious negligence or material and/or equipment being presented in a state, which does not corresponds to the proposed procedure or is clearly not acceptable such an inspection shall be repeated. The cost incurred by the Employer for repeated inspections shall be fully borne by the Contractor.

The Contractor shall state the plan of manufacture, testing and inspection of the various works in the contract, and the representative of engineer in-charge shall also be entitled to access to manufacturer's or, sub-contractor's work at any time during working hours for the purpose of inspecting the manufacture of equipment and materials.

All the required tests as per standard/specifications shall be carried out at Contractor's expenses. If any component of the equipment fails in the specified test, the same shall be replaced/ rectified and again offered for inspection. The expenses incurred in replacing / rectifying and again conducting the required test shall be born by the contractor.

Shop Tests specified in respective section shall be carried out in Employer's presence. The tests not specifically mentioned but

recommended in the relevant standards for such equipment and/or good engineering practice shall also be carried out.

The factory test equipments and the test methods used shall conform to the recommendations of the relevant IEC Publications and shall be subject to approval of the Engineer in-charge.

1.3.1 Material Tests

Unless otherwise specified, the quality of materials shall be verified generally by:

i) Chemical analysis

ii) Mechanical tests (yield point, tensile strength, ultimate strength, elongation, Transverse Contraction and notch impact.)

iii) Welding tests (welding procedure, welding material, welding tensile strength, welding bend test, welding reversed bend test, etc.)

iv) Non-destructive tests (X-rays, Ultrasonic, Magnetic Particle tests, Liquid Penetration inspection, etc.).

v) Electrical tests (voltage, losses, tan delta, insulation, magnetic properties etc.)

For the notched bar impact test, the impact value shall be obtained at plus (+) 20°C ambient temperature unless mentioned otherwise. The material tests shall be performed as per relevant ASTM unless approved otherwise.

Certified mill test reports of plates will be acceptable when these comply with the requirement of specifications. Test specimen and samples for analysis shall be plainly marked to indicate the materials they represent.

Castings and forgings shall be tested in the rough state in order to detect flaws in good time thus avoiding delays. Magnetic particle inspection of important castings shall cover the whole surface of the casting. After partial machining further tests can be conducted.

Load tests on crane hooks, steel wire ropes, chains and other lifting devices, etc. shall be considered as material tests.

1.3.2 Checking of Dimensions

The dimensions, especially clearances and fits, which are essential for operation and efficiency shall be carefully checked in an approved manner, as for example:

Run out and roundness tolerances of shafts, pistons, etc., to be measured on single parts as well as (wherever possible) on the assembled components,

Fits and clearances of bearings, servomotor pistons, valves, guiding, distributing and actual actuating elements, etc.,

Accuracy, surface roughness and shape of sliding and guiding surfaces of seals, bearings, water passages in hydraulic machinery, valves, etc.,

Dimensions of couplings or connections for assembly with other deliveries from the Contractor, Sub-contractors or other contractors.

1.3.3 Workshop Assembly

In addition to the quality and production control tests, the following shop assembly work and tests shall be made to check measurements, fitting and functioning.

Works to be furnished shall be shop assembled to a status sufficient to prove that the design and workmanship have been executed in accordance with the Specifications, that the delivery is complete, and that no work remains to be done at Site, which reasonably can or should be done in the shop.

Where applicable, each item of the Works shall be assembled completely prior to painting.

Field joints shall be temporarily connected.

All parts shall be properly matched, marked, identified and doweled where practicable to facilitate correct and quick field assembly and alignment. Where it is necessary, suitable dowels shall be provided for insertion after field assembly and drilling. The holes for any fitted bolt shall be accurately reamed.

During workshop assembly all instruments, control devices and piping shall be fitted.

If the assembly shows defects in the design or manufacture or unforeseen difficulties in assembling and dismantling, these shall be eliminated. If required, design alterations or corrective measures can be executed provided that reliability of operation or interchangeability are not reduced and provided that the agreement of the Engineer has been obtained.

If the corrections cannot be carried out in accordance with the terms mentioned above, the components concerned will be rejected. The decision on possible subsequent corrections is reserved exclusively to the Engineer. Faulty parts or Works shall by no means be delivered.

The assembled parts shall subsequently be subject to tests as per applicable standards or required by the Engineer.

1.3.4 Pressure and Leakage Tests

All parts subject to internal or external pressure or containing any liquids or gases temporarily or permanently during operation shall be tested prior to painting. As far as practicable, these tests shall be done in the shop but can be repeated at site.

Parts exposed during operation to hydraulic pressure, to gas pressure or to any liquid without pressure, shall be treated distinctively.

As far as practicable and required, the influences of temperatures and temperature differences to which the part will be exposed during operation shall be considered in the performance of the tests.

1.3.4.1 Parts Exposed to Hydraulic Pressure

Unless otherwise specified or required, the following shall apply: the hydraulic pressure tests shall be carried out using the liquid to be used during operation or a liquid with less viscosity.

The hydraulic test pressure shall be l.5 times the maximum operating pressure (except for spiral distributor) and shall be maintained for the period as required by the applicable standards. Afterwards the test pressure shall be reduced to the operating pressure.

1.3.4.2 Parts Exposed to Gas Pressure

Parts which will be subjected to gas pressure during operation for example pressure tanks, pressure air tanks and others, shall be inspected and tested according to the official regulations with respect to design, construction, fittings, etc.

The pressure test shall be executed by applying the test pressure in accordance with the relevant standards and specifications.

1.3.4.3 Parts Exposed to Liquids without Overpressure

Parts which shall not be closed and which are exposed to only small pressures of any liquid during operation (e.g., bearing housings, oil containers, etc.) shall be subjected to a tightness test with a suitable liquid of low viscosity. The testing-period shall not be less than 8 hours, unless otherwise agreed.

1.3.5 Functional Tests

Functional tests shall be defined as tests of the function of assemblies, sub-assemblies or parts of the Works under no load conditions. Functional tests shall be performed on all Works prior to the execution of operational tests.

1.3.6 Operational Tests

As far as practicable operational tests shall be carried out on all Works, simulating operating conditions.

Parts to be delivered by sub suppliers shall be tested either at the premises of the sub supplier or of the Contractor, as agreed by the Engineer.

Before testing the Contractor shall submit a notice containing full information on the tests with detailed tables or graphs on the latest edition of the characteristic values of the Works to be tested and on the test facilities and equipment.

Testing of the electrical Works shall be performed in accordance with applicable Standards; they shall include but not be limited to tests of heating, loading, overloading, losses.

Operational tests of lifting equipment and other machinery shall include tests under nominal load and 125 % of nominal load unless otherwise specified.

1.3.7 Electric Tests

Electrical Works shall be tested in accordance with applicable Standards and agreed test programs and procedures.

1.3.8 Model Tests

Model tests for certain parts of the work or works shall be carried out as specified or agreed between Contractor and Engineer.

1.4 Quality Control and Assurance

To ensure quality during each stage of work, the Contractor shall establish a system defining quality assurance plan/procedures during various stages of work.

The Contractor shall maintain quality control during manufacturing of equipment as per the approved quality assurance plan. The model quality assurance plan for equipment / components for each section

are given hereafter. Final quality assurance plan (QAP) for manufacturing shall be approved during detailed engineering.

The Contractor shall submit the detailed Quality Assurance Plan for the complete equipment/materials during detailed engineering for approval and acceptance by the Employer. The QAP shall include inspection and tests proposed to be conducted on raw material/bought out items at the time of induction in the process of manufacturing and at final stage of assembly.

Based on the test certificate, inspection report dispatch clearance shall be issued by the employer. The materials/equipments/items shall only be dispatched after issue of material dispatch clearance certificate (MDCC).

Detail Model Quality Assurance Plan is attached here with of each and every equipments/ auxiliaries. These are to be strictly observed /followed by the Manufacturer / Contractor/ Sub – Vendor.

Inspections and tests shall be carried out by the Contractor as per approved QAP with due regard to stipulations in "Clause 9 - Inspection and Tests" of "Section 6 - General Technical Specification" at various stages of manufacturing for assuring the full compliance of supply with the requirements of specification.

The Contractor shall follow approved site quality assurance plan and installation procedures. The Contractor shall maintain the quality records during site installation and commissioning which shall be produced to engineer in charge for approval at defined stages.

Inspection and tests shall be carried out at site by contractor during installation and commissioning as described in relevant clauses.

1.4.1 Type Tests

Type tests shall verify that all components of the equipment perform satisfactorily, both electrically and mechanically, at the rating assigned. All equipment proposed according to the specification shall be type tested at typical units in accordance with the relevant standards specified in respective sections.

The type tests for equipment, except wherever mentioned specifically as mandatory in respective section, may not be mandatory if similar typical units of equipment have been type tested and test certificate(s) for relevant tests are accepted by the Employer.

The Contractor shall prepare written documents, in a form agreed upon by the Contractor and the Employer, of all test certificates/ results and hand over these documents to the Employer in due time for review and acceptance as required.

All cost associated with the mandatory type tests shall be included in contract price. Also, the Contractor shall conduct the type test(s) at his own cost for which certificate(s) are not acceptable.

1.4.2 Routine Tests

Routine tests shall be conducted on various equipment/components as elaborated in respective section and/or approved quality assurance plan (QAP).

1.4.3 Field Tests

During erection, commissioning and trial operation, the Contractor shall perform at suitable intervals all inspections and tests in the presence of the Engineer in order to prove the orderly execution of the works in accordance with the Contract.

Unless otherwise specified, all costs for testing at site and of the works and charges associated with it shall be borne by the Contractor. This includes the measuring devices, properly calibrated, and any pertinent accessories, which shall be made available by the Contractor for the entire duration of the tests. The Contractor shall delegate his experts to perform the tests at site.

The Engineer reserves the right to have checked at his own expenses the Contractor's instruments to be used or having been used for any tests by an independent, officially acknowledged institution.

The Contractor's testing at Site shall be complete in every respect to prove the successful performance and operation of all the works and Works supplied and erected under the Contract.

For the procedure of inspections and test at site, notice to the Engineer, reports, commissioning, trial runs and trial operation and acceptance tests, refer to General Conditions of Contract.

All field tests including tests during installation, pre-commissioning, commissioning, performance and field acceptance tests shall be conducted by the Contractor, in the presence of representative of

the Employer. Procedure to be adopted for conducting these tests shall be submitted well in advance, before start of relevant testing, for approval of the Employer.

All test equipment and instruments shall be furnished by the Contractor and will remain the Contractor's property after the fulfilment of all field tests.

The Contractor shall prepare written test certificates in a form agreed upon by the Contractor and Employer of all tests results and hand them over to the Employer in due time.

1.4.3.1 Tests during Installation, Pre Commissioning and Commissioning

Immediately upon termination of commissioning of a part or section of the Permanent Works, which can operate as an independent unit a "Certificate of Suitability for Operation", shall be issued by the Engineer.

This document shall be signed by an authorised representative of the Employer, the Engineer and the Contractor.

This Certificate shall state:

i) The supplier of the Works concerned

ii) The quantity and type of Works concerned

iii) The conditions of commissioning

iv) The names of the participants

v) The date of commencement of trial run

vi) The list of minor defects, if any, which has to be corrected by the Contractor

During the trial run the Contractor shall make familiar the Employer's personnel with the equipment, the operation and maintenance of the Works and its auxiliaries to such an extent that thereafter the duties can be assigned to the Employer's trained personnel.

If any defects or irregularities affecting the safety or reliability of the Works should arise during the trial run, the trial run shall be interrupted and started again after such defects or irregularities have been corrected by the Contractor.

The tests during installation, pre-commissioning and commissioning shall be conducted at site in accordance with provision in respective sections and/or in applicable Indian/International testing standards for the system and system components. However, following generic tests shall be essentially performed on all installation/system:

i) Visual inspection of the equipments/components

ii) Pressure test of all field installed piping at 1.5 times of the design pressure,

iii) Operational and functional tests of components, sub-assemblies, auxiliaries, piping system etc,

iv) Control logic field tests to prove control logic scheme for operation and interlocks of system components, including annunciation and shutdown scheme,

v) Calibration Test - All instruments, gauges, sensors, switches, relays, and similar equipment shall be calibrated and adjusted after installation, wherever practical. Where not practical, the calibration and adjusting shall be done just prior to installation,

vi) Operational Tests For Protection - Field tests for verification of correct operation of protective relays shall be conducted,

vii) Dielectric and insulation resistance test, continuity test, starting current measurement of each motor,

viii) Any other checks/tests to ensure that requirements of the specifications are being met.

1.4.3.2 Performance Testing

If nothing unusual has been observed in load run and load rejection tests, the test service period of 72 hours shall follow. During this test service period, the unit must operate continuously at rated condition without any interruption except of those beyond the control of the Contractor. However, such interrupted period shall not be counted for in the test service period.

During this test service period, all the system/installations must perform satisfactorily.

The Contractor shall be responsible for the equipments during test service and also for the way it is operated. However, Employer will operate the equipment under the Contractor's guidance during test service period.

1.4.3.3 Field Acceptance Tests

The taking-over testing of any part or section of the Permanent Works accordance with the standards and regulations laid down in the "General Conditions of Contract", and as per the test procedure agreed upon between Engineer and Contractor.

Immediately upon termination of any such testing of a part or section of the permanent Works a "Protocol of Acceptance" which shall be

deemed to be the Test Certificate required by General Conditions of Contract shall be issued by the Engineer.

This document shall be signed by an authorised representative of the Employer, the Engineer and the Contractor and shall form an integral part of the later "Taking-Over Certificate".

This "Protocol of Acceptance" shall state:

i) The date of testing

ii) The quantity and type of Works concerned

iii) Statement of all minor defects and/or irregularities, which have to be corrected by the Contractor

iv) Confirmation that the guaranteed data have been proven

v) Confirmation that all contractual documents have been submitted

vi) Confirmation that the Employer's personnel have been familiarised with the Works and that they will be able to operate and maintain the Works.

If any test for the verification of the guaranteed data could not be performed for operational reasons beyond the Contractor's responsibility, this part of the acceptance shall be stated in the "Protocol of Acceptance" and be postponed for a mutually agreed period.

11 415V SWITCHGEAR SYSTEM

11.1 Type Test

The contractor is required to carry out all type tests as per relevant IEC / International Standards on one apparatus of each type of similar rating and shall submit the reports to the Employer. The type test may not be mandatory if similar equipment has been type tested and test certificates for relevant tests are accepted by the Employer.

11.2 Shop Test

The 415 V Switchgear system shall be routine tested as per relevant IEC with latest amendments. Following shop tests shall be carried out by the manufacturer at their works:-

Following Tests on 415 V Cubicle assembly as per relevant IEC:

- Visual & BOM Check,
- Scheme Checking,
- Insulation Resistance Test
- High Voltage Test.

The details of tests are given in Model Quality Assurance Plan of 415 V Switchgear system.

11.3 Field Test

All field tests including tests during installation, pre-commissioning, commissioning and field acceptance tests shall be conducted by the Contractor, in the presence of representative of the Employer.

Procedure to be adopted for conducting the operational, pre-commissioning, commissioning, performance and field acceptance tests shall be submitted well in advance, at least six (6) months before start of relevant testing, for approval of the Employer.

11.4 Tests during installation and pre commissioning

At least following inspections/ tests shall be performed:-

i) Functional and operational tests,

ii) Measurement of the insulating resistance of the different power and control circuits, including cables, instruments and apparatus, against earth,

iii) Adjustment of the protection equipment,

iv) Calibration of releases,

v) Verification of component temperatures,

vi) Contact resistance measurement of circuit breaker,

vii) Verification of interlocks: ensure that interlocks are correctly installed and that access is prevented to live portions of the system when interlocks are in place and that access is permitted when interlocks are removed,

Other test as suggested by the Contractor and/or the Employer at site.

- Visual & BOM Check,
- Scheme Checking,
- Insulation Resistance Test
- High Voltage Test.

The details of test mentioned above are given in Model Quality Assurance Plan of Fire Fighting System.

13.3 Field Test

All field tests including tests during installation, pre-commissioning, commissioning and field acceptance tests shall be conducted by the Contractor, in the presence of representative of the Employer.

Procedure to be adopted for conducting the operational, pre-commissioning, commissioning, performance and field acceptance tests shall be submitted well in advance, at least six (6) months before start of relevant testing, for approval of the Employer.

The tests at site should include the following:

i) Before installation of system components like nozzles etc., the piping system shall be checked for cleanliness and after installation, the systems shall be effectively flushed out with clean water and filled up for testing,

ii) Hydrostatic pressure tests of the whole piping system,

iii) Pressure-flow tests on water distribution system and supplies,

iv) Calibration of the aspirator/ air sampling type smoke detectors and other detectors,

v) Verification of performance of suppression system, detectors of all types including aspirator type smoke detectors, notification devices, control system etc. for the specification intended,

vi) Operation of exit doors and release of fire and smoke dampers,

vii) Monitoring and initiation of self-contained automatic fire extinguishing systems and equipment,

viii) Control of powerhouse Air conditioner and Ventilation system equipment to provide smoke control,

ix) Control of process, data processing and similar equipment as necessary during fire alarm conditions.

The power plant fire alarm system must be in any case, ready for operation prior to the commissioning of the first generating unit.

14 POWER, CONTROL, INSTRUMENTATION AND COMMUNICATION CABLES

14.1 Type Test

The contractor is required to carry out all type tests as per relevant IEC / International Standards on one apparatus of each type of similar rating and shall submit the reports to the employer. The type test may not be mandatory if similar equipment has been type tested and test certificates for relevant tests are accepted by the employer.

Type test reports of the following items shall be submitted for acceptance with adequate details/drawings to establish equivalence with the offered type:

- All type of cables, termination kits and accessories,
- Conduits, ducts, channels etc.,
- Cable trays and supports.

14.2 Shop Test

The Power & Control Cable and Cable Tray shall be acceptance & routine tested as per relevant IEC with latest amendments. Following shop tests shall be carried out on Power & Control Cable by the manufacturer at their works as per IEC: 502, IS: 7098, IS: 1554:-

- Annealing Test (For Cu)
- Tensile Test (For Al)
- Wrapping Test (For Al)
- Conductor Resistance Test
- Tests for thickness of Insulation & Sheath
- T.S. & E.B. of Insulation & Sheath
- Hot Set Test for Insulation (XLPE Cable only)
- Insulation Resistance Test
- High Voltage Test (At Room Temp.)
- Partial Discharge Test (for Screened XLPE Cable only)

The following FRLS tests are to be conducted as per the referred standards:

- HCL gas evolution test (IEC - 754.1),
- Oxygen Index (ASTM-D-2863),
- Temperature Index (ASTM-D-2863),

- Smoke density test (ASTM-D-2863),
- Flammability test (IEC-332.1),
- Swedish Chimney test (SS-424 14 75),
- Ladder Test (IEEE-383),
- Heat Shock Test (IS:1554) &
- Anti Rodent & Termite Test.

Following test on Cable Trays as per relevant IS

- Galvanization Test
- Load Capacity Test (Deflection Test)

The details of tests are given in Model Quality Assurance Plan of Power and Control Cables including Cable Trays.

14.3 Field Test

All field tests including tests during installation, pre-commissioning, commissioning and field acceptance tests shall be conducted by the Contractor, in the presence of representative of the Employer.

Procedure to be adopted for conducting the operational, pre-commissioning, commissioning, performance and field acceptance tests shall be submitted well in advance, at least six (6) months before start of relevant testing, for approval of the Employer.

Before commissioning of complete system, all cabling system shall be checked as per cable schedule and complete report shall be prepared by Contractor and shall be submitted.

Field test shall include:

i) Cabling checking,

ii) Continuity checking,

iii) Meggar testing in accordance with the applicable codes and standards,

iv) Resistance checking.

v) Insulation resistance measurement,

vi) Verification of phase order,

vii) HV test

15 PROTECTION SYSTEM

15.1 Type Test

The contractor is required to carry out all type tests as per relevant IEC / International Standards on one apparatus of each type of similar rating and shall submit the reports to the Employer. The type test may not be mandatory if similar equipment has been type tested and test certificate(s) for relevant tests are accepted by the Employer.

15.2 Shop Test

All Relays shall be routine tested as per IEC: 60255 and British Standards 142 & 5992 and submit reports to Employer. Following shop tests shall be carried out by the manufacturers at their works:-

- Visual inspection
- Check for BOM
- Wiring test
- Insulation test
- High voltage test on outgoing circuits
- Functional tests of all relays
- Functional tests of protection scheme

The details of tests are given in Model Quality Assurance Plan of Protection System.

15.3 Field Test

All field tests including tests during installation, pre-commissioning, commissioning, field acceptance tests shall be conducted by the Contractor, in presence of representative of the Employer.

Procedure to be adopted for conducting the operational, pre-commissioning, commissioning, performance and field acceptance test shall submitted well in advance, at least six(6) month before start of relevant testing, for approval by the Employer.

15.3.1 Tests during installation and pre commissioning

Following tests shall be performed by the Contractor:

i) Ratio and polarity of CTs, CVTs and PTs,

ii) Correctness of interconnections between CTs, CVTs and PTs as well as CT groups and associated relays,

iii) Testing, calibration and adjustment of protection relays,

iv) Check of functional characteristics of each of the electrical protections,

v) Check of tripping sequence,

vi) Check of orders issued by each of the protections with respect to the corresponding tripping sequence,

vii) The systematic testing of the operation of each chain forming the protection, the associated tripping sub-assembly, the links to the connected systems and all fault simulations by test kit for which the system is to react,

viii) The co-ordination of protection and relay setting,

ix) The testing of the protection system behaviour during failure of one of its components,

x) The testing of the protection system behaviour in the event of failure of one of the connected system to which it is connected,

xi) Analysis of information consistency and of alarms supplied by protection system.

15.3.2 Commissioning tests

Following tests shall be performed by the Contractor:

i) The systematic testing of the operation of each chain forming the protection, the associated tripping sub-assembly, the links to the connected systems and all fault simulations by creating real fault for which the system is to react,

ii) The final co-ordination of protection and final relay setting,

iii) The testing of the protection system behaviour in the event of failure of one of the connected system to which it is connected,

iv) Analysis of information consistency and of alarms supplied by protection system.

Checks shall be made after the protection systems have been commissioned to ensure that all connections and test links have been replaced and test leads removed and relay setting has been done, as well as to confirm the integrity of the current transformer circuits. Where necessary, voltage readings shall be taken at the

terminals on each relay to ensure that loop connections between the relays are complete.

19 HEATING VENTILATION AND AIR CONDITIONING SYSTEM

19.1 Type Test

The contractor is required to carry out all type tests as per relevant National / International Standards on one apparatus of each type of similar rating and shall submit the reports to the Employer. The type test may not be mandatory if similar equipment has been type tested and test certificate(s) for relevant tests are accepted by the Employer.

Type Test reports of the following items shall be submitted for acceptance with adequate details/drawings to establish equivalence with the offered type:

- Air Handling Unit including Fan / Blower & Motor,
- Other items felt necessary during detailed engineering.

19.2 Shop Test

The equipments / components of HVAC SYSTEM like Air Handling Unit Chilling Unit including Compressor, Motor, Condenser & Evaporator, Pumps, Damper, Copper Coil, Heat Exchanger, Instrumentation, Valves, Piping, Control Panel (which ever is applicable) etc. shall be routine tested as per relevant National / International Standards with latest amendments.

Following shop Test shall be carried out by the Manufacturer at their works.

i) Test on Air Handling Unit

- Dynamic Balancing of Blower/Fan
- IR & HV, Speed of Blower/Fan
- Air Delivery on complete assembly
- Noise Level

i) Test on Motor

- IR & HV
- No Load Running

- Locked Rotor
- Reduced Voltage Running

o **Performance Test on Pump - Motor Assembly** - Measurement of Rate of Flow, Head, Power Input, Speed & Efficiency

o **Test on Control Panel**
- IR & HV
- Functional Test

The details of tests mentioned above are given in Model Quality Assurance Plan of HVAC system.

19.3 Field Test

All field tests including tests during installation, pre-commissioning, commissioning and field acceptance tests shall be conducted by the Contractor, in the presence of representative of the Employer.

Procedure to be adopted for conducting the operational, pre-commissioning, commissioning, performance and field acceptance tests shall be submitted well in advance, at least six (6) months before start of relevant testing, for approval of the Employer.

The Following tests shall be conducted during commissioning:

- Dimensional check of Duct, Duct Sheet
- Functional test of louver, Damper, Thermostat/Temperature Sensor
- Pressure test or leakage test,
- Main Air Flow rate
- Performance test of AHU, Package type Air Conditioner, Chiller Unit, Pump etc
- IR & HV Test on Control Panel
- Vibration & Noise Level of AHU & Chiller Unit

20 COOLING WATER SYSTEM

20.1 Type Test

The contractor is required to carry out all type tests as per relevant National / International Standards on one apparatus of each type of

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : RMU of Chilla Power Station

CLIENT: UJVN Limited

VENDOR :

NAME OF EQUIPMENT : Air Conditioning and Ventilation System

NIT/P.O. REFERENCE :

SR. NO.	ITEM /COMPONENTS & CHARACTERISTICS	NATURE OF CHECKS	QUANTUM OF CHECKS	REFERENCE DOCUMENTS ACCEPTANCE NORMS	RECORD FORMAT	INSP. AGENCY			REMARKS
						Perform	Witness	Verify	
1	**Filter**								
a	Dimensional Check	Test	100%	Approv. Drg. / Tech. Spec. / Relevant Std.	IR	3/2	-	1	RR
b	Eurovent Test	Test	100%	-do-	TC	3/2	-	1	TC
c	Fire Test	Test	100%	-do-	TC	3/2	-	1	TC
2	**Mixing Box**								
a	Material Properties	Chemical & Mechanical	Sample	-do-	TC	3/2	-	1	TC
b	Dimensional Check	Measurement	100%	-do-	IR	3/2	-	1	RR
3	**Louver Damper & Motorised Damper**								
a	Material Properties	Chemical & Mechanical	Sample	-do-	TC	3/2	-	1	TC
b	Galvanizing Test	Test	Sample	-do-	TC	3/2	-	1	TC
c	Dimensional Check	Measurement	100%	-do-	IR	3/2	-	1	RR
d	Functional Test	Test	100%	-do-	TC	3/2	-	1	TC
e	Routine Tests of Motor for Motorized Damper	Test	100%	-do-	TC	3/2	-	1	TC
4	**Blower & Fan**								
a	Type, Make & Rating	Visual	100%	-do-	TC	3/2	-	1	TC
b	Chemical Properties for Blade & Shaft	Chemical	Sample	-do-	TC	3/2	-	1	TC
c	Mech. Properties including Bend Test	Mechanical	-do-	-do-	TC	3/2	-	1	TC

Note: a. In 'Inspection Agency'column figure 1,2,or 3 to be filled. 1- will indicate 'UJVNL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR-Review of Records, T.C. - Test Certificate Submission , CHP - Customer Hold Point & JIR - Joint Inspection Report
c. Test certificates shall be submitted at the time of final inspection.

Signature
UJVNL

Signature & Seal
(VENDORS Q.C. DEPT. OR REPRESENTATIVE)

Dy. General Manager,
M&U-Ganga Valley
UJVN Limited,
Ganga Bhawan, Dehradun

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : RMU of Chilla Power Station

CLIENT: UJVN Limited

VENDOR :

NAME OF EQUIPMENT : Air Conditioning and Ventilation System

NIT/P.O. REFERENCE :

SR. NO.	ITEM /COMPONENTS & CHARACTERISTICS	NATURE OF CHECKS	QUANTUM OF CHECKS	REFERENCE DOCUMENTS	ACCEPTANCE NORMS	RECORD FORMAT	INSP. AGENCY			REMARKS
							Perform	Witness	Verify	
d	Dimensional Check	Measurement	100%	Approv. Drg. / Tech. Spec. / Relevant Std.		IR	3/2	-	1	RR
e	Dynamic Balancing of Blower impeller	Measurement	100%	-do-		TC	3/2		1	TC
f.	Routine Tests	Test	100%	-do-		TC	3/2	-	1	TC
g	Acceptance Test with Motor	Test	100%	-do-		JIR	3/2	1	-	CHP
5	**Motor for Fan & Blower**									
a	Type, Make & Rating	Visual	100%	-do-		TC	3/2	-	1	TC
b	Routine Test	Test	100%	-do-		TC	3/2		1	TC
6	**Sheet for Duct**									
a	Chemical Properties	Chemical	Sample	-do-		TC	3/2	-	1	TC
b	Mechanical Properties	Mechanical	-do-	-do-		TC	3/2	-	1	TC
c	Galvanizing Test	Test	-do-	-do-		TC	3/2	-	1	TC
d	Dimensional Check	Measurement	100%	-do-		IR	3/2	-	1	RR
7	**Copper Coil**									
a	Thickness & Diameter	Measurement	100%	-do-		IR	3/2	-	1	RR
b	Hydrostatic Pressure Test	Test	-do-	-do-		TC	3/2	-	1	TC

Note: a. In 'Inspection Agency'column figure 1,2,or 3 to be filled. 1- will indicate 'UJVNL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR-Review of Records, T.C. - Test Certificate Submission , CHP - Customer Hold Point & JIR - Joint Inspection Report
c. Test certificates shall be submitted at the time of final inspection.

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Signature & Seal
(VENDORS Q.C. DEPT. OR REPRESENTATIVE)

Dy. General Manager,
M&U-Ganga Valley
UJVN Limited,
Ganga Bhawan, Dehradun

QUALITY ASSURANCE PLAN (MODEL)

PROJECT : RMU of Chilla Power Station

CLIENT: UJVN Limited

VENDOR :

NAME OF EQUIPMENT : Air Conditioning and Ventilation System

NIT/P.O. REFERENCE :

SR. NO.	ITEM / COMPONENTS & CHARACTERISTICS	NATURE OF CHECKS	QUANTUM OF CHECKS	REFERENCE DOCUMENTS	ACCEPTANCE NORMS	RECORD FORMAT	INSP. AGENCY			REMARKS
							Perform	Witness	Verify	
8	**Pipes, Flanges & Valves**									
a	Make, Type & Size	Visual	100%	Approv. Drg. / Tech. Spec./ Relevant Std.		TC	3/2	-	1	TC
b	Hydrostatic Test	Test	100%	-do-		TC	3/2	-	1	TC
9	**Control Panel**									
a	Verification of Bill of Material	Visual	100%	-do-		TC	3/2	-	1	TC
b	Functional Check	Functional	100%	-do-		TC	3/2	-	1	TC
c	IR and HV Test on Control Panel	Elect.	100%	-do-		TC	3/2	-	1	TC
10	**Complete Assembly of AHU**									
a	Dimensional Check	Measurement	100%	-do-		TC	3/2	-	1	TC
b	Functional Test	Test	100%	-do-		TC	3/2	-	1	TC
c	Noise Level	Test	100%	-do-		TC	3/2	-	1	TC
d	Routine Tests	Test	100%	-do-		TC	3/2	-	1	TC

Note: a. In 'Inspection Agency' column figure 1, 2, or 3 to be filled. 1- will indicate 'UJVNL', 2- will indicate 'supplier' & 3- will indicate 'sub-supplier'.
b. In 'Remarks' column following abbreviations shall be used - RR-Review of Records, T.C. - Test Certificate Submission , CHP - Customer Hold Point & JIR - Joint Inspection Report
c. Test certificates shall be submitted at the time of final inspection.

Signature
UJVNL

Signature & Seal
(VENDORS Q.C. DEPT. OR REPRESENTATIVE)

Dy. General Manager,
M&U-Ganga Valley
UJVN Limited,
Ganga Bhawan, Dehradun

SECTION: I

SUB-SECTION: C2-B

CUSTOMER SPECIFICATION

(PROJECT SPECIFIC GENERAL REQUIREMENTS)

VOLUME III A
General Technical Specifications
Table of content

Dy. General Manager
M&U-Ganga Valley
UJVN Limited,
Ganga Bhawan, Dehradun

1. GENERAL REQUIREMENTS

1.1 GENERAL

The Contractor shall strictly observe this General Technical Specification in conjunction with the other sections of these specifications. He shall carry out all works in a skilled and workman like manner in conformity with modern methods of engineering. All design; calculations, materials, works, manufacturing and testing shall conform to the latest applicable standards.

In addition, the Contractor shall conform to all applicable regulations regarding the execution of construction and installation work, and shall follow all instructions issued by the competent Authorities, and the Engineer.

The other technical specifications shall take precedence over the general technical specifications in case of any contradiction or conflict.

Clause number cross-references refer to the Section in which they occur unless stated otherwise.

1.2 SCOPE OF WORK

The scope of work covered by these Electro-Mechanical Works-General Technical Specifications is established in the other sections (Section 7 to Section 14). In addition to this, the Contractor shall prepare the detailed design, construction and installation drawings as well as calculations, material specifications, operating and maintenance instructions, etc., for the works as stipulated in the other sections of Specifications.

The Contractor shall refurbish, design, manufacture, supply, erect, test & commission and hand-over to Owner and guarantee for Twenty Four (24) months after commissioning all works complete in every respect with all necessary accessories for reliable, efficient and trouble free continuous operation as per the detailed technical specifications.

These Specifications include the performance of all works and the provision of all labours, materials, permanent and temporary equipment, tools, accessories for transport to the site, including loading, unloading, if necessary reloading in the port of arrival, intermediate storage, protection of the Works from the effects of the weather, cleaning, drying, storage at site and preservation related works, complete installation, painting, testing and commissioning of all works and accessories of the works.

The Contractor shall make competent and experienced staff available for the training and assistance of the operating staff during commissioning and trial operation and, if required by the Employer, for a period after completion of the trial operation which shall be agreed separately.

The Contractor shall supply the Operation and Maintenance Instruction Manuals in a number and at a time as stated in the General and Special Conditions of Contract.

1.3 STANDARDS

Although European or IEC standards for design, stipulated testing, workmanship material and Works have been mostly stipulated in these specifications as a basis of reference, other standards and recommendations of standard international organizations will be acceptable provided they ensure equal or higher quality than those specified, and provided, furthermore, that the Contractor submits for approval detailed standards which he proposes to use.

When IEC or ISO Recommendations or other Standards are referred to, the Edition shall be that current at the time of issue of Tender Documents, and any Amendments issued till then.

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 national standards, if these are not English, which are applicable to the Contract.

Standard publications issued by the following organizations of standardization are considered as acceptable standards for the works subject to acceptance of the Employer:

1.3.1 Standards for General Application

AGMA	American Gear Manufacturers Association
AISI	American Iron and Steel Institute
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing of Materials
AWS	American Welding Society
BS	British Standards
CCITT	International Telephone & Telegraph Consulting Committee
CECT	European committee for Manufacturing of Boilers & Kindred Steel Structures
CMAA	Crane Manufacturers Association of America
DIN	Deutsche Institute for Normung
IEC	International Electro-technical Commission
IEEE	Institute of Electrical and Electronic Engineers
IIW	International Institute of Welding
IPCEA	Insulated Power Cable Engineer's Association

IS	Indian Standards
ISO	International Standards Organisation
JEC	Standards of the Japanese Electro-technical Committee
JIS	Japan Industrial Standards
KS	Korean Industrial Standards
NEMA	National Electrical Manufacturers Association
VDE	Verein Deutscher Elektroingenieure
VDI	Verein Deutscher Ingenieure
SIS	Swedish Standards Institute
USAS	United States of America Standards Institute

"Not withstanding reference made to various standards all equipment and works as per provisions and requirements of relevant and latest Indian Standards shall be acceptable"

1.3.2 Basic Design Standards

ISO System for Limits and Fits,	ISO/R286-1963
Part I, General Tolerances and Deviations	ISO/R1829-1975
Permissible Machining Variations in Dimensions without Tolerance Indication	ISO/2786-1973
Screw Threads	ISO 68-1973 ISO262-1973 ISO/R724-1978

1.3.3 Manufacturing and Testing Standards

Methods and Definitions for

Mechanical Testing of Steel Products	ASTM-A370
Tension Testing of Metallic Materials	ISO/R82-1959
Notched Bar Impact Testing of Metallic Materials	ASTM- E23 and ISO/R83-1976

Bend Test for Steel	ISO/R85-1959
Liquid Penetrant Inspection	ASTM-E165
Recommended Practice for	ASTM- E94
Radiographic Testing	
Ultrasonic Examination of	ASTM-A388
Heavy Steel Forgings	
Guided Bend Test for Ductility of Welds	ASTM-E190
Welders' Qualification Tests	AWS (American Welding Society) Group B,
	DIN EN 287
Preparation of Steel Surfaces for	
Painting by Sand blasting	SIS 05-5900
Designation of Degree of Rusting of Painted Surfaces	DIN53210
Certificates of Material Testing	DIN50049

"Notwithstanding reference made to various standards all equipment and works as per provisions and requirements of relevant and latest Indian Standards shall be acceptable".

1.3.4 Material Standards

ASTM (American Society for Testing Materials), AISI (American Iron and Steel Institute), DIN (German Industrial Standards) and BS (British Standards) are approved standards for the supply of materials.

Material tests according to DIN 50 049-3.1 C shall be provided for all important parts of the equipment such as: steel plates for parts under hydraulic pressure, all major castings (runner, shut-off valve, etc.), Large forgings (turbine and generator shaft etc.), high stressed large bolts etc.

Dy. General Manager
Middle Ganga Valley
UJVN Limited,
Ganga Bhawan, Dehradun

Power Sector Hydro Business Group
Sector-142, Noida U.P.

For less important parts, certificates according to DIN 50 049-2.3 are acceptable.

Materials shall be new and of first-class quality, suitable for the purpose, free from defects and imperfections, and of the classifications and grades in conforming to the latest issue of conforming the respective ASTM, AISI, DIN or BS standard. Materials conforming 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 detailed drawings submitted for review.

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

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

"Notwithstanding reference made to various standards all equipment and works shall be as per provisions and requirements of relevant and latest Indian Standards and shall be acceptable".

1.3.5 Electrical Standards

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

IS (Indian Standards)

Standards issued by IEC (International Electro technical Commission)

Standards issued by CCITT (International Telephone and Telegraph Consultative Committee)

For specific standards see the Particular Technical Specifications.

1.4 UNITS OF MEASUREMENTS

The international SI-system of units shall be used in documents, calculations, correspondence, drawings, etc., relevant to the Tender and the subsequent Contract.

1.5 WORKS IDENTIFICATION SYSTEM

An approved, uniform Works identification system shall be applied for all Mechanical, Electrical and Instrumentation and Control (I&C) Works to be agreed upon during detailed design.

1.6 TIME SCHEDULE

According to the relevant articles in the General and Special Conditions of Contract, the progress of the work shall conform to the basic Programme of Work on which the Contract is based.

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

Design work

Shop work

Testing and inspection of works

Transport to the Site

Storage at site

Preparations at the Site

Interdependence with works of other Contractors

Erection and commissioning

Acceptance testing

Handing over

Trial operation for fifteen (15) days

Removal of erection equipment and clearing of the Site

The Contractor shall pay particular attention to the dates established for the submission of installation and foundation drawings with loading data, anchoring details, recesses, block-outs etc.

2. TECHNICAL DOCUMENTS

2.1 GENERAL

This clause specifies the general scope and gives a definition of the documents which, together with those listed in the Technical Specifications, shall be delivered by the Contractor to the Engineer within the periods, and in a number and quality as specified in the General and Special Conditions.

The Engineer reserves the right to request the Contractor for additional documents as may be required for proper understanding and definition of constructional, operational, co-ordination or other matters.

All documents to be supplied shall be submitted in accordance with the agreed programme so that any comment made and change requested by the Engineer can be taken into account before starting the manufacture in the workshop and/or erection or installation at the Site.

If the Contractor fails to submit such documents, then the later execution of changes requested by the Engineer and the resulting additional cost and/or delays shall be the Contractor's responsibility and liability. The Contractor shall not be relieved of his responsibility

and guarantee after drawings and computations have been approved by the Engineer.

The preparation of drawings, computations or other technical documents shall not be sublet by the Contractor without the written authorization of the Engineer. In such a case the Contractor shall be fully responsible for such drawings, computations and other technical documents as if they were done by him.

On drawings, catalogue sheets or pamphlets of standard Works submitted to the Employer or Engineer in charge, the applicable types, paragraphs, data, etc. shall either be marked distinctively or the non-applicable parts shall be crossed out. Documents not marked in such a manner will not be accepted and approved by the Engineer-in-Charge.

For proper understanding of the documents, additional descriptions/explanations shall be given on these documents or on separate sheets if so requested by the Employer. All symbols, marks, abbreviations, etc., appearing on any document shall clearly be explained by a legend on the same document or on an attached sheet.

Each device appearing on any document (drawing, diagram, list, etc.) shall clearly be designated. The abbreviation mark used for an individual device shall be identical throughout the complete documentation so as to avoid confusion. All documents shall have a uniform title-block and agreed by the Engineer in charge. Beginning with the very first submittal to the Engineer in charge, the Contractor's drawings shall bear a serial number corresponding to a drawing classification plan to be agreed upon by the Contractor and the Engineer in charge.

Revised technical documents replacing previously submitted documents shall be marked accordingly. Also, the revised part in the Document itself shall be marked clearly with cloud mark. Annex No. 3 of this Section specifies the documents to be supplied and the purpose, namely "FOR APPROVAL" (A) or "FOR INFORMATION" (I), respectively.

Any comment given by the Engineer on a "I" type drawing shall have the same effect as if it were given on a "A" type drawing.

2.2 DRAWINGS

2.2.1 Loading Drawings

For all larger pieces of Works which, due to their dimensions and/or weight and transport limitations, will require special means for their transportation, the Contractor shall submit binding loading drawings indicating dimensions, weights, etc., of the respective pieces of Works and the necessary trailer for its transportation to the site.

2.2.2 Foundation Drawings

If a piece of Works requires its own foundation or needs a special area for installation, the Contractor shall submit drawings indicating all pertinent dimensions, static and dynamic loads, etc. They shall include all essential details required for proper design and construction of the foundations and/or buildings.

In addition, they shall include openings, sleeves, slopes and the arrangement of any supporting structure, i.e. base-frames or other steel constructions for permanent fixing or erection purposes.

If conduits are to be installed in the foundations, the relevant information such as diameter, length, and purpose shall be indicated on the drawings.

2.2.3 Arrangement Drawings

All arrangement drawings shall be drawn to scale. The General Arrangement Drawings shall show the physical arrangement of Works (constructions, machines, complete switchgears, control panels, instrument cubicles, etc.), civil constructions (buildings, rooms, foundations, ducts, etc.) and reserved areas (for pipes, cables, lines, etc.) in relation to each other and to agreed co-ordinates and boundaries. Such drawings shall be prepared for the whole plot, for separate plots and for each building (building, hall, room, ducts and trenches, etc.).

The Arrangement or Layout Drawings of electrical and instrumentation and control equipment shall indicate the location of all apparatus wherever used, i.e. in or on machines, control boards, switchboards, cubicles, control desks and panels, etc. The apparatus shall be denominated with the same standardised abbreviations as used in all other documents.

2.2.4 Outline Drawings

The Outline Drawing shall show all elements and the main dimensions of individual components where necessary in plan view, cross-section, side and top views. If reasonably possible such dimensions can be shown on Arrangement Drawings.

2.2.5 Design Drawings

The Design Drawings shall include the shop drawings, assembly drawings, erection drawings, piping diagrams and piping arrangement drawings, etc., showing the dimensions, design and data of all constructions, apparatus and Works to be furnished under this Contract.

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The drawings shall, where applicable, substantially conform to the Tender Drawings and shall show:

- - Details of manufacturing and treatment of major single work pieces specially manufactured for this Contract
- - Assembly of the Works in plan and elevation with main dimensions
- - Sub-assembly of the principal components of the Works with overall dimensions, adjustment and clearance tolerances, numbers of corresponding detail drawings
- - Sub-assemblies in which the Contractor proposes to ship the Works
- - All necessary details of the parts connecting to the Works supplied by others
- - Location and sizes of auxiliary connections for oil, grease, water, air, electrical power etc.
- - Location and size of the instruments and accessories provided Methods of lubrication and sealing
- - Instructions for heat treatment, pressure tests, surface preparation and anti-corrosive protection
- - Full details of parts for which adjustment is provided or which are subject to wear
- - Method and sequence of installation, field joints, erection and lifting devices, jacks, grout plugs, anchoring details, etc., if not shown on foundation drawings.

2.2.6 Installation Drawings

The construction, mechanical, electrical and I & C Installation Drawings shall provide detailed information on the disposition of the various items of a system (e.g. lighting fixtures, socket outlets, connection boxes, transmitters, actuators, loudspeakers, telephones, pipes, valves, pumps, compressors, etc.) and of the piping and wiring respectively included in the installation or assembly. They shall be based on dimension drawings of cubicles, rooms, buildings or areas containing the Works.

2.3 DIAGRAMS

For electrical diagrams general reference is made to IEC 113-1.

"Notwithstanding reference made to various standards all equipment and works as per provisions and requirements of relevant and latest Indian Standards shall be acceptable".

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2.3.1 Single-Line Diagrams

This is a simplified diagram of the essential electrical Works and their interconnections. Each circuit shall be represented by a single line only. It shall contain all required technical information of the Works represented, e.g. voltage, current, capacity, short-circuit level, ratios, voltage variations, positive and zero sequence impedances, measuring transformer and protection relay indices, interlocking, kind of switch drive, code designation, etc. as applicable.

Single-line diagrams of individual main components and switchboards shall additionally show the control, indicating, measuring, metering, protection, automatic, and other auxiliary electric devices separated for each individual installation site and location as applicable:

Local:	Switchboard control compartment, switch compartment, cable termination compartment, etc.
Remote:	Control room (from workstation). Unit control Board (from MMI) Relay (in auxiliary relay cubicle, UCB, LCB, protection cubicle) Separate energy meter cubicle.

Furthermore, the applied recommended setting of adjustable devices (protection and control elements, time relays, etc.) shall be indicated.

2.3.2 Circuit Diagrams

The Circuit Diagrams shall show the power circuits in all the phases with the main apparatus as well as the pilot circuits (measuring and control circuits). It shall show in full the functioning of part or all installations, Works or circuits with all required technical information.

The control part shall be subdivided into separately drawn "current paths", each showing all its components regardless of their actual physical location. The individual circuits are to be drawn in a straight-line sequence, avoiding line crossings. The current paths (to be designated by numbers) shall be drawn starting from two horizontal lines, which represent the control voltage source. All devices belonging to the Works or forming part of the Works or control devices shall appear between these two lines.

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

Interconnections to other circuit diagrams shall be clearly marked by means of dotted line separations and the corresponding functional designation.

The power circuit portion of the installation shall be drawn at the left side of the drawing.

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Circuit diagrams shall also contain all terminals and their correct designations. Terminals grouped together to terminal blocks of switchboards, distributors, etc. shall be shown on the circuit diagrams in one fictitious horizontal line surrounded by demarcation lines. If, for any reason, the current paths of circuit diagrams must be separated, the corresponding counter terminal has to be indicated by all means.

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

Standard Circuit Diagrams are patterns of circuit diagrams which have been standardised with regard to scope, arrangement, representation and allocation of Works with the aim of simplification and easy surveillance of electrical circuitry.

2.3.3 Block Diagrams

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

Wherever possible, a Block Text Diagram may be prepared, consisting essentially of explanatory texts enclosed in outlines which are linked by lines showing the functional relationships that exist between the various parts of an installation, Works or circuit.

2.3.4 Logic Diagrams

The Logic or Functional Diagrams shall be used for representation of logic and sequence controls and interlocking by showing only binary logic elements and their effect on the various process equipment disregarding their electrical realisation. Logic function elements (AND, OR, NOR, NAND, STORAGE, etc.) shall be used for processing and combining binary signals.

2.3.5 Terminal Diagrams

Such diagrams shall be prepared for any type of terminal box, marshalling rack, control cubicle, switchboard, etc., and shall show the terminals (properly numbered) and the internal and/or external conductors (wires or cables) connected to them.

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

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

2.3.6 Protection Co-ordination Diagrams

These diagrams shall show in a graphical manner separately for each power supply circuit:

A simplified single-line diagram of the circuit with technical data of all instrument transformers and relays.

Co-coordinated tripping curves of related protection devices.

Setting of the protection devices.

2.3.7 Emergency Shutdown Diagram

This diagram shall show the sequential steps and interdependencies during emergency closure.

2.4 SPECIFICATIONS

2.4.1 Material Specifications

Such specifications shall be prepared for all principal Works and installations. They shall describe the performance (design, material, dimensions, corrosion protection, etc.) of the Works and include a list of components providing information on the manufacturer, type and technical data to obtain the following:

- Full information on the Works, completing the general requirements fixed in the Tender Specification by the data/information of the specific manufacture.
- Proof of compliance with Contract Specification.

For standard Facilities (for example valves, switchgear, control gear, relays, transmitters, indicators, lighting fittings, etc.) catalogues or pamphlets shall be submitted.

The technical data of electrical Works shall include as a minimum:

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- Max. Permissible ambient conditions (temperatures, humidity)
- Rated current and rated output/capacity
- Same data as above under specified severest site conditions
- Rated voltage and ratio or regulation/setting range
- Max. Service voltage (acc. to IEC)
- Power frequency and impulse withstand voltages
- Type and code No. of protection relays and of instantaneous or thermal releases directly attached to circuit breakers and contactors
- Power requirements for each voltage level (A.C./D.C.).
- Specific requirements are described in the following paragraphs.

2.4.1.1 Motor Specifications

The motor specifications shall include the thermal motor characteristic both for cold and hot condition, the start-up characteristic when running with the driven machine and all data required for selection of the appropriate motor protection relay (both for cold and hot condition) and for locked rotor protection. Construction type, class of protection and insulation shall also be given.

2.4.1.2 Cable Specifications

The General Cable Specification shall include the calculation of the de-rating factors for the individual modes of installation at applicable ambient temperatures and grouping of cables, and furthermore, for each cross section:

- The rated current carrying capacity
- The maximum Short-circuit capacity
- The voltage drop
- Type, insulation serving, armouring and sheathing of cable
- Type, description and catalogue/pamphlet of cable termination.

Separate specification(s) shall be prepared for cable trays, conduits, supporting structures and other accessories.

2.4.1.3 Measurement and Control Apparatus Specifications

The accuracy of performance with respect to variable ambient conditions and the power supply requirements shall be included.

2.5 LISTS AND SCHEDULES

2.5.1 Motor Lists

The motor lists shall be prepared according to the power distribution boards. The motors are connected to, and shall contain at least the following information/data:

- Works identification number
- Description
- Manufacturer, type, rated data of driven machine
- Manufacturer and type of electric motor/consumer
- Rated capacity
- Service factor (ratio between motor output and power requirement of the driven machine)
- Rated speed
- Rated voltage
- Rated current
- Ratio of starting current to rated current
- Ratio of pull-out torque to rated torque
- Power factor at rated capacity
- Efficiency at rated capacity
- Power consumption at machine design loading
- Total weight
- Design/enclosure/cooling (acc. to IEC)
- Duty (continuous/intermittent/start-up)
- Starting method/permissible starting frequency
- Denomination of feeder
- Motor protection
- Applicable Standard Circuit Diagram (Category)
- Maximum number and overall diameter of power cable(s)
- Manufacturer and type of bearing(s)
- Manufacturer, type and quantity of lubricant, service interval
- Manufacturer, type, number, size, spring pressure and service interval of brushes (if applicable).

2.5.2 Motor Starter Lists

The motor starter lists shall include all starters and contactors used for motors and contain the following technical information as a minimum:

- Works identification number

- Electrical design data as nominal and actual current rating, voltage rating, coil rating, making and breaking capacity, mode of operation
- Maximum power cable size
- Maximum control cable size
- Current transformer ratio, class and capacity
- Type of protection relaying and catalogue number
- Setting of protection relays and maximum continuous rating of the protected circuit
- Type and current rating of the back-up fuses/MCBs for the main and control circuits.

Note: Motor Starter Lists can be substituted by part lists, already forming part of switchgear manuals

2.5.3 Cable Lists/Interconnection Lists

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

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

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

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

2.5.4 List of Measurements

This list shall indicate all measurements, local as well as remote, and shall contain at least:

- Item/code number, function code
- Description and denomination of measuring loop
- Data of tapping point
- Data of local devices (as detectors, instrument transformers, transmitters)
- Data of remote devices.

2.5.5 Alarm Lists

These lists shall indicate all alarms and shall contain at least:

- Item/code number and function code
- Description and denomination of alarm
- Data of alarm detector (contact) referring to applicable circuit diagram
- Data of alarm annunciator (location and clear text labeling)

2.5.6 List of Final Control Elements

This list shall indicate all control actuators and control valves and shall contain at least:

- Item/code number
- Data of pipe and valve connections
- Data of valve layout
- Rated power

2.5.7 Workshop Test Schedules

Individual Workshop Test Schedules shall be prepared for Works/installations (such as pipes, cranes, machines, switchgears, control gear, cables) and shall contain at least:

- Works identification number
- Manufacturer
- Place of manufacture
- Place of test
- Date of test
- Objective of test (all individual tests)
- Standards applied
- Certification
- Inspection (by Engineer / Independent Test Authority / Contractor/ Subcontractor)
- Release for shipment
- Remarks

On the above schedule or on separate sheets the Test Procedure shall be specified giving for each test item (kind of test) a description, test method / Standards, used instruments, sample/routine test, test judgment.

2.5.8 Site Test Schedules

Testing at site shall include tests specified in the Technical Specifications and any tests recommended by the manufacturers as per their standard practices.

2.5.9 List of Tools and Appliances

Lists of Tools and Appliances shall detail for all tools and appliances included in the scope of supply:

- Item and code number
- Description
- Quantity
- Weight
- Gross storage requirements (separate for open-air, indoor, air-conditioned) for individual component sets.

2.5.10 Spare Part Lists

Spare part lists shall detail for all spare parts included in the scope of supply:

- Detailed drawing (where possible)
- Item and code number
- Description
- Quantity
- Weight
- Gross storage requirements (separate for open-air, indoor, air-conditioned) for individual component sets.

2.5.11 List of Works Identification Numbers

This list shall contain the identification numbers of Works in alphanumeric order and for each of them a description (the defined Works denomination, for example as written on the Works label) and the location (short definition of outdoor area and level elevation or building/room with elevation and room number).

2.6 CALCULATIONS

In addition to the drawings or whenever the contractual documents do so require, the Contractor shall submit to the Engineer for checking, the appropriate calculations for determining the main sizes, stress levels, dimensions and operational characteristics, safety factors, clearly indicating the principles on which the calculations were based. The calculations shall include the formulae, standards, test results, basic assumptions, etc. Submission of computer calculations without baseline information such as derivation of the calculation method,

applied formulas, definition of variables and constants, explanation of abbreviations etc., will not be accepted.

2.6.1 Short-Circuit Calculations

Short circuit calculations showing various steps shall be provided in accordance with VDE Standard 0102, part 1 / IEC 60909. In case, the contractor intends to submit the same in ETAP software, a licensed copy of the said software shall also be provided by the contractor to the owner.

2.7 INSTALLATION AND COMMISSIONING PROCEDURES

2.7.1 Installation Procedures

The installations 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, leveling, 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/employer to plan and supervise the Works at site, if required.

2.7.2 Pre-Commissioning Tests and Procedures

Pre-commissioning tests and procedures shall be described in sequential steps for the pre-commissioning of all electrical and mechanical equipments and shall also contain sufficient details viz. checking of installations, ratings, cable terminal checking and operation test of all auxiliary equipments etc.

2.7.3 Commissioning Procedures

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

2.7.4 Commissioning Test

Commissioning acceptance tests shall be carried out, on all generating units to verify the rating characteristics of generating units and other equipment's in accordance to relevant standards. The complete field acceptance test reports shall be prepared by the Contractor and submitted to the Employer for approval.

2.7.5 Test Run

The test run on generating units shall be carried out as per relevant provisions of IEC standards.

2.8 OPERATION AND MAINTENANCE MANUALS

2.8.1 Contents

The Operation and Maintenance Manuals shall be provided in Ten (10) copies along with CD-ROM (three sets), and shall contain the following information in sufficient detail to enable the Employer to maintain, dismantle, reassemble, adjust and operate the Works with all its items of Works and installations:

- Table of Contents
- List of Illustrations
- Introduction

The Introduction shall contain:

- A brief general description of the Works items
- A brief description of the use of the Works items
- Definitions of technical terms used in subsequent graphs of the instruction book
- A complete list of all items used in accordance with the Works Components Identification System.
- Detailed Description

Detailed description shall contain a complete and accurate description of the Works, all components and ancillaries, their assembling and dismantling. An accurate list stating clearances, tolerances, temperatures, fits, etc. shall be included.

- Operating Principles and Characteristics

A brief summary of the technical operating principles of the Works, including diagrams, circuit diagrams, sequence diagrams, piping, etc.

- Operating Instructions

The instructions shall be accurate and easy to understand, and shall contain the sequence of individual manipulations required for operation. The information shall be presented in such a manner that the contents of this paragraph can be used for instructing personnel in the operation of the Works. Tables, lists and graphic presentations should be used whenever possible for making the description readily understandable. An appropriate trouble-shooting list shall be included in this chapter.

- Testing and Adjustment

The entire testing and adjustment procedure required for the Works after overhauls and during operation shall be described.

- Maintenance Instructions

This section is divided into six parts:

1) Preventive maintenance, indicating the inspections required at regular intervals, the inspection procedure, and the routine cleaning and lubricating operations, the regular safety checks and similar steps.

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- The maintenance instructions shall include a tabular (or in other approved form) summary of the required activities sorted according to
- Daily
- Weekly
- Monthly
- Quarterly
- Yearly
- (Or other) cycles as applicable.

This document shall provide the maintenance engineer with brief and yet fully comprehensive information including all references to the applicable, detailed service and maintenance instructions.

2) Repair and adjustment, describing the inspections, fitting and dismantling of parts, fault tracing as well as repair and adjustment procedures.

3) Spare part lists, containing all the necessary data for ordering spare parts. These lists shall include all spare parts, those to be supplied and those not to be supplied under the present Contract. Detailed drawing for each item of spare parts shall be supplied. The above list should include minimum and maximum quantities of spares to be maintained by the project.

4) Tool lists, containing all necessary data for identification of tools to be delivered under the present Contract.

5) List of suppliers and alternative suppliers and addresses.

6) As-built drawings

2.8.2 Performance

Each drawing aforementioned shall have a uniform size. The final size of drawings for the Operation and Maintenance Manual shall be decided by the Engineer-in-charge. Catalogue sheets, illustrations, printed specifications, etc., shall be checked and prepared by the Contractor in such a way that the figures, statements and data valid for the delivered sizes and types of the Works concerned are clearly marked. All figures, statements and data valid for sizes and types not delivered must be crossed out.

2.8.3 Revisions and Supplements

The completeness of the manuals shall be checked during installation, testing, commissioning and trial operation jointly by the Contractor and Engineer- in- charge.

If it becomes evident during the installation, commissioning trial operation and defects liability period of the Works that the Operation and Maintenance Manuals are inadequate or incorrect, the Contractor

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shall supply immediately the necessary supplements and corrections. This shall be handled in the following manner:

- Deletions:

One sheet of errata, printed on pink paper, shall be issued indicating the pages and date of issue of those pages, which are to be deleted, and are no longer valid.

- Corrections, Revisions, Replacements:

New sheet or sheets shall be issued to replace the wrong pages. Whenever a new sheet is added to the instruction manuals, this sheet shall be given the new date of issue and a revision symbol, and an indication "Substituted for ... " and a marking of the corrected/revised items.

- Insertions, Supplements:

Insertions or supplements shall be accompanied by a new respective "Table of Contents" page, where the latter shall be handled as described above under replacements.

The revisions and supplements requested by the Engineer-in-charge shall be made by the Contractor at the Site as far as possible and shall be submitted in each case to the Engineer for checking and approval as stated above.

Before issuing the "Taking-Over Certificate", the ten sets of revised copies of the Operation and Maintenance Manuals shall be submitted together with the specified number of complete sets of drawings of the Works as completed. The Works shall not be considered complete for purposes of taking over under the terms of the General Conditions of the Contract until the above documents have been supplied by the Contractor.

2.9 PROGRESS REPORTS DURING DESIGN AND MANUFACTURING

During every quarter design and manufacturing the Contractor shall quarterly submit four (4) copies of 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 CPM programme. Appropriate comments shall explain any differences.
- The percentages of each main work activity completed during the reported quarter vis-à-vis 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 two (2) months, with expected starting and completion dates. If the expected starting and/or completion dates are different from those shown on the CPM programme, an explanation shall be given.

2.10 PROGRESS REPORTS DURING INSTALLATION AT SITE

During erection the Contractor shall, before the tenth (10th) day of each calendar month, submit four (4) copies of the 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 includes any notable problems, which were encountered.
- The total overall percentages of erection works completed, with reference to the CPM programme. Appropriate comments shall explain any differences.
- The percentages of each main work activity completed during the reported month with reference to 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 and scheduled starting dates and actual completion dates, scheduled completion dates for each activity. Appropriate remarks shall explain any differences.
- A list of activities scheduled to be started within the next period of two (2) months, with expected starting and completion dates. If the expected starting and/or completion dates are different from those shown on the CPM programme, 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 and materials available at the Site at the beginning of the report period. Also a list of equipment and materials, which arrived at Port of entry and status of custom clearance.
- Photographs of progress of significant events. The Engineer-in-charge may demand 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 & an explanation of actual and 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.

3. SPARE PARTS AND TOOLS

3.1 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 Taking-Over Certificate the spare parts shall be checked at the Site by the Contractor in presence of the Engineer in charge/Employer.

Acceptance of any spare part 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 English. 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.

3.1.1 General Spare Parts

At least the quantity of general spare parts specified below shall be included in the Total Tender Price and consequently in the scope of Works of the Contract.

If the same spare parts are listed twice under "General Spare Parts" as well as under "Spare Parts", the quantity listed under "Spare Parts"

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shall take priority over the quantity stipulated under "General Spare Parts".

- Spare Parts subjected to Wear and Tear.

For each installed assembly such as Servomotors, Pumps, Motors, Main Inlet Valves, Pressure Oil Units, Gates, Valves, Compressors, Cranes, Machine Tools etc. the following general Spare Parts shall be delivered.

One (1) complete sets of:

- Facing rings of mechanical seals
- Protection sleeves
- Carbon brushes for motors (if applicable)
- Inserts of filters
- Bearing bushings
- Brake liners
- Pickings
- Roller bearing for rotating shafts and seals for rotating shafts
- Driving belts
- Wearing parts of couplings
- Frequently actuated springs
- Outdoor installed pressure hoses

Wear and tear items shall be defined as such, which require replacement several times during the service life of the assembly.

- Customary Spare Parts:

For a number of like and identical assemblies the following spare parts shall be delivered, whereas one set shall be defined as the total quantity for one assembly:

- "X" Complete Sets related to "Identical Assemblies":
- Seals, gaskets and packing
- Thermometer, manometer, flow meter, level indicator (with and without contacts)
- Transducer 4/20 mA for position, pressure, temperature, flow
- Indoor installed pressure hoses
- Lamps, signal lamps, push button and switches
- Fuses, clamps
- Limit switches, auxiliary relays, pressure switches
- Roller bearings, sleeves and bushings for movable parts including for spherical joints
- Ball bearings.

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- Resistance thermometer without indicator
- Motor-starters, contacts for feeder switches
- Springs
- "X" Complete Valves and Gates:

Related to "Identical Installed Standard Valves and Gates" (manually, hydraulically or electrically driven) including Drive like

- Shut-off valves and cocks
- Globe valves, needle valves or butterfly valves
- Non-return valves
- Pressure relieve valves
- Pressure reducing valves
- All solenoid valves
- Safety valves
- Aeration and venting valves
- Float controlled valves

The quantity "X" which shall be furnished is a function of the number "N" of supplied "Assemblies" or "Valves and Gates" identical in type and size.

N < 3 X = 1

N < 10 X = 2

N > 10 X = N/10 + 1, rounded-up to the next higher whole number

The Contractor shall provide 5%, but at least two pieces of all bolts, screws, nuts, washers, spanner rings and cotters. The quantity may be taken from the surplus handed over to the Employer after completion of the installation as described under 5.2 "Bolts, Screws, Nuts, etc." of this Section.

For all items under this Contract the Contractor shall deliver 5 % of the quantity of painting material, but at least one litre, in new sealed containers, for later repair work other than the Contractor's.

Parts with a special size or properties, as listed below are excluded as General Spare Parts:

- Bolts, screws, nuts, washer, spanner rings and cotters with a nominal diameter of more than 80 mm
- Roller bearings, bearing shells, sleeves and bushings for movable parts including for spherical joints with an inner diameter of more than 200 mm
- All valves and gates with a nominal diameter of more than 600 mm
- Main seals for gates, valves, access doors and openings with a total length of more than 2.40 m in straight length or circumference.

3.1.2 Spare Parts

The required specified spare parts are listed separately in the Technical Specifications. The price for each listed special spare part shall be provided individually in the Billing Breakup; the total price shall be included in the Total Tender Price.

3.1.3 Recommended Spare Parts

If any additional spare parts are recommended by the Contractor, these shall be stated in quantity and description in the Technical Data Sheets for each item.

Orders for recommended spare parts shall be optional to purchase by the Employer for a period of five (5) years after the date of the completion of the project. However optional spare parts will not be considered in tender evaluation.

3.2 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 Total Tender 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 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 itemised 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.

Ropes, slings etc. shall be handed over in new condition. The Employer shall be entitled to take over from the Contractor the entire erection tools, appliances, instruments at mutually agreed conditions.

Specials tools as per the availability at site shall be provided to the Contractor for dismantling of existing equipment at site. However, non-availability of said special tools at site shall not absolve the Contractor from the responsibility to carry out the services such as dismantling and erection by arranging for special tools on its own.

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4. DESIGN AND MANUFACTURE

4.1 GENERAL

Design, manufacture and construction requirements shall generally be as described below besides complying with the specific requirements elaborated in particular technical specification

4.2 DESIGN AND CONSTRUCTION REQUIREMENTS

The following directions, information and technical requirements for layout, design and erection shall be observed as far as they are applicable to the Works to be offered. The technical requirements of the General Technical Specifications are valid for all parts of the Works except where they are modified by additional and/or special requirements, specified in the other Technical Specifications.

Whenever a Contractor deviates from these Specifications, he shall furnish the data called for in Section 3 and give a summary of and the reasons for all deviations in the "Deviations from Technical Specification". Failure to accomplish this may cause the rejection of his Tender, especially when a major deviation is involved.

All changes in the design of any part of the Works, which may become necessary after signing the contract, have to be submitted in writing to the Engineer for approval, with substantiation and justification.

Additional cost can only be accepted, in case of a basic design change, required by the Engineer-in-charge after award of Contract.

The Works shall be designed, manufactured, arranged and installed to meet functional needs and to provide neat appearance. All parts of the Works shall be arranged to facilitate supervision, maintenance and operation. All control sequences shall be simple and rational.

The parts of the Works shall be designed and arranged so that they can be easily inspected, cleaned, erected and dismantled without involving large scale and time consuming complex dismantling of other parts of the Works. They shall be designed, and manufactured in accordance with the latest recognised rules of workmanship and modern engineering practice.

The regulations, standards and guidelines listed in these Specifications shall be observed in the design, calculation and manufacture of the Works.

All parts of the Works shall be suitable in every respect for continuous operation at maximum output under the climatic conditions and operating conditions prevailing at the Site.

Special attention shall be given to Works, parts of which are delivered by different manufacturers. Problems arising in this conjunction shall be solved by the Contractor and be defined in writing.

For individual items of the Works, materials and design are to be selected which are best suited for the most severe operating conditions

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to which the parts in question will be subjected. Only such design and types of Works shall be offered which have proven reliability in long-term continuous operation.

All live, moving and rotating parts shall be adequately secured in order to avoid danger to the operating staff. All electrical components shall be electrically earthed.

Contractor shall take appropriate measures to prevent the ingress of dust into any Works (such as bearings, relays, control and measuring equipment, winding, oil tanks, etc.), which may be endangered thereby.

Suitable lifting eyes and backing-out bolts shall be provided where required or where they will be useful for erection and dismantling.

Pockets and depressions likely to hold water shall be avoided, and if not avoidable they shall be proper self draining arrangement.

Parts of the Works principally intended for standby purposes shall be protected from corrosion by careful choice of material and if necessary, by additional means; these should not reduce their continuous standby readiness.

All design details and layout matters shall be discussed in periodic meetings with the Engineer- in- charge. The first design meeting between the contractor and the Engineer – in - charge shall take place within 60 days after the date of signing of the contract or placement of the order. Further design meetings shall take place as agreed between the participants until the design work is completed.

4.3 ALLOWABLE STRESS

The design of the parts of items of Works shall fundamentally consider the most severe conditions to which they will be subjected during testing and operation.

If different stress values are given in the General/Particular Technical Specifications or in the relevant standards and regulations, then the most stringent values shall be applicable.

The dimensions of the parts which are exposed to repetitive and alternating stresses as well as to impacts and vibrations shall take into account the safety measures approved in practice.

4.4 DESIGN CRITERIA

The plant equipment shall be designed for the worst possible combination of the following loading conditions as applicable:

- All static and dynamic hydraulic loads,
- All loads due to dead weight and frictional forces,
- Seismic or wind loads, and
- Other loads

4.4.1 Deleted

4.4.2 Seismic Loads

The forces being caused by earthquake including hydraulic loads, which may occur additionally, shall be taken into account as per the seismic Zone-IV for the computations.

Stresses resulting after including these loads shall not exceed permissible stresses.

4.4.3 Wind Loads

The basic wind load as per IS 875 (Part - 3) shall be applied on the vertical projected area, multiplied with the applicable factor for the different type of structures.

4.5 TOLERANCES

Gates

Water leakage under any head and without the use of any additional sealing materials per m length of seal:

- For Intake gates 1.0 l /m/m

4.6 STANDARDIZATION OF WORKS

Every effort shall be made to standardise parts and minimise costs of the Works throughout the Works in order to facilitate keeping stocks, maintenance, replacement, interchangeability, etc.

The Engineer-in-charge, therefore, reserves the right to demand the different contractors to use uniform types or makes of works & materials. The contractor shall not be entitled to claim extra payment on this account. This shall especially be applicable to small mechanical and electrical works such as:

- Valves
- Thermometers
- Pressure gauges
- Flow meters
- Water level gauges
- Terminals & terminal racks
- Indicating instruments & meters
- Auxiliary relays
- Contactors, fuses
- Motor protection switches
- Control devices
- Lights, bulbs, plugs, sockets

- Limit switches
- Level switches

The types or makes to be used shall be decided later by the Engineer-in-charge. All instrument scales shall be written in the ruling language of the contract and in the international SI- System of units.

4.7 QUALITY OF MATERIALS AND WORKS

For general requirements concerning the quality of materials and Works, the applicable sections of the Technical Specifications, Section-14 may also be referred.

4.8 NOISE

The noise level caused by the installed Works shall not exceed the following values if not otherwise stated in the Technical Specifications:

- Machine hall, workshops, etc.- max. 85 dB (A) at any place 1 m distant from operating equipment.
- Offices, control rooms, first aid rooms, canteens, etc.- max 55 dB (A)
- Emergency diesel generators max. 85 dB (A) at 1 m distance, open field

The noise level definition and measurement shall be in accordance with relevant ISO and IEC. The values stated shall be adhered to taking a normal civil construction into account.

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

4.9 IDENTIFICATION PLATES

4.9.1 General

Each important part to be delivered under this Contract shall be equipped with permanent identification plates in readily visible locations. Whether a part shall be considered as important in this respect shall be decided by the Engineer.

The identification plates shall be protected during erection and especially during painting. Damaged or illegible identification plates shall be replaced by new ones. The identification plates of non-corroding, non-disintegrating material (except manufacturer's nameplates of small standardised components) shall be inscribed in the Contractual language.

The inscription shall be printed, stenciled, or hand-written, but in any case, waterproof, oil-proof and wear-resistant. Works (machines, transformers, etc.) nameplates shall be either of the enamelled type or be of stainless steel covered after stamping with a transparent paint.

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Wording, size and material of all labels and plates shall be subject to the Engineer's approval.

4.9.2 Manufacturer's Nameplates

The following data shall be shown in accordance with the relevant standards:

- Manufacturer's name and address
- Work's serial number and date of manufacture
- Main design data.

As a general rule, standardised components, such as small or medium-sized electric motors, transformers, instruments, etc., may be delivered with the manufacturer's standard nameplate.

The design of the Manufacturer's nameplates for the main components such as gates, cranes, valves, hoists, servomotors, pumps etc., shall be submitted for the Engineer's approval sufficiently in advance.

4.9.3 Functional Plates

Each part appearing under a certain symbol or number in functional diagrams, piping diagrams, in the Operation and Maintenance Instructions, etc., shall be equipped with a plate showing the same symbol or number.

4.9.4 Instruction Plates

All plates showing designations or instructions for operation, safety, lubrication, etc. shall have a uniform design.

4.10 COLOUR CODE

4.10.1 Colour Coding For Electrical Connections

Live parts of electrical connections shall be Colour coded as follows:

Conductor Designation	Coding Alphanumeric	Symbol	Colour
A.C. Network 3 Phase	Phase 1	R	Red
	Phase 2	Y	Yellow
	Phase 3	B	Blue
	Neutral	N	Black
A.C. single phase	Phase	P	Red
	Neutral	N	Black
	Earth	E	Green-yellow
D.C. Network	Positive	a	Red
	Negative	b	Black

4.10.2 Colour Coding For Mimic Diagrams

Mimic diagrams to be arranged on switchgear cubicles, control panels/desks, etc. shall be colour coded as follows:

132 kV	Gold
11 kV	Signal red
415 V	Black
220 V DC	Violet
48 V DC	White

Note: Colours mentioned above shall be finally agreed upon during detailed design .The colour code for equipment not listed in the above mentioned Specifications shall be agreed upon after award of the Contract. The colouring of pipelines, moving parts, etc., shall be according to internationally recognised standards

4.11 WORKMANSHIP

The Contractor shall level and adjust all parts of the equipment on the foundations and after each item is set up and the Engineer-in-charge approval obtained, grouting or concreting will be carried out by other contractors and verified by the Contractor. The Contractor shall be responsible for ensuring that such work is carried out to his satisfaction and that level and adjustments made by him are not disturbed by the grouting operation. The Contractor shall be responsible for ensuring that the positions, levels and dimensions of the Works are correct according to the drawings notwithstanding that he may have been assisted by the Engineer in setting out the said position, levels and dimensions.

4.11.1 Finished Surfaces

Where the finish is not indicated or specified, the type of finish shall be most suitable for the surface to which it applies and shall be consistent with the class of fit required.

Surfaces to be machine-finished shall be indicated on the shop drawings by symbols. Compliance with the specified surface shall be determined by the sense of feel and by visual inspection of the work compared to applicable "Standard Roughness Specimens", or with roughness feeler gauge instruments. Both "Standard Roughness Specimens" and feeler gauge instrument shall be procured by the Contractor at the request of the Engineer.

4.11.2 Unfinished Surfaces

As far as practicable, all works shall be laid out to secure proper matching of adjoining unfinished surfaces. Where there is a large discrepancy between adjoining unfinished surfaces, they shall be chipped and ground smooth, or machined to secure proper alignment.

Unfinished surfaces shall be true to the lines and dimensions shown on the drawings and shall be chipped or ground free of all projections and

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rough spots. Depressions or holes not affecting the strength or usefulness of the parts shall be filled in a manner approved by the Engineer.

4.11.3 Protection of Machined Surfaces

Machine-finished surfaces shall be thoroughly cleaned of foreign matter. Finished surfaces of large parts and other surfaces shall be protected with wooden pads or other suitable means. Unassembled pins or bolts shall be oiled or greased and wrapped with moisture-resistant paper or protected by other approved means.

4.11.4 Rounding, Chamfers, Edges

The edges of surfaces to be painted shall be rounded (minimum radius 2 mm) or chamfered accordingly. This requirement must be stated in all shop drawings for the relevant parts.

4.12 WELDING AND HEAT TREATMENT

4.12.1 General

All welds shall be as shown in detailed drawings and shall be made in such a manner that residual shrinkage stresses will be reduced to a minimum.

The Contractor shall submit with his Tender adequate information concerning the proposed:

- Extent to which automatic welding techniques will be applied;
- Extent to which manual welding techniques will be applied;
- Extent to which he intends to use pre-weld heat treatment, post-weld stress relieving, full anneal stress relieving or normalising consistent with the thickness and types of material proposed;
- Weld electrodes, welding wire and flux, which will be used with the selected plate material or materials;
- Standard tolerances for the deviations of mating weld profiles.

4.12.2 Welding

Pieces to be joined by welding shall be cut accurately to size including the required allowances. According to the proposed welding method, the welding edges shall be sheared, flame-cut or machined to allow thorough penetration and fusion of the weld with the base material.

The cut surfaces shall be free of all visible defects, such as laminations, surface defects caused by shearing or flame-cutting operations. The edges and surfaces to be welded shall be free of rust, mill scale, grease, oil, paint or any other foreign matter. Welding over zinc primers shall be permitted subject to submission of a certificate of a recognised institution stating the pertinent limiting parameters for this welding procedure. In all other cases, welding over paint shall be

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prohibited; all painting materials next to the joint to be welded shall be removed well beyond the heat-affected zone.

Unless otherwise allowed by the Engineer in charge, all steel parts to be welded shall be manufactured of steel produced by the open hearth or electric furnace with Carbon content not higher than 0.20 % and a phosphorous content of not more than 0.05 %.

Wherever welding is specified or permitted, a welding process approved by the Engineer-in-charge and conforming generally to DIN or other approved standards shall be used. Approval of the welding process shall not relieve the Contractor of his responsibility for correct welding, the use of correct electrodes and for minimizing distortion in the finished structure.

When the welding process has been approved by the Engineer in charge, the Contractor shall produce a record drawing to show the approved process. The drawing shall include details such as the form of edges to be welded, electrodes and other welding materials, welding sequence, etc. Changes in the welding process after the welding method has been approved shall require the consent of the Engineer in charge.

Where possible, welding shall be carried out in the workshop. Welding which has to be performed in the field shall be clearly so indicated on drawings.

The Contractor shall follow the steel manufacturer's recommendations concerning electrodes, welding and material pre- and post heat treatment. Notwithstanding the above, the suitability of the electrodes to be used for welding and the welding methods to be used for both shop and field welding shall be demonstrated by trials and tests to the satisfaction of the Engineer-in-charge.

Additional copies of all records of all welding procedures, including preheating and stress relieving, chemical analysis and physical properties, shall be made available to the Engineer upon request.

Design, preparation, performance and testing of welded constructions shall suit the kind of stresses and the grade of risk, considering a supposed failure of the welded member.

The following table shows a general classification by means of numbers with the significance of each number explained thereafter.

Any structure not especially mentioned shall be classified by the Contractor and shall be subject to approval by the Engineer-in-charge.

	STRESS		
	Compression	Bending	Alternating, Dynamic Tension>0.9 allowable stress
Small risk Stairs, Rails, doors	0	0	1
Medium risk Cranes,	4	4	7

trusses, bridges			
High risk Penstocks, steel linings, spiral distributor, nozzle, runner, gates, stop logs etc.	5,6,7,8	5,6,7,8	5,6,7,8

Significations

0= without special prescriptions. Only skilled welders shall be employed which follow proven rules of workmanship.

1= Full penetration welds. The weld preparation shall allow the filling of the weld profile without defects. The root of double welded butt joints shall be ground before welding the second side. If the second side is inaccessible for welding, such single welded butt joints shall be built up against a backing strip.

2= Weld ground flush. The weld shall be ground on both sides of the steel plate. The weld surface shall be finished so as not to reduce the plate thickness by more than 3%. Butt welds with a smooth surface and a chamber of less than 8% of the width of the top layer need not be ground.

3= Connections rounded. Where stresses are to be deviated, already the design shall care for a reduced notch effect. Welds shall be smoothly ground and rounded.

4= Welder qualification test. All welders and welding operators shall have passed qualification test in accordance with the respective National Standard or rules of AWS-American Welding Society, or the DIN EN 287.

5= Welding procedure test. The Contractor shall describe the proposed welding procedure. Further he shall prove with tests, that the properties of the weld and transition zone are at least equal to those specified for the base material.

The welding procedure test may be combined with the welder's qualification test.

6= Welding performance test, executed during fabrication and site welding. Run-off plates shall be tack-welded to one end of the plate under work. The weld shall continue on that run-off plate (test plate), welded in the same manner and under normal working conditions.

One test plate is required every 20 m of weld seam, but at least one of each weld type.

The laboratory tests shall cover the same range as the welding procedure tests.

On request by the Engineer test plates shall be welded in his presence.

7= Ultrasonic and/or radiographic test. Depending on the location of the weld seams and the plate thickness, ultrasonic and/or radiographic tests shall be performed. The Contractor shall submit a proposal subject to approval by the Engineer. If not stated differently in the Technical Specifications, 20% of the weld length shall be checked

through ultrasonic testing, but at least one film per weld type. The Contractor shall record the results of the ultrasonic and/or radiographic testing in these reports and drawings.

8= Marked with welder's stamp. The welder shall mark every seam welded by him with his number, so it can be recognized until the end of the fabrication period.

4.12.3 Welding Qualifications

For welding of principal stress carrying parts, the standard of welding procedures, welders and welding operators shall conform to standards equivalent to the requirements of the ASME Boiler and Pressure Vessel Code, Sections VIII and IX, or DIN 8560, DIN 8563, EN 287

For welding of less important parts, the standards and qualifications shall conform either to the AWS Standard Qualification Procedure or equivalent standards.

All welders and welding operators assigned to the work shall have passed a performance qualification test. If more than one year has elapsed since the welder or welding operator passed his last test, then he shall again be tested.

Welders' and welding operators' test certificates shall be submitted to the Engineer.

4.12.4 Welding Work

All welding (except welding of thin plates or piping of small sizes) shall be performed by the electric-arc method and where practical, with process controlled automatic machines.

The strength of welding of all equipment subject to high and /or alternating stresses, vibrations etc. shall be at least equal to the strength of the parts being weld-jointed.

Between plates and other sections where such stresses are to be transmitted only butt welds shall be permitted. All main butt welds shall have 100% penetration and where possible, shall be welded from both sides. The backside of the first run shall be suitably gauged out to clear metal before the sealing runs are deposited.

Butt welds on site, which can be welded from one side, only shall be provided with back strips on the whole length of the seam to be welded. The back strips shall be fixed to the downstream side of the upper element, to prevent accumulation of water and dirt.

For any welding work, only the appropriate welding rod, either arc or gas, shall be used. The properties shall conform to the material to be welded as specified in the respective standards.

The electrodes for arc welding shall be classified on the basis of mechanical properties of the as welded deposited weld-metal, type of covering, hydrogen absorption, welding position of the electrodes and type of current.

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Electrodes shall be used only in the positions and under the conditions of intended use in accordance with instructions with each container. Electrodes for manual welding shall preferably be of the heavily coated-type and shall be suitable for welding in any position.

After being deposited, welds shall be cleaned of slag and shall show uniform sections, smoothness of weld metal, feather-edges without overlap, and no porosity and clinker. Visual inspection of the ends of welds shall indicate good fusion with the base metal.

Where weld metal is deposited in successive layers, each layer shall be thoroughly preened before the next layer is applied.

The difference in thickness of adjacent butt-welded plates shall not exceed 3 mm. where plates of greater thickness are to be welded; a transition with a gradient of 1:5 shall be formed.

Welds shall be balanced as far as possible to minimise distortion and residual stress. Box type girders shall be welded in such a way as to be completely airtight.

All welds transverse to the direction of flow and the longitudinal welds of distributors, shut-off valves and manifolds shall be ground flush with the plates on the inside. Welds shall be ground flush on both the inside and the outside wherever dynamic stress occurs.

Particular care shall be taken in aligning and separating the edges of the members to be joined by butt-welding so that complete penetration and fusion at the bottom of the joint will be ensured.

All pinholes, cracks and other defects shall be repaired by chipping or grinding the defects to sound metal and re-welding. Where fillet welds are used, the members shall fit closely and shall be held together during welding.

The ignition of weld electrodes shall not be started at the plate beside the weld, but at the seam flanks to prevent detrimental increments of local hardness. Where ignition points of electrodes are discovered, they shall be ground appropriately.

Where auxiliary structural members are welded to components for the purpose of assembly or installation, these connecting welds shall be given particular care.

These auxiliary structural members shall be removed not by knocking them off, but by burning, followed by grinding the affected areas flush with the plate, without producing additional thermal stresses.

4.12.5 Heat Treatment

The cost of any heat treatment prescribed by the manufacturer of the materials and the Contractor respectively for the welded parts to be supplied shall be included in the Contract Price.

Heat treatment of field erection welding seams shall be performed according to the specifications for the welding procedure for the

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corresponding parts, which shall be submitted to the Engineer for approval.

4.12.6 Quality and Procedure Control

Quality control methods, e.g., radiography, ultrasonic crack detection, etc., shall be done in accordance with the appropriate codes. However, the Contractor shall indicate clearly in the Technical Data Sheets the extent to which these methods shall be used.

All welded joints, which have to be tight, shall be inspected or tested by dye penetration tests.

All major welds carried out on parts under hydraulic pressure shall be subjected to a minimum of 20 % radio-graphic testing and 100% ultrasonic testing. All welds on the skin-plates shall be tested additionally by dye penetration method as decided by the Engineer- in-charge.

The Contractor shall indicate in the corresponding drawings the type of non-destructive testing to be carried out during manufacture and at Site.

The following or other equivalent Standards shall apply:

- For radiographic examination:

  DIN 54109 Non-destructive Testing; Image Quality of Radio-graphs of Metallic Materials

  DIN 54111 Non-destructive Testing; Testing of Welds of Metallic Materials by X- or Gamma Rays; Radiographic Techniques

  DIN EN 287 Quality Assurance of Welded Structures; Fusion-welded Joints Steel; Requirements Classification

  AD-leaflet HP 5/3 Manufacture and Testing of Pressure Vessels

- For ultrasonic examination:

  According to the approved "Test and Examination Instructions" of the Contractor based on AD-leaflet HP 5/3.

  All radiographic films and data shall become the property of the Employer.

Additional non-destructive controls can be required when it is desired to examine the acceptability of any welds when, in the opinion of the Engineer, serious doubt exists as to their quality; in this case, the expense of this examination shall be borne by the Contractor.

When required in the Particular Technical Specifications, the detailed description of welding procedure (including type of welding electrodes, sequence of welding seams, etc.) for certain parts of the delivery shall be submitted to the Engineer before commencement of manufacture.

4.12.7 Defects and Repairs

Plates with laminations discovered after cutting shall be rejected unless the laminated portion is only local and can easily be repaired; such repairs shall require the consent of the Engineer.

Defects in welds will be reported to the Engineer. The Contractor shall use his discretion in determining whether or not it is advantageous to remove and repair the weld. His decision will require approval by the Engineer.

Defects in welds, which are to be repaired, shall be chipped out to sound metal and the areas magnifluxed or ultrasonically tested to ensure that the defective material has been completely removed before repair of welding is carried out. The Engineer shall be informed and given the opportunity of making an examination after the defect has been removed and before repair welding commences. Repairs shall be carried out in accordance with the relevant Standards and to the approval of the Engineer. The Contractor shall be fully responsible for the in-service performance of all welding work.

The Work shall be 100% inspected again by the method used first to determine such faulty work.

4.13 Corrosion Protection

4.13.1 Scope of Work

The Contractor's services shall cover the procurement of all materials, and the preparation and application of the painting and other protective coats as specified; all costs shall be included in the Tender Price.

4.13.2 Painting Materials

The Contractor shall provide a complete, reliable coating system. Coating materials shall be standard products of a paint manufacturer with proven experience in the field of corrosion protection of the type of works to be supplied.

The Contractor shall submit for the Engineer's approval full details of the preparation, type of materials, methods and sequences he proposes to use to comply with the requirements for the protection of the Works.

Paint material shall be delivered in unopened original containers bearing the manufacturer's brand name and colour designation, storage directions and handling instructions. The entire paint material for a particular specified paint system shall be supplied by one manufacturer only; who shall guarantee the compatibility and quality of the paint material. A complete list of the proposed paint material shall be submitted to the Engineer. For multicoated painting systems each coat shall have a different colour.

With regard to materials, the Contractor shall submit full details including the source of the basic raw materials, volatile matter content, nature of solvent, number of components, type of coat, coverage, time interval between coats and number of coats, compatibility of each coat with the previous coat, toxic properties, physical properties, shelf life, resistance against chemical attack, resistance against ozone and UV-radiation, compatibility with drinking water standards, etc.

It shall describe in detail the treatment he proposes to apply in order to give adequate protection during transport, site storage, building and concreting and subsequent erection.

The different coats of primer and subsequent coats shall be each of different shades of colour where practicable.

The Contractor shall submit to the Engineer-in-charge for approval an overall colour scheme in accordance with the Technical Specifications, for the finished surfaces of all Works. All final coats shall be in the colours approved by the Engineer. On request of the Engineer, painting samples for the different coats and colours shall be provided.

All pigment, paints and primers shall be delivered to Site in sealed containers packed by the manufacturer. The manufacturer's instructions for preparation and application of all painting and protective coats shall be strictly observed.

Paint materials shall be stored and mixed by the Contractor in strict accordance with the manufacturer's instructions. Paint material shall be used before the expiration of the shelf life. All safety regulations shall be observed, especially with regard to fire.

4.13.3 Painting Systems

Annex 1 "Painting system", indicates painting materials considered suitable for the various parts of the Works.

4.13.4 Workmanship

4.13.4.1 Contractor's Equipment

The Contractor shall observe all safety and health precautions to protect his workers and others. The necessary equipment, such as fans, air-conditioning units, safety masks, nets, safety belts etc. shall be provided by the Contractor. All equipment shall be in strict accordance with the respective safety codes and regulations assuring efficient work of high quality.

The Contractor shall be responsible for the collection and disposal of empty containers, dirty rags and other wastes. It shall also be the Contractor's entire responsibility to protect equipment and structures not being painted such as nameplates, instruments, panels, floors, walls, etc. and he shall provide and install all necessary drop cloths and screens.

4.13.4.2 Preparation of Paint Material

Paint shall be delivered ready mixed wherever possible. Adding of diluting agents and mixing of two or multi-component systems shall be done in the field in accordance with the directions of the manufacturer. Mixing and homogenising of the paint material shall be done by a mechanically driven paddle or agitator in the original container. After mixing, the paint shall be poured into a clean container to ensure that no settled pigments are at the bottom.

The Contractor's equipment shall be of perfect quality and servicing and maintenance must be guaranteed. Cleaning of equipment shall be consistently carried out at each working interval.

4.13.4.3 Application

The most commonly used methods of application are painting by brush, roller, pressure and airless spraying equipment. Selection of the application method depends on the surface to be painted. The quality of the paint shall in no way be negatively influenced. The manufacturer's directions shall govern the choice of application method. Inaccessible surfaces shall be painted prior to erection with prime and finish coats according the specification. Areas inaccessible to spraying equipment shall be painted by brush. Corners and edges shall be pre-coated. Bolts, screws, studs, rivets etc. shall be painted as a whole with the complete paint system after erection.

The primer shall be applied to an absolutely clean and dry surface only. Temperature and dry-out time shall be in accordance with the manufacturer's directions. Whenever possible the prime coat as well as one intermediate coat shall be applied in-doors at the Contractor's shop.

During painting the air temperature shall be at least +5°C and the temperature of the items being painted must be at least 3°C above the dew point. During drying of the paint, the temperature shall not be below 0°C. For all paints the surface temperature of the metal shall not be higher than +50°C during the painting. Concerning special paints, the requirements set by the paint manufacturer shall be followed.

Cleaning and painting work outdoors and in non-conditioned rooms shall be stopped under the following conditions: rain, fog, dew, polluting winds, sand and other dusts. The object to be painted shall be removed to safe places or indoor suitably protected with cover etc. Surface preparation and application of the first paint layer are parallel operations to be carried out within a maximum delay of 4 hours.

All painting shall be free of cracks and blisters and all runs shall be brushed out immediately. After application of the last coat the paint system shall be free of pores. After erection of the equipment all damages to painted surfaces shall be repaired. Welds, rusty spots, slag, beads, flux deposits etc. shall be repaired and repainted. For touching up, the same materials shall be used as for the main painting

work. Repaired finish coats shall be of the same appearance as the original coating.

Electrical plates, surface hardware, fittings and fastenings shall be removed before starting painting operations and shall be stored, cleaned, and reinstalled after completion of work.

Equipment requiring special knowledge, skills and tools shall be prepared to receive field coating and painting to meet requirements of the painting schedule.

Parts, which are embedded in concrete, need not be protected against corrosion. However, transition zones of large steel pipes and of steel linings shall be painted over a length of 1 m within the concrete, all other concreted in steel surfaces over a length of 200 mm within the concrete.

In linings surrounded by concrete, surface preparation and painting works shall be carried out after all Works such as concreting, welding, grouting and cleaning have been completed. The Contractor shall take into account the local climatic conditions and use adequate installations for sandblasting, dust control and sand extraction.

A properly equipped paint shop shall be set up at the Site with a crew of specialists experienced and skilled in the preparation and application of protective coatings, to deal with all site-protective treatment.

4.13.5 Surface Preparation

The term "preparation" as used below includes any cleaning, smoothing or similar operations that shall be required to ensure that the material to be painted attains a suitable condition.

To be ready for painting, a surface should be clean, dry and sound. The surface to be coated shall be free from any deleterious material liable to impair good paint adhesion or attack the coat.

For removing rust and mill scale on structural steel, piping and other steel surfaces, those parts suitable for sandblasting shall be sandblasted to a grade specified or required in accordance with SIS 05.59.00 (Sveriges Standardise rings Kommission) or the American Standard SSPC-SP. This applies particularly to parts, which will be in contact with water, exposed to heavy condensation and humidity or subjected to high temperature.

For health reasons, sandblasting with quartz sand shall be avoided.

Sand blasting shall be such as to obtain a smooth surface free of foreign matters with a roughness of min. 0.04 mm. Corundum or an equivalent mineral shall be used and the grain size of the blasting medium shall not exceed 1.2 mm.

All parts of the Works shall be sandblasted at the shop unless otherwise specified or approved by the Engineer. The sandblasted surfaces shall receive a shop coat with a quick-drying highly pigmented 2-pack zinc-rich primer, unless otherwise specified.

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Parts, which cannot be sandblasted, shall be cleaned of rust by power tool cleaning to the highest degree possible.

Hand or power tool cleaned parts of minor importance and not exposed to water or humidity may be coated with a quick-drying rustproof primer formulated on a combination of synthetic resins (ready-mixed paint).

4.13.6 Quality Control

The minimum dry-film thickness prescribed in these Specifications shall be observed. Of each 100 m^2, one area of 10 m^2 will be measured for dry-film thickness. No measured thickness shall be less than the specified thickness. Where the minimum thickness is not achieved, the coat shall be repaired to reach the specified minimum dry-film thickness.

The dry-film thickness shall be measured by approved gauges; the cost of two new electronic gauges shall be included in the Tender for use of the Engineer in charge.

For checks on porosity, the Contractor shall furnish a D.C. variable high-tension test instrument with built-in pore counter. The test voltage shall not exceed 2000 V. The tests shall not be performed within 0.5 m distance from uncovered, corrosion resistance surfaces.

The instruments purchased for quality control shall be handed over to the Employer after commissioning of the Project without any payment to the Contractor.

Upon completion of each coat, the painter shall make a detailed inspection of the painting finish and shall remove from adjoining work all spattering of paint material. He shall make good all damage that can be caused by such cleaning operations.

A detailed inspection of all painting work shall likewise be made, and all abraded, stained, or otherwise disfigured portions shall be touched up satisfactorily or refinished as required to produce a first-class job throughout and to leave the entire work in a clean and acceptable condition.

4.13.7 Guarantee

The guarantee period for all painting shall be 24 months, starting from the issue of the "Taking-Over Certificate". This painting guarantee period shall be effective regardless of any other guarantee periods for the project or parts of the project issued prior to the elapse of the painting guarantee period.

At the end of the painting guarantee period the anti-corrosive protection of the painted or galvanised surfaces shall not have a degree of rusting higher than RE 1 (one) on the European scale of degree of rusting for anti-corrosive paints, (the corrosion committee of the Royal Swedish Academy of Engineering Sciences, Stockholm).

4.13.8 Priming

4.13.8.1 Surface Preparation

Blast cleaning can be undertaken with only when the following time and relative humidity schedule for application of the first coat can be achieved and maintained:

RELATIVE HUMIDITY	Time
85% or above	Do Not Blast
80-84	2 Hours
70-79	4 Hours
60-69	10 Hours
50-59	12 Hours
30-49	24 Hours
Under 30%	1 Week

4.13.8.2 Primer

The primer serves, in the first place, as protection against corrosion. In addition, adherence between base, primer and finish paint is achieved. Primers have only a limited weather resistance. The specified dry film thickness shall be applied to all surfaces of the equipment as required. After the aforesaid has been done, the equipment or parts thereof may be stored in the open air for a limited time only until the finish coat is applied. Only 2-component epoxy resin zinc rich primer shall be used for priming on sandblasted surfaces.

4.13.8.3 Galvanizing

Unless otherwise specified, all structural steel including ladders, platforms, hand rails and the like and all exterior and interior steel surfaces of outdoor Works, as well as bolts and nuts associated with galvanised parts shall be hot-dip galvanised, electrolytic galvanised or serialised, as may be appropriate to the particular case.

Galvanising shall be performed in accordance with VDE Standard 0210 (Verband Deutscher Elektrotechniker) or IS 4795:1996.

Material:

For galvanising, only original blast furnace raw zinc shall be applied, which shall have a purity of 98.5%.

The thickness of the zinc coat shall be:

- For bolts and nuts, approx. 60 micrometer
- For all other parts, except for hydraulic steel structures or parts intermittently or permanently submerged in water, approx. 70 micrometer

- For hydraulic steel structures or parts intermittently or permanently submerged in water, approx. 140 micrometer, in accordance with "VDEW, Druckrohrleitungen -Association of German Electricity Utility Companies, Steel Penstocks".

Cleaning:

All material to be galvanised shall be cleaned carefully of rust, loose scale, dirt, oil, grease, and other foreign matters. Particular care shall be taken to clean slag from welded areas.

Galvanising of plates and shapes:

Where pieces are of such lengths that they cannot be dipped in one operation, great care shall be exercised to prevent warping.

Finished compression members of steel structures shall not have lateral variations greater than one-thousandth of the axial length between the points, which are to be supported laterally. Finished tension members shall not have lateral variations exceeding 3 mm for each 1.50 m of length. Materials with sharp kinks or bends shall be rejected. All holes in material shall be free of excess spelter after galvanising.

Galvanising of hardware:

Bolts, nuts, washers, locknuts and similar hardware shall be galvanised in accordance with the relevant standards. Excess spelter shall be removed by centrifugal spinning.

Straightening after galvanising:

All plates and shapes, which have been warped by the galvanising process, shall be straightened by being re-rolled or pressed. The material shall not be hammered or otherwise straightened in a manner that will injure the protective coating. Materials that have been harmfully bent or warped in the process of fabrication or galvanising shall be rejected.

Repair of galvanising:

Material on which galvanising has been damaged shall be re-dipped unless the damage is local and can be repaired by soldering or by applying a galvanising repair compound; in this case, the compound shall be applied in accordance with the manufacturer's instructions.

Soldering shall be done with a soldering iron using 50/50% solder (tin and lead). Surplus flux or acid shall be washed off promptly and the work shall be performed so as not to damage the adjacent coating or the metal itself. Any member on which the galvanised coating becomes damaged after having been dipped twice shall be rejected.

4.13.8.4 Items which are not to be painted

These items shall be given a protective coating of e.g. Tectyl 506 or another adequate material before leaving the Contractor's workshop. This protective coating shall be removed and the surface cleaned before erection.

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4.13.9 Painting

4.13.9.1 Surface Preparation (Primed, Galvanised or Stainless Steel Surfaces)

All surfaces to be painted shall be thoroughly cleaned by suitable means before application of paint. After cleaning the surfaces shall be rinsed in a manner that no residues will remain.

Primed surfaces contaminated with oil or grease shall be de-greased in a manner not affecting the quality of the primer. 2-component coatings older than six (6) months shall be roughened prior to the application of the next coat.

Hot-dip galvanised surfaces, which are to be painted, shall be lightly sandblasted prior to through cleaning.

4.13.9.2 Finishing Coats

Whenever specific colouring is required or where priming is not sufficient for protection against corrosion a finishing coat shall be applied. If not otherwise specified, finishing coats shall be applied to primed surfaces. The primed surface shall be prepared as specified above. Selection of finishing coats with regard to quality and quantity shall be governed by the ambient conditions and its effect on the painted surface.

The Engineer-in-charge will select the type and shade of colouring in accordance with a standard colour code (e.g. VSLF, RAL, Munsell etc.). For this purpose the Contractor shall submit colour cards or colour samples. On request of the Engineer colour samples shall be applied to selected surfaces to be painted.

4.13.9.3 Painting Systems

The specified painting systems including surface preparation and the permissible application methods are listed on the enclosed charts (Painting Systems) Annex 1.

4.13.9.4 Cutting and Welding of Painted Structures

All painted structures to be cut by torch or blade for fitting and welding purposes and all field-welds shall be prepared.

Reason for this preparation work is the development of aggressive residue when the paint is burned. This residue cannot be removed and thus a proper surface preparation is not warranted.

Repair of the damaged surface protection shall be executed according to "Repair of Primer and Finish Coats" described below.

4.13.9.5 Repair of Primer and Finish Coats

General

For touching up, the same paint shall be used as for the original painting work. Repaired finish coats shall be of identical appearance with the original and no difference in the colour shall occur.

Galvanised and Painted Structures

Repairs on galvanised and painted structures shall be carried out as follows:

- Damages to painting and galvanisation:

Surface Preparation: Scraping, wire brushing or grinding to Grade ST 3 according to SIS 055 900-1967.

Repair of Coatings: One coat of 2-component epoxy resin zinc-chromate primer. Dry film thickness minimum 0.050 mm.

Two coats of 2-component epoxy-resin micaceous iron oxide (mio) paint. Total film thickness min. 0.160 mm.

The colour of the paint shall be the same as originally applied.

- Damage to Painting only:

Surface Preparation: Thorough cleaning of the damaged surface i.e. removal of oil, grease, dust, etc.

Repair of Coatings: Two coats of 2-component epoxy-resin micaceous iron oxide (mio) paint. Total film thickness min. 0.160 mm. The colour of the paint shall be the same as originally applied.

Painted Structures

Repairs on painted structures shall be carried out as follows:

Surface Preparation: Scraping, wire brushing or grinding to Grade ST 3 according to SIS 055 900-1967.

Prime Coat: One coat of 2-component epoxy resin zinc-chromate primer. Dry film thickness minimum 0.050 mm.

Intermediate and finish Coats: Type, number of coats and dry film thickness, shall correspond to the specified "Painting System" in Annexure- 1

4.14 METAL WORK

4.14.1 Embedded Metal Work

Unless otherwise specified, any foundations, wall & roof openings & coverings, concrete floor filling, sleeves in foundations & walls & trenches with floor plates for cables, will be provided by the contractor.

The contractor shall supply & install all anchors, fasteners, embedded metal work, piping, & sleeves associated with & required for the equipment to be installed under this contract, except if otherwise mentioned in the specifications.

As far as practicable, the supports shall be of good design throughout and preferably of an approved type.

Attachments to concrete shall wherever practicable be by means of embedded inserts of an approved proprietary type.

The Contractor will be responsible for the determination and details of all loads and forces exerted by his equipment and transferred to the foundation.

The Contractor shall show the location and full details of all embedded components on his drawings and shall be responsible for the completeness and accuracy of his drawings and the information supplied to others.

Any steel work which is to be built into the concrete foundations shall not be painted or coated unless otherwise approved or specified.

4.14.2 Miscellaneous Metalwork

Except where otherwise indicated elsewhere in the Particular Technical Specifications, the Contractor shall supply the following:

- All platforms, ladders, guards and handrails necessary for easy and safe access to Works, shall be supplied under the Contract. Handrails shall be of tubular steel construction except that the top rail shall be of flat bar, fitted with a formed plastic covering.

The use of ladders shall be kept to a practicable minimum. Where ladders are approved for use they shall be of steel, have an inclination of 70° to the horizontal and a minimum width of 450 mm.

- Safety guards at each point where normal access provision would permit personnel to come within reach of any moving equipment to be provided under the Contract.

All covers for pipe and cable trenches, required for completing the floors around and over Works supplied under the Contract will be supplied and installed. Unless otherwise approved, floor plates shall be of an angular pattern.

Covers and curbing for dismantling hatches in main floors will be provided by the contractor of civil works.

5. MECHANICAL WORKS AND STEEL STRUCTURES

5.1 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 Technical Specification.

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

The design and arrangement of Works and installations shall facilitate erection, testing, operation and maintenance with utmost ease.

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

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

Unless otherwise stipulated in other sections, all materials subjects to hydraulic pressure shall have an impact strength (Charpy V-notch) of not less than 35 J/cm^2 (at 0°C) whereby this figure shall be the minimum of each of 3 specimens. For steel plates this figure shall be understood for the transverse direction.

Where ever IEC specifications are mentioned in the tender specifications, equivalent Indian standards (IS) shall also be applicable/ may also be acceptable.

5.2 BOLTS, SCREWS, NUTS, ETC.

All bolts, studs, screws, nuts, and washers shall be to the ISO metric system except other standards will be considered for specific applications. 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 in charge. 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 un-tightening by commercially available pneumatic impact wrenches shall be drilled for heaters or 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.

5.3 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 temperature changes. The degree of hardness according to Shore shall be 50-55 for sill sealing and 60-80 for lateral sealing. In case the Contractor intends to supply synthetic rubber material, with or without fluro-carbon cladding, he shall furnish the name of the manufacturer and technical data of the material for the Engineer-in-charge approval.

Rubber Seals

Seals shall be designed and mounted in such a manner that they are adjustable, water tight 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, and 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. Joints shall be watertight and seal materials shall have following physical properties as determined by tests made in accordance with the relevant Standards.

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

5.4 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 in charge, 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 bearing supports shall be machined, and shall rest on machined-surfaces.

5.5 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 recognised 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

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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 filling of oil or grease 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.

5.6 PIPING, FITTINGS, VALVES, GATES AND HEAT EXCHANGERS

5.6.1 General

Unless otherwise stated, all piping shall be designed for a "nominal pressure". All piping shall be tested at 1.5 times the design/nominal pressure. All required piping shall be furnished complete with flanges, joints, expansion joints, gaskets, packing, valves, drains, vents, pipe suspensions, supports, etc.

Steel structures, walkways, platforms, stairs and ladders shall be provided to cross pipes with diameters of 600 mm and larger.

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

Flanged connections or joints shall be provided only as required for transport, installation or for reasons of dismantling for repair.

Metric (DIN)-flanges shall be used throughout. 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.

5.6.2 Piping, Fittings

Steel pipes of a diameter <100 mm shall be of carbon Steel. Steel pipes larger than 100 mm in diameter shall be made of galvanised carbon steel. Pipe connections embedded in concrete shall be welded. Other pipe connections shall be flanged. The flange material shall be in conformance with the pipe material. The Contractor shall select the location of the weldments as to ensure sufficient access for adequate touch-up treatment for corrosion protection.

Ductile iron pipes shall conform to ISO R 2531; class K9, fittings to class K12. Unless waived by the Engineer-in-charge, D.I. pipes and fittings shall be mortar lined to AWWA C 104, double thickness.

Stress calculations of steel pipes shall be in accordance with DIN 2413, "Steel Pipes under Internal Pressure" or with "AD-Merkblätter; German Association of Manufacturers of Pressure Vessels, Memos" or ASME equivalent. In no case, the superimposed stress of bending, tension, compression, etc., calculated to the shape variation hypothesis, shall exceed 0.7 of the yield point at maximum applied load at any point of the piping.

The maximum applied load shall take into account test pressure, water hammer pressure waves, thermal forces, dead weight, etc. On request of the Engineer-in-charge, a calculation on pipe stresses has to be submitted by the Contractor at no extra cost. The requested calculation will be subject to approval of the Engineer-in-charge.

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

Bends shall preferably be of the forged type. Mitered bends shall be allowed for larger sizes subject to the Engineer's approval. For smaller fittings ductile iron will be permitted, too.

5.6.3 Valves, Gates

Small valves and gates shall conform to DIN 3230, "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 higher than PN 10 and diameters larger than DN 100 shall be workshop-tested to DIN 3230 for tightness and soundness of materials.

The change of the disc 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 energised.

To facilitate operation, large valves and gates shall be provided with by-pass 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, nuts and bushes of bronze, and the body of Cast Steel.

All pressure reduction valves; safety valves and similar components shall be workshop-tested and provided with a work certificate 2.3 to DIN 50049.

5.6.4 Oil Piping

Piping of a diameter < 50 mm shall be of non-corrosive material. Pipes larger than 50 mm in diameter shall be seamless .Oil pipes shall be as far as possible be prefabricated in the manufacturer's works. They shall be welded except at terminal points and as necessary for erection and future dismantling. The Contractor shall select the location of the weldments so as to ensure sufficient access for adequate touch-up treatment for corrosion protection. Pipe connections larger than 50 mm in diameter shall be provided with steel-flanged connections.

All piping shall be hydrostatically tested at a pressure 100 % greater than the maximum working pressure. The entire pipe arrangement shall be subjected to the pressure test after complete assembly at the site.

Oil pipes shall not be embedded in concrete. Oil pipes crossing civil structures shall be routed through sleeves embedded in the concrete.

All oil piping shall be acid-treated to guarantee clean surfaces, completely free from welding residues.

This treatment shall be applied to workshop and site manufactured piping respectively.

The piping can either be treated in an acid-bath or be completely filled with acid. The duration of the treatment shall be approx. 6 hours. After that the piping shall be neutralised, flushed and corrosion protected for final installation.

5.6.5 Pipe Supports and Hangers

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

All brackets, stays, frames, hangers and supports for carrying and staying the pipes, including their fasteners shall be included in the supply and completed by the Contractor at the Site. Pipes and fittings

shall be supported at or near flanges wherever feasible from the view point of handling.

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-in-charge.

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

5.6.6 Heat Exchangers

Unless otherwise stated, all the heat exchangers shall be designed for a nominal pressure PN 10. 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 — 1mm or more
- Frame/body — Mild/cast steel

5.7 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., glycerin, to compensate vibrations. Pressure gauges without damping means are not permitted, unless approved by the Engineer-in-charge.

5.8 PRESSURE OIL SYSTEMS

Pressure tanks shall be designed, fabricated 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 Systems" 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.

5.9 COMPRESSED AIR SYSTEMS

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-in-charge.

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 number as required or specified.
- 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

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- 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 time delayed after start to avoid compressor start against full pressure.

The compressors shall be delivered as package units on common frame 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 x maximum working pressure for 8 hours in the manufacturer's workshop before coating is applied.

If requested by the Engineer-in-charge, each compressor shall pass a performance test in the manufacturer's workshop to a standard mutually agreed upon, e.g., DIN 1945, VDMA 4362, 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 underwriters' society.

5.10 PUMPS

Non- submersible pumps & motors

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

Materials of the pumps shall be:

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

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:

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- 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

Submersible pumps & motors

For submersible pumps, pump and motor shall be contained in the same casing and designed as a package unit with incorporated suction strainer and check-valve.

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 operating in potable water shall not be filled with oil or other media detrimental to potable water. Motors of submersible pumps operating in dirty water may be filled with oil.

Dirty water submersible sump pumps with the motors mounted on top of the pump shall be suitable for running dry continuously, without 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%.

If requested by the Engineer-in-charge for pumps of a capacity higher than 30 kW, one in three pumps shall pass a performance test to DIN 1944, class II, with measurements taken at 0%, 50%, 80%, 100%, and 120% of specified discharge at rated speed. The results have to be certified in a workshop certificate 2.3 to DIN 50049. For pumps of a capacity higher than 100 kW, the shop tests shall be compulsory; test certificate 3.1 B in accordance with DIN 50049.

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

5.11 LIFTING EQUIPMENT

5.11.1 Design and Calculation Standards

Generally, for design, stress calculation, manufacture and installation, the following standards and codes, besides other relevant standards and regulations, shall be applicable:

- DIN 4'100 Welded Steel Structures
- DIN 4'114 Steel Structures: Stability (pp. 1 and 2)
- DIN 15'018 Cranes, Steel Structures, Calculation and Design

- DIN 15'020 Rope Drives Safety devices for the operating personnel
- CMAA Crane Manufacturer's Association of America

Safety devices for the operating personnel shall be provided wherever it is deemed necessary.

The safety rules outlined in VBG 8 of the German "Verband der Berufsgenossenschaft" or similar internationally recognised codes shall be observed.

Unless otherwise specified, the lifting equipment shall be classified to DIN 15020 as follows:

- For lifting capacity up to 100 kN (10 tonnes) "class 2 m", representing an average daily working time of 2 to 4 hours and an equal share of small, medium, and heavy loads (normal duty);
- For lifting capacity above 100 kN (10 tonnes) "class 1 Am", representing an average daily working time of 2 to 4 hours and a small share of heavy load lifts (light duty).

The Contractor shall state the various load combinations and factors of safety taken as a basis for calculation of the different components of the crane. In addition, the various factors of safety for the different load combinations shall be stated.

Each lifting equipment such as cranes or elevators shall be subject to a test operation with an overload = 1.25 x nominal load.

The crane girders and rails shall be calculated for a deflection not exceeding 1/1000 of the span at maximum nominal load.

Steel structures of lifting equipment shall be of welded construction, which can be assembled at Site. All field connections and joints shall be bolted.

For maintenance and inspection, appropriate ladders, platforms and steps shall be provided, fitted with anti-slip chequered plates, tabular handrails and skirting. Walkways, stairs and platforms for lifting equipment shall generally be designed for a service load of 3000 N/m^2.

For hand operation a handle shall be provided to allow operation under the disconnecting condition from electrical system and the operation force on the handle shall be less than 100 N per man, at the handle diameter of 600 mm which shall be located within 600 to 800 mm in height from the base.

5.11.2 Material Standards

The material to be used for manufacturing lifting equipment (steel structures) shall conform to DIN EN 10'025 or to the equivalent ASTM standards. However, the Contractor shall restrict the structural steel to FE 360 B and FE 510 C or ASTM A 36; the latter may be regarded as

equivalent to FE 430 C. For these structural steels, connecting bolts and welds, the allowable stresses given in DIN 15'018 shall apply.

If the Contractor intends to supply material other than that mentioned above, he can do so, provided their equivalence to the specified material standards is verified by the Contractor and approved by the Engineer in charge.

The stresses between the track rails, their fixing elements and the concrete shall not exceed the following values:

Mean allowable compressive stresses	6	MPa
Allowable compressive stresses on edges	10	MPa
Allowable bond stresses	0.6	MPa

The stresses induced by maximum torque shall not exceed 80% of the material yield point.

5.11.3 General Design Particulars

Nameplates stating the nominal capacity in tonnes 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 DIN 15'020 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 Brinnel hardness number of 400, 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 central lubrication systems. 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

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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.

5.12 STEEL STRUCTURES

Generally, design and stress calculation shall conform to:

- DIN 1'050 Steel Structures, Construction
- DIN 4'100 Welded Steel Structures, Calculation and Design
- DIN 4'114 Stress Calculation of Steel Structures
- DIN 18'800 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 DIN 18'800.

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.

Load assumptions for ordinary platforms shall be:

- For platforms used by personnel and for support of light equipment with single weights of less than 1000 N and 5000 N/m2
- For all other platforms 5000 N/m^2

Unless otherwise specified or stipulated in the applicable standards.

Platforms and stairs shall be provided with anti-slip chequered plates.

The materials used for general steel structures shall conform to mild steel FE 360 B and FE 510 C or ASTM A 36.

6. ELECTRICAL WORKS

6.1 GENERAL

The electrical items of Works of any electrical or mechanical installation to be provided under this Contract according to the Particular Technical Specifications shall - if not stated otherwise therein-fulfil the requirements of this Section.

All components shall be of an approved and reliable design. The highest extent of uniformity and interchangeability shall be reached. The design shall facilitate maintenance and repair of the components with ease and speed.

The Works shall be pre-assembled to the highest possible extent in the Contractor or Sub-Contractor's works, complete with all devices and wired up to common terminal blocks.

The power supply and control cables shall be laid up to these common terminal blocks. The required control and protection devices, instruments, etc., within the different scopes of work shall be supplied and connected by the relevant Contractor.

Unless otherwise agreed, ratings of main electrical Works (in feeds, bus-ties) as selected or proposed by the Contractor, whether originally specified or not, shall generally include a safety margin of 10% under consideration of the worst case to be met in service. Prior to approval of such basic characteristics, the Contractor shall submit all relevant information such as consumer lists, short circuit calculations, de-rating factors, etc.

Short-circuit calculations shall be evaluated giving full evidence that every electrical component can withstand the maximum stresses under fault conditions, for fault levels and durations obtained under the worst conditions, e.g., upon failure of the corresponding main protection device and time delayed fault clearing by the back-up protection device.

All Works shall be suitable for the prevailing climatic conditions.

Outdoor installations needing protections shall be protected against solar radiation by means of adequate covers, where required.

The Contractor shall ensure that all the equipments and devices are insensitive to any signals emitted by wireless communication equipment.

6.2 STANDARDS

The design, manufacture and testing of all Works and installations shall strictly comply with the latest edition of the relevant IEC standards or any other international standards.

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6.3 COLOUR CODE

In general, the colour code for electrical Works shall be as described in the Particular Technical Specifications.

The manufacturer's painting systems shall be used to the maximum possible extent, but shall by all means be subject to the approval of the Engineer. Final coats of paint shall be matching adjacent installations, where required.

6.4 ELECTRIC MOTORS

6.4.1 General

All motors shall be of approved manufacture and shall comply with the requirements of this Chapter. Motors of the same type and size shall be fully interchangeable and shall comply - as far as applicable - to IEC standard motor dimensions.

The general construction shall be stiff and rigid; no light metal alloy casings will be accepted. All precautions shall be taken to avoid any type of corrosion.

All motors shall be fitted with approved types of lifting hooks or eyebolts as suitable.

AC motors shall have squirrel cage type rotors.

Motor Voltages and Power Ratings

The service voltages and corresponding power ratings for electric motors to be used in the Project shall be as follows:

- Motors up to 100 kW
- Service voltage : 3-phase a.c. 415/240 V,50 HZ
- Mode of starting : direct-on-line up to 50 kW

Above 50 kW with suitable starters

- Motors up to 0.75 kW
- Service voltage : single-phase a.c. 240 V, 50 HZ
- Mode of starting : condenser
- Motors intended to work on the d.c. System
- Service voltage : 220 V D.C.
- Mode of starting : resistor

6.4.2 Rating

The rating of the motors shall be adequate to meet the requirements of its associated equipment. The service factor, being the ratio of the installed motor output to the required power at the shaft of the driven machine at its expected maximum power demand, shall be applied as follows:

Power Demand of Driven Machine	Service Factor
Up to 5 kW	1.2
More than 5 kW	1.1

A.C. motors shall be capable of operating continuously under rated output conditions at any frequency between 95% and 105% of the rated frequency and/or with any voltage variation between 90% and 110% of the nominal voltage. A transient over voltage of 130% of the nominal voltage shall as well be sustained.

Further, the motors shall be capable of maintaining stable operation when running at 70% nominal voltage for a period of 10 seconds. The pullout torque for continuously loaded motors shall be at least 160% of the rated torque and for intermittently loaded motors 200% of the rated torque.

D.C. motors shall be capable of operating continuously under rated output conditions at any voltage between 90% and 110% of the nominal voltage with a fixed brush setting for all loads. Unless otherwise approved, the speed drop between no-load and full-load shall not exceed 10% of no-load speed.

6.4.3 Starting

A.C. motors shall be designed for direct on-line starting. They shall be capable of being switched on without damage to an infinite bus bar at 110% of the nominal voltage with an inherent residual voltage of 100% even in phase opposition. For starting the motors from the individual main and auxiliary bus bars, a momentary voltage drop of 20% referred to nominal voltage should be taken into consideration. With 85% of the nominal voltage applied to the motor terminals, each motor shall be capable of accelerating its associated load to full speed with a minimum accelerating torque of 5% of full load torque.

The maximum starting currents (without any tolerance) shall not exceed the following values: -

- 5 times of rated current for low voltage motors rated 100 kW or above
- 2 times of rated current for D.C. motors (by means of starting resistors)

Generally, all motors shall be able to withstand three cold starts per hour, equally spaced. In addition, each medium voltage motor shall be capable of enduring two successive starts with the motor initially at operating temperature. Each low voltage motor shall be capable of withstanding three successive starts under the same conditions or once every twenty minutes without detrimental heating.

Motors for frequent automatic starting shall have an adequate rating. In the motor list the Contractor shall state the frequency of starts permitted in compliance with the motor design.

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6.4.4 Windings and Insulation Class

The insulation of all motors shall be of class F but will not exceed the temperature limits of class B materials in operation. It shall be suitable for operation in damp locations, for occasional contact with corrosive gases and vapours and for considerable fluctuations in temperature.

The stator winding shall be suitably braced to withstand the forces due to direct-on-line starting and transfer conditions as mentioned before. The winding envelopment and tails shall be non-hygroscopic. The stator winding shall withstand the maximum fault current for the period determined by the associated protective devices.

The rotor winding (if applicable) shall be designed to give trouble-free continuous service including repeated direct-on-line starting. The rotor shall be subjected to a 120% over speed test for 2 minutes without showing any winding dislocation.

6.4.5 Ventilation and Type of Enclosure

All motors shall be of the totally enclosed fan-cooled type, protection class IP 54 according to IEC Recommendation 144. Cable termination points shall be of class IP55.

They shall have a closed internal cooling air circuit re-cooled by an external cooling air circuit drawn from the opposite side of the driving end.

Where motors are installed outdoors, a weatherproof design shall be chosen. L.V. motors of IEC size 132 and above shall be equipped with automatically controlled heating elements for protection against internal condensation of moisture during standstill periods. Such A.C. heater shall be suitably fixed inside the motor casing; the leads shall be led to a separate L.V. terminal box.

Motors installed outdoors and directly subjected to solar radiation shall be rated such as not to exceed a maximum metal temperature of 85°C. Where necessary, such motors shall be provided with sun shields.

Vertical motors shall be provided with a top cover to prevent the ingress of dirt, etc.

6.4.6 Bearings

As far as possible, the motors shall have sealed ball or roller bearings. All motors with ratings of about 1 kW and above shall be equipped with lubricators permitting greasing while the motor is running and for preventing over-lubrication. Additionally, the bearings shall be fitted with grease nipples permitting the use of a universal grease gun.

Vertical motors shall have approved thrust bearings.

Where sleeve bearings are being used, they shall be of the self or forced lubricating type. If forced lubrication is required, it shall be arranged common to both the motor and the driven machine and provisions shall be made to ensure lubrication during start-up and

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shutdown operations without the necessity to start an auxiliary lube oil pump. Self-lubricated bearings shall be equipped with an easily accessible oil reservoir with overflow pipe and oil collecting vessel.

All bearings shall be easily controllable during operation or standstill without dismantling the bearings. The bearings shall further be protected and sealed against dust penetration and oil leakage.

In case of independent bearings, motor and bearing pedestals shall be fitted on a common base plate.

For the transport of motors equipped with ball or roller bearings, special bearing inserts shall be provided to prevent transport damage.

6.4.7 Shafts and Couplings

The motors shall be provided with a free shaft extension of cylindrical shape with key and keyway according to IEC Recommendation 72-1 and with the motor side coupling, which shall be pressed on the motor shaft and be balanced together with it. A coupling guard shall be provided.

6.4.8 Brush gear and Commutators

Brush gear for D.C. motors shall be designed to ensure constant brush pressure. Carbon brushes shall be provided which stand at least 6 months of operation without replacement. Each brush shall be independently adjustable but should not require adjustment throughout its life. A design of brush gear which permits the brush holder to touch the commutator as the brushes wear or which passes current through the pressure fingers will not be accepted.

A sufficient number of brushes, not less than two per pole, shall be fitted to ensure that vibrations do not affect the commutation.

The minimum safe wearing margin of commutators shall not be less than 20 (twenty) per cent of the total thickness of the commutator bars and the minimum safe diameter shall be clearly marked on it.

6.4.9 Terminal Boxes and Earthing

The terminal leads, terminals, terminal boxes and associated equipment shall be suitable for terminating the respective type of cables as specified in these General Technical Specifications and in the Particular Technical Specifications.

The terminal boxes shall be of ample size to enable connections to be made in a satisfactory manner. Supports shall be provided at terminal boxes as required for proper guidance and fixing of the incoming cable.

The terminal boxes with the cables installed shall be suitable for connection to supply systems with the short-circuit current and the fault clearance time determined by the motor protective devices.

A permanently attached connection diagram shall be mounted inside the terminal box cover. If motors are provided for only one direction of rotation, this shall be clearly indicated.

Terminal boxes shall be totally enclosed and designed to prevent the ingress of moisture and dust. All joints shall be flanged with gaskets of neoprene or similar material. For motors above 1 kW, the terminal box shall be sealed from the internal air circuit of the motor.

Depending on the size, the terminal box of L.V. motors shall be fitted either with an approved cable sealing-end or with a gland plate drilled as required and provided with suitable fittings for cable fixing and sealing. Such openings shall be temporarily plugged or sealed during transportation.

For earthing purposes, each motor shall have adequately sized bolts with washers at the lower part of the frame. In addition, each terminal box shall contain one earthing screw. Each equipment/panel shall be earthed by at least two separate earthing strips.

The cable termination philosophy to be adopted shall be such that extensive grouping of signals by a large scale use of field-mounted group. Junction boxes at strategic locations (where large concentration of signals are available, e.g. switchgear) is done. Termination / Junction boxes shall have either maxi- terminal or cage clamp type terminals

6.4.10 Noise-Level and Vibrations

Under all operating conditions, the noise level of motors shall not exceed 85 dB (A).

In order to prevent undue and harmful vibrations, all motors shall be statically and dynamically balanced.

Vibration displacements or velocity shall be measured in accordance with DIN 45 665 for IEC motor sizes 80 to 315. The results for all motors shall be within the "R" (reduced) limits.

6.4.11 Tests

Each motor shall be factory tested and shall undergo a test at site. The following tests shall be performed under full responsibility of the Contractor.

- Workshop Tests:
- Measurement of winding resistances
- No-load and short-circuit measurements
- Measurement of starting current and torque
- Efficiency measurement (type test)
- Heat test run
- Dielectric test
- Measurement of insulating resistance

- Over speed test
- Site Tests:
- Measurement of insulation resistance
- Measurement of motor vibrations
- Measurement of starting time.

6.5 M.V. AND L.V. SWITCHGEAR, CUBICLES AND PANELS

6.5.1 Starters and contactors

Motor starters and contactors shall be equipped with short circuit protection and local disconnecting devices. Preferably, all starters shall be from one manufacturer. The control circuit voltage shall be obtained from a 415/240 V isolating transformer with primary circuit breaker and secondary fuse. The secondary winding of this transformer shall be grounded. The operating coils of the contactor shall be connected between the grounded side of the transformer and the control contacts.

Starters and contactors shall comply with IEC 292.1 or NEMA IC 1 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 enclosures for outdoor installation, unless otherwise approved by the Engineer. The enclosures shall be complete with locks, cable sealing boxes, conduit entries, cable gland plates, bus bars, internal wiring, terminal boards, etc. as required by the duty of the starter or contactor.

Starters and contactors shall be of minimum size compatible with motor size and capable of satisfactory operation, without damage, for a period of 5 minutes at a voltage 25 percent below nominal, at nominal frequency.

Thermal type overload and phase failure relays shall be supplied with starters for motors of 7.5 kW or greater. For motors of less than 7.5 kW, suitable rated 3-phase thermal overloads will be acceptable. Ammeters to read current in one phase shall be provided for motors above 7.5 kW.

Each starter shall have sufficient number of auxiliary contacts required for interlocking and indication purposes plus two spare convertible contacts for Owner's use.

6.5.2 Moulded case circuit breakers

All moulded case circuit breakers shall be of 2 or 3-pole type as required, having thermal time delay and instantaneous trips with "On-Trip-Off", indicating/operating mechanism. Circuit breakers used in combination type motor starters or contactors shall have the operating mechanisms interlocked with the starter or contactor cover so that the cover cannot be opened unless the circuit breaker is open. The

breakers shall comply with applicable section of IEC 157/1 or equivalent standards.

6.5.3 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 thermal current rating of 10A over a range of 6 to 600 V AC.

6.5.4 Pilot devices

Pilot devices such as selector switches, push-button starters and thermostats shall be of heavy duty type and, where mounted outdoors, shall be housed in weather proof enclosures specially designed for the environment.

All electrical contacts for control, alarm and shutdown shall have a thermal current rating of not less than 10 A at 220 V DC.

6.5.5 Terminal blocks

All terminal blocks shall be mounted in an accessible position with the spacing between adjacent blocks not less than 100 mm and 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 addition, 20 percent spare terminals shall be provided. In enclosed cubicles, the terminal blocks shall be inclined toward the door for facilitating terminations.

Terminals shall be of the channel mounting type and shall comprise a system of individual terminals so that terminal blocks can be formed for easy and convenient cabling consistent with the high reliability required of the circuits.

Terminal blocks shall be provided with shorting links and paralleling links where applicable and mounting identification numbers and/or letters.

Terminal blocks shall conform to the applicable standards. The smallest size to be used shall be designated for 2.5-sq. mm wire and not more than two conductors shall be connected under one terminal clamp.

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

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

6.5.6 Equipment wiring

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 dressed 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 equipments.

Multi conductor cables shall be connected to the terminal blocks in such a manner as to minimise crossovers. Approved claw washers of crimp type connector shall be used to terminate all small wiring. Each conductor shall be individually identified at both ends through a system providing ready and permanent identification, utilising slip-on ferrules approved by the Engineer.

Markers may be typed individually or made up from sets of numbers and letters firmly held in place. Open markers will not be accepted.

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 shall be effectively shielded against extraneous signals and interference. A separate terminal shall be provided for termination of individual cable shields, which will be grounded at source end only.

6.5.7 Cubicles and control panels

Cubicles and control panel enclosures shall be of sheet steel with minimum thickness of 1.8mm, of rigid, self-supporting construction and supplied with channel bases.

Cubicles shall be fitted with close fitting, gaskets, hinges, lift-off doors capable of being opened through 105 degrees. The doors shall be provided with integral lock and master key.

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 shall the floor/roof plate be used as a gland plate. The cables and wiring shall enter from bottom or top as approved or directed by the Engineer.

The cubicles and panels shall be adequately ventilated, if required, by vents or 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.

Where cubicles are split between panels for shipping, terminal blocks shall be provided on each side of the split with all necessary cable

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extensions across the splits. These cable extensions shall be confined within the panels with suitable internal cable ducts.

Unless stated otherwise, all cubicles and panels shall be provided with a ground bus with 40mm copper bar extending through out the length. Each end of this bus shall be drilled and provided with lugs for connecting ground cables ranging from 70 to 120mm^2.

The standard phase arrangement when facing the front of the motor control centres and switchboard shall be RYB from left to right, from top to bottom and front to back. All instruments, devices, buses and other equipments involving 3 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 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 the manufacturer.

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

Switched interior light and socket outlets shall be provided for all cubicles and control panels.

All cubicles and control panels shall be provided with lamacoid nameplates, identifying the purpose of the panel and all of its components.

6.5.8 Alarm contacts

Where applicable, all alarm contacts shall be of galvanically isolated type and provide inputs to the following devices.

- -Local annunciator
- -Station annunciator
- -Supervisory control and sequence of events / fault recorder system.

All alarm contacts shall be changeover type. Where required, relays shall be provided as contact multiplier.

6.6 CABLES

Refer to particular technical specifications Section-IX.

6.7 EARTHING SYSTEM

The contractor of Electro-Mechanical Equipment will make the design calculation and supply the necessary material and install the earthing system during powerhouse construction in co-coordination with civil contractor

6.8 EXPLOSION PROOF WORKS

6.8.1 General

According to the kind of oils and fuels used, explosion in hazardous locations may be caused by standard type electrical works. Therefore, the installation in such locations shall generally be kept to a minimum with said works designed or installed in compliance with the latest issue of IEC recommendation 79 and the appropriate articles of the American National Electric Code (NEC) or the German VDE Standards 0165, 0170 and 0171.

6.8.2 Definition of Hazardous Locations

Hazardous locations shall be defined as follows:

- Class 1, Div. 1 locations are those:
- Where hazardous concentrations of inflammable vapours or gases exist continuously, intermittently, periodically under normal conditions of operation and maintenance and with normal leakage, and
- Where the breakdown or faulty operation of process equipment could release explosive concentrations of fuel and cause simultaneous failure of electrical works.
- Class 1, Div.2 are those:
- Adjacent to Div.1 locations which may occasionally be reached by hazardous concentrations, and
- Where inflammable volatile liquids or gases are handled, processed, or used, but where concentrations are not normally hazardous because liquids or gases are handled in closed systems, and
- Where hazardous concentration is normally prevented by positive ventilation. These locations become hazardous only when the ventilation system fails.

6.8.3 Design features

The design features of electrical works and /or circuits to reach explosion proof condition shall be selected with due regards to the place of installation and the kind of works.

The main features shall be as follows:

- Pressure & flame –proof Enclosure:

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All parts, which may ignite a hazardous atmosphere, shall have an enclosure of sufficient strength to withstand the maximum pressure caused by ignition of the most inflammable mixture of the gas involved. All necessary joints of such enclosures shall be provided with long fits (minimum 25 mm) and close clearances (equal or smaller than 0.6 mm) to cool the escaping flame and to prevent flame propagation to the outside atmosphere.

- Oil Immersion:

The parts capable of igniting inflammable or explosive mixture shall be immersed in oil to such an extent as to prevent ignition of explosive mixtures above the surface of oil by means of sparks or hot gases produced under oil.

- Increased Safety:

To obtain an increased degree of safety on electrical works, special measures shall be taken to prevent non-permissible high temperatures, sparks or arcs inside or outside of the works on which they don't occur under normal working operations.

- Intrinsic safety

All electrical circuits or part of such a circuit shall be considered as intrinsically safe if neither during normal working operation nor under fault conditions explosive mixture is ignited by means of arcs, sparks or any heat generation.

- Any other approved feature not mentioned above but may be felt necessary during the course of execution.

All explosion proof works shall be of approved design and must have undergone type tests according to appropriate standards.

The selection of such works with reference to design features and allocation to hazardous groups shall be subject to approval by the engineer.

6.9 LABELS AND PLATES

6.9.1 General

Labels and data plates shall be provided in accordance with applicable standards and as detailed hereunder.

The proposed material of the labels, size, exact label lettering and proposals for the arrangement of the labels shall be submitted to the Engineer-in-charge for approval.

Where applicable, designations in the selected local language shall appear above or to the right of the designation in the Contract language. The translations into and writings in the local language shall be submitted for approval.

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6.9.2 Equipment Labels and Instruction Plates

Labels written in the Contract language shall be provided for all instruments, relays, control switches, push buttons, indication lights, breakers, etc. In case of instruments, instrument switches and control switches, where the function is indicated on the device, no label is required. The label shall be fixed close to the devices in such a way that easy identification is possible. Fixing on the dial glass of instruments will not be accepted. The wording shall conform to the wording used in engineering documents.

Each separate construction unit (cubicle, panel, desk, box, etc.) shall be identified by its Works identification number. Cubicles and similar units shall also bear this identification number on the rear side if rear access is possible. The overall designation of each unit shall be given in the Contract language and - if required - also in a selected local language. These labels shall be made of anodised aluminium with black engraved inscriptions, arranged at the top section of the units. Manufacturer's trade labels shall - if desired - appear in the bottom section of the units.

All Works inside cubicles, panels, boxes, etc., shall be properly labelled with their item number. This number shall be the same as indicated in the pertaining documents (wiring diagrams, Works list, etc.).

Instruction plates in the Contract and selected local language, the sequence diagrams or instructions for maintenance shall be fitted on the inside of the front door of the electrical switchboards.

6.9.3 Warning Labels

Warning labels shall be made of synthetic resin with letters engraved in the Contract and selected local language, where required in particular cases.

For indoor circuit breakers, starters, etc., transparent plastic material with suitably contrasting colours and engraved lettering would be acceptable.

Details are stated in the Particular Technical Specifications or will be fixed at a later date.

6.9.4 Labels for Conduits

The material shall be non-corrosive and the inscription be done with 4 mm high letters/figures.

6.9.5 Labels for Cables

Each cable when completely installed shall have permanently attached to each end and at intermediate positions as may be considered necessary by the Engineer-in-charge, non-corrosive labels detailing identification number of the cable, voltage, and conductor size.

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The cable identification numbers shall comply with those of the cable list.

All cables in cable pits and at the entry to buildings shall be labelled utilising the aforementioned type of label.

6.9.6 Rating Plates

Works (hoists, machines, transformers, etc.) rating plates and other technical data/informative plates shall either be of the enamelled type or be of stainless steel suitably protected after engraving with a transparent paint resistant to aggressive atmosphere and solar radiation.

6.9.7 Single-Line Diagrams

Each switchgear room shall be furnished with a copy of the final as-built single-line diagram detailing all electrical data and denominations, separate for each individual switchgear / distribution board / MCC, placed under glass and frame/wall mounted at an approved location.

The same applies to the Station Single-Line Diagram one copy of which shall be arranged in the control room(s).

6.8 KEY SYSTEM FOR ELECTRIC BOARDS

Key interlocked switches shall be provided with Yale or other approved locks for locking in the neutral position. Similar locks shall be provided for selector switches for locking the switches in any of the positions.

The locks or padlocks shall be co-ordinated for the different applications and shall be supplied with three keys. A key cabinet at the end of each board (distribution board, MCC, control cubicles, etc.) shall be provided for storing the keys of that board. All keys shall have six master keys to open any lock or padlock supplied. Each key shall have one identification label fixed above the key-hanging hook inside the cabinet.

The cabinet door keys shall be similar and shall be six (6) in number.

7. INSTRUMENTATION AND CONTROL EQUIPMENT

7.1 GENERAL

All instrumentation and control equipment shall be of internationally reputed make having proven performance and acceptability in the field.

7.2 DESIGN CRITERIA

7.2.1 General

Chapter 6, "Electrical Works", shall be considered for I & C equipment as far as applicable. Special reference is made to cabling, wiring and labeling.

All components shall be of an approved and reliable design. The highest extent of uniformity and interchangeability shall be reached. The design shall facilitate maintenance and repair of the components.

The Works shall be pre-assembled to the highest extent in the Contractor's or Sub-Contractor's workshop, e.g., shop welding of thermometer wells and other connections, wiring of boards, desks, etc., including internal wiring and installation of devices shall be carried out. Fragile instruments shall be removed for transportation to site.

All components shall be suitable for continuous operation under site conditions.

Materials for instrumentation and control equipment, including piping material, which is exposed to the measured media, shall be selected accordingly.

All components shall be compatible with other electrical, electronic and mechanical Works.

All instrumentation and control functions shall be shown on the piping and instrumentation diagrams. The symbols to be used shall be in accordance with ISO standard. The identification system (tag numbers) shall be in accordance with the Works identification system and is subject to approval by the Engineer. All measurements and alarms shall be listed in a measuring list of a standard form subject to Approval by the Engineer. For remote controls, a schedule of interlocks shall be provided. The features of automatic controls shall be shown in block diagrams.

Shielded cables shall be provided for the control and supervisory equipment where required.

7.2.2 Standards

If the Contractor intends to apply Standards and Regulations other than those specified, he shall provide the Engineer-in-chargewith two (2) sets of such documents, which shall be complete, unabridged and written in the Contract Language.

7.2.3 Sizes of Indicating Instruments and Recorders

The meters, instruments and recorders shall be of standard size, to be selected to guarantee aesthetic appearance of switchgears, control panels, control desks, etc. The front glasses shall be of the anti-glare type. The scales shall be 90 degrees type for local control panels but must be 240 degrees type for control room instrumentation.

The control switches, adjusters, etc., on the panels and desks shall harmonise with the utilised indicator sizes.

7.3 TESTS

The single components and pre-erected assemblies shall undergo functional and routine tests in the Contractor's or Sub-Contractor's workshop. The ready mounted control and supervisory system shall undergo functional tests on Site prior to commissioning of the power Works.

Calibration tests shall be made on all-important pressure gauges and other instruments as required by the Engineer in charge.

7.4 MEASURING SYSTEMS

Electric measuring signals of 4-20 mA shall be transmitted to the control room for emergency or regulating circuits. In this case the absence of live zero signal shall lead to a warning signal. Measuring signals for indicating purposes will be 4-20 mA.

The components shall quickly respond to any changes of the measured magnitudes. Measuring ranges of indicators, transducers, etc. shall be selected in such a way that the rated value of the measured magnitude covers approx. 75% of the range.

All local instruments shall, as far as practicable, be mounted vibration free to allow good reading. Wherever required, damping elements shall be used.

Corresponding systems shall be grouped together in local panels.

All local indicating instruments and test connections shall be included in the respective Works as integrated parts. The scope of local indicating instruments and test connections shall enable the operator to properly survey the Works, and shall also allow to adequately carrying out all acceptance and other tests.

The binary sensors shall be fused separately and supplied with 24 V D.C.

7.4.1 Flow Measurements

The primary elements of flow meters shall be standard Venturi tubes, pitot tubes, standard orifices, anubar inductive , Electro-Mangetic Type or ultrasonic type. Their design and performance shall be in accordance with applicable standards.

The design and arrangement of tapping points, piping and valves shall be in accordance with VDI/ VDE rules 3512.

Beginning at a rate of flow of at least 5% of the measuring range all flow transmitters shall measure correctly. The error limit shall be ±1% for a rate of flow higher than 10%. The error of the primary elements is not included in this accuracy. The root extraction of flow measurement shall be effected electrically within the transmitter.

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Arrangement:

The arrangement of the throttling devices, the straight lengths upstream and downstream from the throttling device shall be in accordance with the said standards. Bends shall be at a sufficient distance upstream from the throttling device, particularly when large orifice ratios are used.

7.4.2 Temperature Measurements

All wells for capillary type thermometers, resistance temperature sensors and thermocouples shall be of the weld-in type. Wells for thermometers and temperature sensors of the screw-in type shall be restricted to measuring points for lubrication oil, and to such measuring points where welding is not suitable, e.g., at cast-iron parts. Shop-welded thermometer wells shall be covered by screw caps for protection during transportation and erection.

Resistance thermometers and thermocouples shall be equipped with waterproof connection heads. Thermometer arrangements shall be such that the connection heads do not become warmer than 80 °C, and the measuring inserts are easily exchangeable.

The temperature sensors shall be selected in such a way to minimise the number of different spare inserts. Resistance thermometers shall be used as far as possible and shall generally be of type Pt 100. Double resistance thermometers (with two resistors in one insert) should be avoided.

The use of dial-type contact thermometers shall be restricted to bearing metal and oil temperature measuring. In all other cases, thermocouples or resistance thermometers and electric contact modules (monitors) shall be used. Glass thermometers and similar thermometers will not be accepted as contact thermometers.

7.4.3 Pressure Measurements

Pressure gauges shall be shock and vibration-proof (preferably by filling with glycerin) and shall be equipped with toothed wheels and toothed segments of the machined type. They shall completely be made of stainless steel.

Higher than rated pressure shall not deteriorate the pressure gauge or affect its calibration. The pressure gauges shall be equipped with a radial-connecting stud, to allow the mounting on a gauge holder.

Pressure gauges with potentiometers will not be accepted for use as a pressure transmitter.

The error for pressure transmitters shall be limited to ±0.5%.

Pressure gauges and transmitters for inflammable liquids shall have filled systems and the filling liquid shall be separated from the inflammable liquid by means of adequate isolating membranes.

Each gauge, pressure switch and transmitter for absolute or differential pressure shall be equipped with a pressure gauge isolating valve including a test connection of the screwed type M20 x 1.5 mm so that such device can be removed without any disturbance of the plant operation.

Pressure gauges and transmitters for pressures of 10 bar and above shall not be directly mounted on the pressure tapping point. They shall be mounted apart from the tapping point on gauge holders or gauge boards. Whenever possible, pressure gauges and transmitters shall be group wise combined on racks or consoles.

Pressure gauges for high pressures shall be equipped with a relief valve for safety reasons in case of leaks (with a rubber reverse flow check).

In case of flowing substances, the measuring point shall be selected in locations of undisturbed flow.

If the pressure is pulsating, the devices concerned shall be connected via flexible tubes or other pulse-absorbing means.

In general, all pressure gauges, transmitters and pressure contacts shall easily be accessible for maintenance and supervision.

The design and arrangement of tapping points, piping and valves shall be in accordance with VDI/VDE rules 3512.

The scales shall have a diameter of 150 mm with black letters and figures on a white background. The calibration shall be in "bar".

The adjustment of the pointer shall be possible by means of an adjustment device without removing the pointer from its axle.

The high and low-pressure connections of differential pressure gauges shall be marked accordingly.

All casings shall be dust and watertight and be made of stainless steel.

7.4.4 Level Measurements

The liquid level measurements in reservoirs and tanks with atmospheric pressure shall be made by means of pressure transmitter of mercury less-type, by displacement-type transmitters or float-disc-transmitters. The errors shall not exceed ± 1.0% of the total measuring range. Level switches shall be of the externally mounted float or displacement operated type. The switch shall be of packing less construction; there shall be a minimum of moving parts.

7.4.5 Electrical Measurements

All Electrical instruments shall be of flush mounted design, dust and moisture-proof. A.C. ammeters and voltmeters shall have digital type system of not less than 1.5 accuracy class for connection to the secondary side of instrument transformers. D.C. measuring instruments shall have digital type systems of the same accuracy. Watt meters/energy meters shall have electro-dynamic measuring

mechanisms if fed by transmitters. Watt meters shall be suitable for unbalanced systems and accuracy of energy meters should be of 0.2 % accuracy class.

All indicating instruments shall generally withstand without damage a continuous overload of 20% referred to the rated output value of the corresponding instrument transformers. Ammeters shall not be damaged by fault-currents within the rating and fault duration time of the associated switchgear via the primaries of their corresponding instrument transformers.

All instruments and apparatus shall be capable of carrying their full load currents without undue heating. All instruments and apparatus shall be rear connected, and the enclosures shall be earthed. Means shall be provided for zero adjustment of instruments without dismantling.

All voltage circuits to instruments shall be protected by MCB's in the unearthed phases of the circuit, installed as close as practicable to the instrument transformer terminals, or, where instruments are direct-connected, as close as practicable to the main connection. All power factor indicators shall have the star point of their current coils brought out to a separate terminal which shall be connected to the star point of the current transformer secondary windings.

When more than one measured value is indicated on the same instrument, a measuring point selector switch shall be provided next to the instrument and shall be engraved with a legend specifying each selected measuring point.

All instruments shall be of the flush mounting type and shall be fitted with non-reflecting glass and shall comply in every respect with the requirements of IEC Publication 51. Except for instruments employed for Works performance tests all instruments shall have an accuracy class of 1.5.

Scales shall be arranged in such a way that the normal working indication is between 50-75% of full-scale reading permitting an accurate reading. CT connected Ammeters provided for indication of motor currents shall be provided with suppressed overload scales of twice full scale. The dials of such ammeters shall include a red mark to indicate the full load current of the motor.

Instrument scales shall need the approval by the Engineer-in-charge. All instruments mounted on the same panel shall be of same style and appearance.

Transmitter connected ammeters (for example those in mosaic-type control desks) shall have 90 degrees or 240 degrees circular scales calibrated 0-120 %. The rated motor current shall correspond to 100% scale indication.

All metering circuits shall be terminated in marked terminal blocks for remote metering purposes.

7.4.6 Position Measurements

Position transmitters of the potentiometer type will not be accepted. Inductive or capacitive type shall be provided.

Position transmitters for continuous position indication and measuring transducers shall have an output current of 4-20 mA and aux. supply voltage (if required) 220 or 48 V D.C. The "potentiometer-type" position measuring principle is not permitted.

7.4.7 LIMIT SWITCHES

Limit switches shall be provided for each electrically operated gate, valve or gantry to automatically stop the motor at both ends of travel. Additional switches shall be provided where necessary for control, interlocks and indication.

Limit switches shall be mounted suitable for easy adjustment and for rigidly locking in position after being adjusted. They shall be of heavy-duty rating and have two changeover contacts suitable for 220 V D.C. operations.

Switch fixings shall be positive and shall be unaffected by vibration. At the same time they should be capable of easy adjustment to suit changing parameters of the associated plant.

Particular attention shall be paid to potentially harmful environmental conditions, including water, oil, dust, dirt, temperature variations and differential expansions. Where switches operate through linkages, precautions shall be taken to eliminate variations of settings and incorrect operations resulting from wear or tolerances.

7.4.8 Contact Devices

Contacts of level switches, pressure switches, temperature switches, limit switches, and of all other devices shall be of the snap action type (SPDT). Contact devices for interlocking systems shall be separate, i.e., contact devices serving commonly for interlocking and other purposes will not be accepted.

7.5 PROTECTION SYSTEMS

Electrical/Mechanical Protection and Interlocking Systems shall be provided for all works components and individual systems to ensure a safe and reliable operation and to limit harm and damage to personnel and works to an utmost extent.

The primary functions of these facilities shall be to disconnect selectively faulty sections of the systems prior to influence or damage to other works and to maintain operative systems as far as possible.

Moreover these devices shall facilitate the duty of the operation staff and prevent mal-operation.

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7.6 TRANSMITTER RACKS AND PIPING

Wherever practicable, transmitters for flow, pressure, etc., shall be installed in readily accessible positions in the proximity of the measuring point, free from vibration and protected against damage, moisture, dust, corrosive air, and great temperature changes.

The transmitters shall be grouped and assembled as far as practicable on local transmitter racks or in cubicles with glass or plexi-front.

The connecting lines between the primary elements and the transmitters shall be installed to falls in order to ensure that no air pockets or water locks are created.

8. TRANSPORT AND INSTALLATION

8.1 GENERAL

Shipping, loading, transportation, unloading, storage, erection and test running shall be performed by the Contractor. The Contractor is required to carryout survey for obtaining the transportation limitation data on its own.

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. 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-in-charge with complete packing lists of each performed shipment.

8.2 PACKING

The contractor shall prepare all plant, devices & materials for shipment to 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 into convenient sections, so that the weights & sizes are suitable for transport to site & 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, galvanising, etc., and shall be clearly legible after painting, galvanising etc. In labeling, the Contractor shall endeavor to use as few designations as possible and each part of identical size and

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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 may be 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 Engineer-in-charge 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.

8.3 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 :
- Contract No. :
- Country of Origin :
- Port of entry :
- Item number (if applicable)
- Package number, in sequence
- Quantity per package :
- Description of Works :
- Net and gross weight, volume :

8.4 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 the Indian railway or highway authorities any permit that may be required for the transport of loads exceeding the normal gauges.

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.

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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. 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 already have been finally 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 etc. of the suppliers.

8.5 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.

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.

8.6 REFERENCE POINTS

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-in-charge 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 or 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-in-charge 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-in-charge or the Engineer's Representative shall not in any way relieve the Contractor of his responsibility for its correctness.

8.7 GENERAL NOTES ON INSTALLATION WORK

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 that the installation of all plant 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 kept.

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-in-charge. After alignment, the parts shall be held firmly in position by means of set pins, fitted bolts, etc.

All parts to be embedded in concrete shall be set accurately 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.

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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-in-charge 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-in-charge.

The Contractor shall provide all necessary anchors and braces to ensure the alignment and stability of the parts to be installed. All temporary 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-in-charge 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 galvanised or specially treated plant during erection. Care shall be taken to prevent or remove any rust streaks or foreign matters deposited on galvanised 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 be operated pneumatically. They are to be handed over at the end of the installation work in good condition in accordance with the instructions of Engineer-in-charge.

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-in-charge, he shall remove waste from the place of installation to the defined deposit site at his own cost.

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8.8 CIVIL WORK AT SITE

The following works shall be carried out as part of the civil works and is included within the scope of work covered by the equipment specifications :

- Dismantling of the required equipment (including civil work) as per the scope of work.
- All concrete work, including reinforcement and form-work, and all grouting required for filling in, around and under the various parts of the works to be embedded in concrete.
- All necessary excavation and backfilling required for installing the plant in its final position, unless otherwise stated in the Technical Specifications.
- Providing and grouting the block outs for all anchoring and foundation bolts needed to support and fix the plant in its final position.
- All protective measures, e.g., pumping, etc., to keep the various parts of the plant and the erection site free from water during the time of erection.
- Provision of cable and pipe ducts, trenches, block-outs, etc., in accordance with the drawings.
- Adequate safety covers and protective measures against injury or damage to the Contractor's employees and equipment and to the works due to any operations of the contractor.
- If chequer plates or other covers provided under the contract require special care for fitting to plant and installations, such work (cutting, matching, welding of supports, etc.) shall be performed by the contractor.

9. INSPECTIONS AND TESTS

9.1 GENERAL

In addition to the provisions established in the Conditions of Contract regarding general procedure of inspections and tests, terms and definitions, and time schedules for inspections and tests the following stipulations shall apply.

Approval of assemblies, tests, inspections, related procedures etc. and acceptance of pertinent test and inspection certificates, or waiving of inspections or tests, shall in no way relieve the Contractor of his contractual obligations for finishing the Works in accordance with the provisions of the Specifications.

Three (3) sets of all test records, test certificates, performance curves, tables etc. of all inspections and tests, whether or not attended by the Engineer-in-charge shall be supplied soonest after performance of each inspection or test. After completion of all tests, two (2) sets of the

above-mentioned documents shall be supplied, properly bound in books.

All test certificates shall be endorsed with sufficient information for identification of the equipment and material to which the certificates refer.

In addition, the following references shall be entered in the top right-hand corner:

- Employer's name
- Project title
- Plant's (stage's) name
- Number of Contractor's drawing
- Date

9.2 SHOP INSPECTIONS AND TESTS

As far as practicable, quality of materials, workmanship and performance of all items of the Works to be furnished under this Contract shall be inspected at the places of manufacture.

Where the Contractor desires to use stock material, not manufactured specifically for the Works, satisfactory evidence that such material conforms to the requirements of the Contract shall be submitted.

Arrangements shall be made for expediting the shop inspection by having all shop assemblies or pieces covering a single shipment ready at one time. Any painting work as well as transport to the site of the Works shall not be started before the approval of the Engineer-in-charge has been obtained.

Free and unrestricted access to the Contractor's factory and shops (including those of his Subcontractors) shall be granted to the Engineer-in-charge also and upon reasonable notice by the Engineer-in-charge if deemed necessary by the same for additional witnessing of assembly work or inspections and tests.

If an agreed inspection could not be carried out as proposed because of lack of preparation, obvious negligence or material and/or equipment being presented in a state, not corresponding to the proposed procedure or is clearly not acceptable such an inspection shall be repeated. The cost incurred by the Employer for repeated inspections shall be fully borne by the Contractor.

9.2.1. Material Tests

Unless otherwise specified, the quality of materials (new as well as the equipment parts to be retained) shall be verified generally by:

- Chemical analysis.

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- Mechanical tests (yield point, tensile strength, elongation, and notch impact.)
- Welding tests (welding procedure, welding material, welding tensile strength, welding bend test, welding reversed bend test, etc.)
- Non-destructive x-rays, ultrasonic, magnaflux, liquid tests, penetration inspection, etc.).
- Electrical tests (voltage, losses, tan delta, insulation, magnetic properties etc.) Note : Tan delta on sample bar and PD on 100% generator bar .

Certified mill test reports of plates will be acceptable when these comply with the requirement of specifications. Test specimen and samples for analysis shall be plainly marked to indicate the materials they represent.

Castings and forgings shall be tested in the rough state in order to detect flaws in good time thus avoiding delays. Magnetic particle inspection of important castings shall cover the whole surface of the casting. After partial machining, further tests can be conducted.

Load tests on crane hooks, steel wire ropes, chains and other lifting devices, etc. shall be considered as material tests.

9.2.2 Checking of Dimensions

The dimensions, especially clearances and fits, (ISO 286) which are essential for operation and efficiency shall be carefully checked in an approved manner, as for example:

- Run out and roundness tolerances of shafts, pistons, etc., to be measured on single parts as well as (wherever possible) on the assembled components,
- Fits and clearances of bearings, servomotor pistons, valves, guiding, distributing and actual actuating elements, etc.,
- Accuracy, surface roughness and shape of sliding and guiding surfaces of seals, bearings, water passages in hydraulic machinery, valves, etc.,
- Dimensions of couplings or connections for assembly with other deliveries from the Contractor, Sub-contractors or other contractors.

9.2.3 Workshop Assembly

In addition to the quality and production control tests, the following shop assembly work and tests shall be made to check measurements, fitting and functioning.

Works to be furnished shall be shop assembled to a status sufficient to prove that the design and workmanship have been executed in accordance with the Specifications, that the delivery is complete, and that no work remains to be done at Site, which reasonably can or should be done in the shop.

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Where applicable, each item of the Works shall be assembled completely prior to painting.

Field joints shall be temporarily connected.

All parts shall be properly match marked, identified and dowelled where practicable, to facilitate correct and quick field assembly and alignment. Where necessary, suitable dowels shall be inserted, after field assembly and drilling. The holes for any fitted bolt shall be accurately reamed.

During workshop assembly all instruments, control devices and piping shall be fitted.

If the assembly shows defects in the design or manufacture or unforeseen difficulties in assembling and dismantling, these shall be eliminated. If required, design alterations or corrective measures can be executed provided that reliability of operation or interchangeability are not reduced and provided that the agreement of the Engineer-in-charge has been obtained.

If the corrections cannot be carried out in accordance with the terms mentioned above, the components concerned will be rejected. The decision on possible subsequent corrections is reserved exclusively to the Engineer-in-charge. Faulty parts or Works shall by no means be delivered.

The assembled parts shall subsequently be subject to tests as per applicable standards or required by the Engineer.

9.2.4 Pressure and Leakage Tests

All parts subject to internal or external pressure or containing any liquids or gases temporarily or permanently during operation shall be tested prior to painting. As far as practicable, these tests shall be done in the shop but can be repeated at site.

Parts exposed during operation to hydraulic pressure, to gas pressure or to any liquid without pressure, shall be treated distinctively.

In addition to the Specifications, the applicable and approved standards and official regulations shall be observed. If any liquid is used for the test that may cause corrosion, all Works and piping shall be thoroughly cleaned immediately after the test.

As far as practicable and required, the influences of temperatures and temperature differences to which the part will be exposed during operation shall be considered in the execution of the tests.

Leaks and defects can be repaired if permitted by the applicable standards and approved by the Engineer-in-charge. If defects are found, the Engineer-in-charge may reject the defective parts, or permit welding repairs with stress relieving, radiographic examination and additional pressure tests.

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Parts Exposed to Hydraulic Pressure

Unless otherwise specified or required, the following shall apply: the hydraulic pressure tests shall be carried out using the liquid to be used during operation or a liquid with less viscosity.

The hydraulic test pressure shall be l.5 times the maximum operating pressure (except for spiral distributor) and shall be maintained for a period of eight hours or longer if required by the applicable standards. Afterwards the test pressure shall be reduced to the operating pressure.

The welded seams of large parts, which are not subjected to any heat treatment during or after welding, shall be rapped with a 500 g hammer during the pressure decrease or treated otherwise to obtain the required effect of stress relief.

Finally, the test pressure mentioned above shall be maintained for ten (10) minutes. Leakages appearing at seals, joints, etc. shall be measured and stated in the test report, together with the relevant pressures.

Parts Exposed to Gas Pressure

Parts which will be subjected to gas pressure during operation for example pressure tanks, pressure air tanks and others, shall be inspected and tested according to the official regulations with respect to design, construction, fittings, etc.

The pressure test shall be executed by applying the test pressure in accordance with the relevant standards and specifications.

Parts Exposed to Liquids without Overpressure

Parts which shall not be closed and which are exposed to only small pressures of any liquid during operation e.g., bearing housings, oil containers, etc. shall be subjected to a tightness test at with a suitable liquid of low viscosity. The testing-period shall not be less than 8 hours, unless otherwise agreed.

9.2.5 Functional Tests

Functional tests shall be defined as tests of the function of assemblies, sub-assemblies or parts of the Works under no load conditions. Functional tests shall be performed on all Works prior to the execution of operational tests.

9.2.6 Operational Tests

As far as practicable operational test shall be carried out on all Works, simulating operating conditions.Parts to be delivered by sub suppliers shall be tested either at the premises of the sub supplier or of the Contractor, as agreed by the Engineer-in-charge.

Before testing the Contractor shall submit a notice containing full information on the tests with detailed tables or graphs on the latest edition of the characteristic values of the Works to be tested and on the test facilities and equipment.

Testing of the electrical Works shall be performed in accordance with applicable Standards; they shall include but not be limited to tests of heating, loading, overloading, losses.

Operational tests of lifting equipment and other machinery shall include tests under nominal load and 125 % of nominal load unless otherwise specified.

9.2.7 Electric Tests

Electrical appliances/devices/equipment shall be tested in accordance with applicable Standards and agreed test programs and procedures.

9.2.8 Model Tests

Model tests for certain parts of the Work or Works shall be carried out as specified or agreed between the Contractor and the Engineer-in-charge as per specification defined in Chapter-2

9.3 SITE INSPECTION AND TESTS

During erection, commissioning and trial operation, the Contractor shall perform at suitable intervals all inspections and tests in the presence of the Engineer-in-charge in order to prove the orderly execution of the works in accordance with the Contract.

Unless otherwise specified, all costs for testing at site and of the works and charges associated with it shall be borne by the Contractor. This includes the measuring devices, properly calibrated, and any pertinent accessories, which shall be made available by the Contractor for the entire duration of the tests. The Contractor shall delegate his experts to perform the tests at site.

The Engineer reserves the right to have checked at his own expenses the Contractor's instruments to be used or having been used for any tests by an independent, officially acknowledged institution.

Special tests to be performed at Site are listed in the corresponding chapter of the Particular Technical Specifications.

The Contractor's testing at Site shall be complete in every respect to prove the successful performance and operation of all the works and Works supplied and erected under the Contract.

In case of disagreement between the Engineer-in-charge and Contractor(s) on the test results, an independent expert shall be appointed by the Employer to whom both parties shall agree. If no amicable settlement can be reached, the Adjudication Clause shall be applied.

The procedure of inspections and tests at site, notice to the Engineer-in-charge, reports, commissioning, trial runs and trial operation, and acceptance tests shall be as per General Conditions of the Contract.

9.3.1 Commissioning and Trial Run

Immediately upon termination of commissioning of a part or section of the Permanent Works, which can operate as an independent unit a "Certificate of Suitability for Operation", shall be issued by the Engineer.

This document shall be signed by an authorised representative of the Employer, the Engineer and the Contractor.

This Certificate shall state:

- The supplier of the Works concerned
- The quantity and type of Works concerned
- The conditions of commissioning
- The names of the participants
- The date of commencement of trial run
- The list of minor defects, if any, which has to be corrected by the Contractor

During the trial run the Contractor shall make familiar the Employer's personnel with the equipment, the operation and maintenance of the Works and its auxiliaries to such an extent that, thereafter, the duties can be assigned to the Employer's trained personnel. For achieving this, 20 to 24 authorised operation & maintenance persons of the Employer shall be trained in operation and maintenance for at least 30 days of trial run, prior to handing-over.

If any defects or irregularities affecting the safety or reliability of the Works should arise during the trial run, the trial run shall be interrupted and started again after such defects or irregularities have been corrected by the Contractor.

9.3.2 Acceptance

The taking-over testing of any part or section of the Permanent Works which can operate as an independent unit, shall be performed in accordance with the standards and regulations laid down in the " General Conditions of contract, and as per the test procedure agreed upon between Engineer-in-charge and Contractor.

Immediately upon termination of any such testing of a part or section of the permanent Works a "Protocol of Acceptance" which shall be deemed to be the Test Certificate required by General Conditions of Contract shall be issued by the Engineer-in-charge.

This document shall be signed by an authorised representative of the Employer, the Engineer-in-charge and the Contractor and shall form an integral part of the later "Taking-Over Certificate".

This "Protocol of Acceptance" shall state:

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- The date of testing
- The quantity and type of Works concerned
- Statement of all minor defects and/or irregularities, which have to be corrected by the Contractor
- Confirmation that the guaranteed data have been proven
- Confirmation that all contractual documents have been submitted
- Confirmation that the Employer's personnel have been familiarised with the Works and that they will be able to operate and maintain the Works.

If any test for the verification of the guaranteed data could not be performed for operational reasons beyond the Contractor's responsibility, this part of the acceptance shall be stated in the "Protocol of Acceptance" and be postponed for a mutually agreed period.

However, the tested part or section of permanent work shall continue to be operated by the Contractor, with the help of Employer's personnel, all the generating units have been tested and commissioned and trial run period of 15 days or that to be agreed with the Owner and the Contractor, has been completed in respect of last unit to be commissioned.

NOTE:

A part or section of the permanent works shall, for the purpose of this contract, mean one generating unit with all its units and station auxiliaries required to operate the unit at its rated load.

9.4 QUALITY ASSURANCE PLAN & INSPECTION SCHEDULES:

9.4.1 Quality Assurance Plan

The Contractor shall submit the detailed Quality Assurance Plan for the complete equipment/materials along with the bid for approval and acceptance by the Employer. This shall form integral part of the contract. The QAP shall include inspection and tests proposed to be conducted on raw material/bought out items at the time of induction in the process of manufacturing and at final stage of assembly.

9.4.2 ISO CERTIFICATION

The Contractor should have ISO–9000 Series certification. In case the Contractor does not posses ISO-9000 series certification, he shall submit following details along with the bid, for assessment of his capacity to supply quality equipment/materials/services under the contract.

- Contractor's quality system details:
- Details of system for dealing with items not conforming to prescribed specification.

- Details of sub vendor analysis procedure
- Details of stage and final inspection and auditing
- Contractor's system for calibration of testing and measuring equipment.
- Details of testing and measuring equipment available with contractor
- Details of important facilities/equipment available with the Contractor to produce reliable products having requisite standard.
- Qualification and experience of contractor's key QA personnel.

9.4.3 Inspection Schedules

To facilitate the Employer in planning its inspection activities, the Contractor shall submit along with the bid, the details of the lots along with the time schedule in which the ordered materials shall be offered for inspection as also the places of inspection. These details shall be finalized and approved and form an integral part of the Contract.

ANNEXURE - I

PAINTING SYSTEM					
Type	Description	Surface Preparation	Paint System	Main Dry Film Thickness in μm	Remarks
A	Internal surfaces of steel linings, penstock, turbine spiral casing, valves and other wetted internal ferrous surfaces		Intermediate Coat: 2 x micaceous iron oxide paint, 2-component Base: epoxy resin	2 x 100	This paint system is for temperatures up to 120°C
			Finish Coat : 1 x topcoat, 2-component Base : epoxy resin	1 x 100	The colours of intermediate and finish coats shall be black - brown - black
			Total	300	

PAINTING SYSTEM					
Type	Description	Surface Preparation	Paint System	Main Dry Film Thickness in μm	Remarks
B	External surfaces of penstocks, Gantries, Cranes, Lifting Beams, Fixed Hoist supports and other Drive Supports	Sa 2 1/2 - 3	Prime Coat: 1 x zinc dust primer, 2-component Base: epoxy resin	1 x 50	The pure metallic zinc shall be at least 92% of the polymerized film
			Intermediate Coat: 2 x micaceous iron oxide paint,	2 x 80	This paint system is for temperatures up to 60°C

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			2-component Base : epoxy resin		
			Finish Coat : 1 x micaceous iron oxide paint, HB epoxy or PU paint coloured, 2-component Base : epoxy resin	1 x 80	
			Total	290	

PAINTING SYSTEM					
Type	Description	Surface Preparation	Paint System	Main Dry Film Thickness in μm	Remarks
C	External surfaces of indoor ferrous parts such as valves, connection pipes, oil carrying tanks and pipes, supporting structures, gantries, etc.	Sa 2 1/2 - 3	Prime coat : 1 x zinc dust primer, 2-component Base: epoxy resin	1 x 50	The pure metallic zinc shall be at least 92% of the polymerized film
			Intermediate Coat: 2 x micaceous iron oxide paint, 2-component Base : epoxy resin	2 x 80	This paint system is for temperatures up to 120°C

			Finish Coat : 1 x topcoat, 2-component Base : epoxy resin	1 x 50	
			Total	260	

PAINTING SYSTEM					
Type	Description	Surface Preparation	Paint System	Main Dry Film Thickness in µm	Remarks
D	Control cabinets, panels, cubicles, electric motors.	Sa 3 and de-grease before painting	Prime Coat: 2 x zinc chromate primer, 2-component Base: epoxy resin	2 x 40	
			Finish Coat : 2 x topcoat, 2-component Base : epoxy resin	2 x 50	
			Total	180	

PAINTING SYSTEM					
Type	Description	Surface Preparation	Paint System	Main Dry Film Thickness in m	Remarks
E	Interior surfaces of oil tanks	Sa 2 1/2 - 3	2 x thixo trop consistent paint Base :	2 x 220	

			epoxy resin		
			Total	440	

PAINTING SYSTEM					
Type	Description	Surface Preparation	Paint System	Main Dry Film Thickness in µm	Remarks
F	Frames, cover plates, pipes and tubes, and miscellaneous steel parts not especially mentioned	Hot-dip-galvanised as specified in Section 4.12.8.3 and de-grease before painting	Intermediate Coat : 1 x micaceous iron oxide paint, 2-components Base : epoxy resin	1 x 80	All the parts inaccessible for painting shall be only hot-dip galvanised
			Finish Coat 1 x topcoat, 2-component Base: epoxy resin	1 x 50	
			Total, incl. zinc	200	

ANNEXURE- 2

SYMBOLS AND ABBREVIATIONS

1. Length, area and volume

µm	micron = m. 10^{-6}
mm	millimeter
cm	centimeter
m	meter
km	kilometer
mm^2	square millimeter
cm^2	square centimeter
m^2	square meter
km^2	square kilometer
ha	hectare
m^3	cubic meter
l	litre
rad	radian

2. Time and time derived units

s	second
min	minute
h	hour
d	day
hr	hour
yr	year
mm/s	millimeters per second
m/s	meters per second
km/h	kilometers per hour

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m/s^2	meters per second squared (acceleration)
m^3/s	cubic meters per second
Hz	hertz (periods per second)

3. Mass, force and derived units

kg	kilogram
g	gram = kg · 10^{-3}
mg	milligram = kg · 10^{-6}
mg/l	milligrams per liter
t	tonne = kg · 10^3
kg/m^3	kilograms per cubic meter
t/m^3	ton per cubic meter
N	Newton
N/m^2	Newton per square meter
N/mm^2	Newton per square millimeter
bar	bar = N/m^2 · 10^5
Pa	Pascal = $1 N/m^2$
MPa	mega Pascal = Pa · 10^6
atm	standard atmosphere = 101325 Pa
J	Joule = 1 Nm (Newton-meter)
KJ	kilo joule = J · 10^3

4. Electrical units

A	ampere
V	volt
kVA	kilovolt ampere
kWh	kilowatt hour
W	watt = 1 J/s
kW	kilowatt = $W \cdot 10^3$
MW	megawatt = $W \cdot 10^6$
A.C.	Alternating current
D.C.	Direct current
HV	high voltage (cables)
LV	low voltage
MV	medium voltage

5. Other symbols and abbreviations

approx.	Approximately
bhp	brake horse power
CIF	cost, insurance and freight
dia. or diam.	Diameter
fig.	Figure
hp	horsepower
horiz.	Horizontal
HT	high tensile (steel)
Max.	Maximum
Min.	Minimum

No.	Number (units) e.g. 6 no.
No.	Number (order)as in No. 6
temp.	Temperature
°C	degrees Celsius
vert.	Vertical
vol.	Volume
wt	weight
%	per cent
M.F.L	maximum flood level
H.W.L	high water level
M.O.L.	Minimum operation level
IEC	International Electro-technical Commission
ISO	International Standards Organisation

ANNEXURE 3

REQUIRED DOCUMENTS FOR E&M EQUIPMENT

1 General

In compliance with clause 2 the following documents for the E&M EQUIPMENT shall be supplied to the Engineer-in-charge.

For approval	marked **A**
For information	marked **I**

For identical items being supplied several times such documents shall be submitted once only.

2 Principal Requirements

The following documents shall be supplied individually or as a whole for equipment/installations wherever applicable.

2.1 Loading Drawings

As per General Technical Specification, Section-VIII, clause 2.2.1.	A

2.2 Foundation Drawings

As per General Technical Specification, Section-VIII, clause 2.2.2.	A

2.3 General Arrangement Drawings

FOR THE WHOLE PLANT AND FOR INDIVIDUAL AREAS / BUILDINGS /ROOMS / TRENCHES AS PER GENERAL TECHNICAL SPECIFICATION, SECTION-VIII, CLAUSE 2.2.3.	A

2.4 List of Plant Identification Numbers

As per General Technical Specification, Section-VIII, clause 2.5.11	I

3 Specific Documents for E&M EQUIPMENT and Installations

3.0 Documents for all E&M EQUIPMENT as Applicable

Shop test programs	A
Material test certificates	I
Shop test reports	A
Welding procedures	A
Welder's qualification certificates	A
Paint schedules	A
Instrument lists	A
Wiring diagrams	I
Installation drawings	A
Erection procedures	A
Site test procedures	A
Commissioning program	A
Commissioning procedures (dry and wet)	A
Operating & maintenance manuals	A
Program for training of Employer's Personnel	A
Site test reports	A
Trial operation programme	A
Emergency shut-down procedures	A

3.1 Turbine & Accessories

Specification	A
Component list(s)	A
Outline drawings	A
HYDRAULIC TRANSIENTS ANALYSIS	A
Stress analysis for main components	A
Model Test Report	A
Design drawings and assembly drawings for turbine	
Runner	A
guide bearing	A
operating mechanism	A
servomotors	A
over speed device	A
instrumentation diagram	I
signal and alarm list	I
Assembly/disassembly drawing of runner removal, maintenance and inspection	A
Drawings for erection/handling facilities	I

3.2 Governors

Specification	A
Component list(s)	A
OUTLINE DRAWINGS	A
Foundation drawings	I
Design drawings and assembly drawings for governor	
arrangement drawing	A
oil unit	A

schematic diagram	A
oil circuit diagram	A
sequence chart of control functions	A
Arrangement of all cubicles including front and inside views and details	I
Logic diagram	I
Design calculation	I
Drawings for erection/handling facilities	I

3.5 Cooling Water System

Specification	A
Component list(s)	A
Outline drawings	A
Foundation drawings	A
Design drawings	
schematic flow diagram	A
piping routing	A
supports and hangers	A
arrangement drawing	A
sequence chart of control functions	A
instrumentation diagram	A
signal and alarm list	A

3.6 Oil Filtration plant

Specification	A
Component list(s)	A
Outline drawings	A

3.7 Drainage water system

Specification	A
Component list(s)	A
Water circuit diagram	A
Arrangement drawing	A
Control panel arrangement	A
Logic diagram	I /A

3.9 HP.&.LP Compressed air system

Specification	A
Component list(s)	A
Arrangement drawing	A
Foundation drawing	I
Control panel arrangement	A
Logic diagram	I
Design calculation	I

3.10 Fire fighting system

Specification	A
Component list(s)	A
Layout drawing/details	A
Arrangement drawing	A
Control panel arrangement	A
Logic diagram	I
Design calculation	I

4 Electrical Equipment

4.1 Generators, Generator Terminal Equipment and Excitation System

Specification	A
Component list(s)	A
Outline drawings	A
Design drawings and assembly drawings for generator	
winding design and insulation	A
field winding	A
thrust and guide bearing	A
cooling system	A
braking and jacking system	A
high pressure lubrication system	A
fire extinguishing system	A
generator wiring cubicles	A
instrumentation diagram	A
signal and alarm list	A
sequence chart of control functions	A
design and assembly drawings including schematic diagrams and control diagrams for:	
line and terminal cubicle	A
neutral cubicle	A
cable terminal cubicle	A
generator circuit breaker	A
Design drawings and assembly drawings excitation system	
outline and arrangement drawings	A
schematic diagram	A
circuit diagram	I
sequence chart of control functions	I
instrumentation diagram	I
signal and alarm list	I
detailed list containing all settings including limiting devices	A
Drawings for erection / lifting and handling facilities	A

4.3 132 kV Outdoor Switchyard

Single line diagram	A
Layout arrangement	A

Cross section of individual bays	A
DIMENSION DRAWINGS FOR COMPLETE DISTRIBUTION BOARDS AND FOR EACH TYPE OF FEEDERS	A
Arrangement drawings of cubicles including front view,	A
An inside view and sections where necessary	A
Control schematics and interlock sequences	I
Instrument transformers detailed drawing, data sheets, curves etc.	A
Complete schematic circuit diagrams of breakers	A
List of measurements	A

4.4 Protection system

Specification	A
Component list(s)	A
Single-line diagram (protection diagram)	I
circuit diagrams (schematic)	I
Block diagrams	A
Logic diagrams including tripping scheme for protection	I
Alarm lists	A
Tripping list	A
Terminal diagrams	I
Specifications for protection relays including tripping curves, setting ranges etc.	A
Arrangement drawings of all panels including front and inside view	A

4.5 Medium Voltage Installations 11 kV Switchgear

Specifications	A
Dimension drawings for complete distribution boards and for each type of feeder	A
Single-line diagrams	A
Standard circuit diagrams	I
Individual circuit diagrams	I
Arrangement drawings of cubicles including front view, inside view and sections where necessary	A
Specification for protection relays	A
List of Measurements	A

4.6 Low Voltage Installations 415 V

Specifications	A
Dimension drawings for complete distribution boards and for each type of feeder	A
Single-line diagrams	A
Standard circuit diagrams	I

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Individual circuit diagrams	I
Arrangement drawings of cubicles including front view and inside view	A
Specification for protection relays	A
List of Measurements	

4.7 220 V & 48 V D.C. Systems

Specifications	A
Dimension drawings for complete distribution boards and for each type of feeder	A
Single-line diagrams	A
Standard circuit diagrams	I
Individual circuit diagrams	I
Arrangement drawings including front and inside view	A
Specification for protection relays	A
List of Measurements	A

4.8 Batteries

Specifications incl. capacity calculation	A
Dimension drawing for individual cells and for complete batteries incl. racks	A

4.9 Battery Chargers

Specification	A
Arrangement drawing including front and inside view	A
Dimension drawing	A
Circuit drawing	I
BLOCK DIAGRAM	I
Logic diagram	I
List of settings	A

4.10 Control and Monitoring Systems

Specifications	A
Component list(s) (both hardware and software)	A
Arrangement drawings of all cubicles including front and inside view and details on mimic diagrams	A
Dimension drawings	A
Circuit diagrams	A
Block diagrams	I
Logic diagrams	A
Start / stop and emergency shutdown logics	A
List of Measurements	A
List of settings	A
System configuration concerning all	A
Work stations	A
system overview	A
alarm lists	A
event lists	A

reports	A
data recording	A
fault history	A
parameter settings	A
Terminal diagrams	I
Schematic drawing	A
Layout drawings	I

4.12 XLPE Cable

Specifications	A
Connection diagrams	I
Layout drawing	A
Arrangement drawing	A
Design calculation	I

4.13 Illumination system

Specification	A
Component list(s)	A
Outline diagram	A
Electrical layout drawing	A
Illumination drawing	A
Terminal diagrams	I

4.14 PLCC system

Specification	A
Component list(s)	A
Arrangement of panels including front and inside view and details	A
Schematic drawing	A
Terminal diagrams	I

4.15 Cabling for power, instrumentation and control installations:

Specifications	A
Calculations for power cables concerning voltage drops and short circuit capability	A
Cable list	I
Connection diagrams	I
Arrangement drawings (cable routing plans) for buried cables	I
Cable tray arrangement drawings	I
Cable allocation drawing for trays at different locations/trench paths, can be combined with above cable tray arrangement drawings	I
Cable laying schedule	I

4.16 Silent DG Set

Specification	A

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Component list(s)	A
Outline drawings	A
Foundation drawings	I
Design drawings	
Arrangement drawing	A
Instrumentation diagram	A
Signal and alarm list	A
Sequence chart of control functions	A
List of settings	A

Note: An indicative list of required document in respect of some of the E&M equipment has been given above for the Contractor to understand our requirements in this respect in general. However similar details in respect of equipment not covered above, shall have to be furnished by the Contractor as per their practice and shall be approved during detail engineering.

CHAPTER – 1: GENERAL TECHNICAL REQUIREMENT

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1.1 INTRODUCTION

This section specifies the general technical requirements applicable to complete technical specification (including Technical Specification, General Technical Specification, Guaranteed Technical Particulars) for dismantling, transportation & storage of items including preservation at site, reverse engineering & site measurements on existing legacy structures & equipment in order to determine site limitations & constraints, detail design and engineering, model testing, manufacture, quality assurance, quality control, shop assembly, shop testing, insurance, transportation, delivery at site, site storage & preservation, erection, testing and commissioning including performance testing, field acceptance test, training of employer's personnel, handing over of plant to the Employer and guarantee of Twenty Four months from commissioning or 16000 hours (unit wise each) of operation whichever is earlier for electro-mechanical, hydro-mechanical plant & Balance of plant as per the tender document primarily comprising of four Nos. Hydro-generating units & all associated components & equipment as per the specifications of the tender document, complete with auxiliaries, accessories, spare parts and guarantee a trouble free safe operation of the installation. The equipment & plant to be supplied under this contract shall be suitable for continuous operation under varying grid parameters as allowed in "Indian Electricity Grid Code". In addition, the equipment shall be designed to operate continuously without any problem under ± 10 % voltage variation and ± 5% frequency variation. Temperature rise/ variation limits for equipment shall be determined considering the above variations. Further, the power plant is required to be operated as a peaking station. Start/ stop requirements (500 each) of all equipment for daily peaking shall be taken into consideration while designing.

The term "Engineer" mentioned in these specifications may be read as "Engineer in Charge" as per definition given in General Conditions of Contract (GCC).

1.2 INTRODUCTION OF CHILLA HYDRO ELECTRIC PROJECT

Chilla HEP was commissioned by erstwhile UPSEB in the year July, 1980 under Garhwal Rishikesh Chilla Hydel Project scheme and falls in the District - Pauri Garhwal, Uttarakhand, India. The annual design energy of the Chilla HEP was 720 M.U. The powerhouse of the Chilla HEP is 9km from the city of Haridwar.

Chilla HEP primarily comprises of a 312m long diversion barrage (Coordinates: 30°04'27"N & 78°17'18"E) called "Virbhadra Barrage" across river Ganga at Pashulok, 5km downstream of Rishikesh town for creating a live storage of 4.7MCM with full reservoir level

(FRL) at El. 337m. The water from the Virbhadra Barrage is diverted in to a 14.3 km long open power channel having a capacity of 20000 cusecs or 565 cumecs which in turn feeds 4Nos. 6m diameter & 55m long penstocks of Chilla Powerhouse (Coordinates: 29°58'34"N & 78°13'11"E) through intake fore bay having FRL at El.330m above MSL. The water through penstocks powers the "BHEL" make vertical Kaplan turbines of 4 Nos. 36 MW hydro-generating units installed at Chilla Powerhouse by harnessing the fall of around 32.5m. The power is generated at 11 kV & stepped up to 132kV through "BHEL" make 42.5MVA, 11/ 132 kV Generator Transformer and fed in to the Northern Grid through three 132 kV feeders viz. After generating the power, the water is channelized through 1.2 km long tail Race channel and flows back into the River Ganga at Bhimgoda Barrage.

1.3 CONFORMITY WITH SPECIFICATIONS & SALIENT FEATURES OF THE HEP

The equipment design should be in conformity with the existing salient features & civil structures of the Chilla HEP described at various places in the tender document. Some of the features are described below:

Salient Features of Chilla Hydro Electric Project		
S. No.	**Description**	**Particulars**
A	**Virbhadra Barrage at Pashulok, Rishikesh**	
1	Location	5km downstream of Rishikesh
2	Coordinates	30°04'27"N & 78°17'18"E
3	River	Ganga / Ganges
4	Catchment area at barrage	21,400 km^2
5	Design Flood (once in 50 years)	13200.00 Cumecs
6	Length	312m
7	Maximum Pond Level	EL. 337.0m above MSL
8	Normal Pond Level	EL. 333.0m above MSL

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9	Live Storage	4.7 MCM
10	No. of river bays	15 Nos.
11	Barrage weir bay gates	11 Nos. vertical lift type gates each of size 10.15x18m
12	Sill level of barrage weir bay gates	EL. 326.5m above MSL
13	Under Sluice gates	4 Nos. each of vertical lift type size 11.15mx 18m
14	Sill level of under sluice gates	EL. 325.0m above MSL
15	Divider wall between 11 Nos. weir bay & 4 Nos. under sluice gates	64m
16	Length of head regulator	63m
17	Nos. of power channel head regulator gates	5 No. vertical lift type each of size 7.7x11m
18	Sill level of power channel head regulator gates	EL. 328.8.0m above MSL
19	Size of opening in the trash rack of power channel head regulator gates	75mm x 400mm
B	**Sediment/ Silt Management Structures for power channel**	
1	Silt excluder tunnel for head regulator gates	5 Nos. upstream of each head regulator gate & outlet at the bottom of first under sluice gate
2	Silt excluder tunnel at Virbhadra Barrage	4 Nos. Under Sluice gates at right angle of head regulator structure and sill 2.8m below the sill of head regulator gates for flushing out the sediments
3	Location of Silt ejector	200m downstream of head

	system	regulator gates
4	Components of Silt ejector system	Comprises of three culverts (covering entire channel width of 42m), each with 4 entrance bays protruding 1.6m from the bottom of the power channel.
5	Control of Silt ejector system	Through a gate
6	Design flow of silt ejector channel	115 cumecs
C	**Power Channel (Virbhadra Barrage to Chilla Powerhouse)**	
1	Method of construction	Cut & fill method with invert slope of the channel covered with concrete tiles.
2	Height of the side dykes	33m (Maximum)
3	Width of the power channel	Varies from 42m at head regulator outlet to 12.5m after silt ejector & again 70.75m at intake forebay
4	No. of bridges	3 Nos.
5	No. of drainage crossings	13 Nos.
6	Longitudinal slope	1:6000
7	Side Slope	1.75:1
8	Bed width	12.5m
9	Length	14.1 km
10	Design/ Rated capacity	20000 cusecs or 565 cumecs
11	Overload Capacity	620 cumecs
C	**Powerhouse Escape weir (By-pass) Control Structure**	
1	Manufacturer of gates	Irrigation Workshop, Roorkee
2	Orientation	50° on right bank of the axis of

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		the power channel at Fore bay intake.
2	Nos. of by-pass gates	5 Nos. fish belly type flap gates
3	Size of the gate	5m x 9.5m
4	Control sill of each gate	El. 326.8m
6	Water level maintained by the bye-pass gate	Between El. 326.8m & El. 330.15m
7	Gate Operating Mechanism	Operation of the by-pass gate is activated by a float (a concrete caisson 4.4m long , 1.7m wide & 1.5m deep) located in a chamber adjacent to the gate. When the fore bay water level rises, water enters in a primary chamber located in the pier through a hole located below El. 330m. When water in the primary chamber exceeds El. 330.15m, water spills over in to the float chamber. This causes the float to rise, which in turn makes the gate rotate & initiate spilling.
6	Stop log gates	3 Nos. for each by pass gate.
7	Length of by-pass outlet bay	95m
8	Width of the outlet collector bay at by-pass control structure	67.5m
9	Width of the outlet collector bay at downstream end	21.0m
10	Elevation of by-pass outlet collector bay floor	EL. 317.14m
11	Elevation of by-pass outlet	EL. 317.75m

	collector bay sill	
12	Angle of curve in the axis of the outlet channel	68°
13	Size (LxW) of return channel from by-pass outlet collector bay to TRC	110mx21m
14	Dissipation Arrangement in the return channel	Dissipation block along with a series of three sills & falls with respective head at each fall 7.0m, 13.3m, 12.7m
15	Alignment angle and position of point of confluence of the by-pass return channel with TRC	20° at 100m from the powerhouse downstream wall.
D	**Tailrace Channel**	
1	Length	1.8 km
2	Width at bed level	75m
3	Longitudinal slope	0.2/1000
4	Side slopes	1.75:1
5	Point of confluence of Mundal Nala in TRC	1.2km from powerhouse downstream wall
6	Location of confluence of TRC with river Ganga	3.7 km upstream of Bhimgoda barrage
7	Maximum reservoir level at Bhimgoda barrage	El. 292.0m
8	Normal reservoir level at Bhimgoda barrage	El. 292.0m
E	**Powerhouse Intake structure & system**	
1	No. of intakes	4 Nos. each equipped with stop log gate guide openings
2	Make	Ms/ Cimmco Limited
3	Trash Rack	Common Single

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4	Intake gates	4 Nos. steel fabricated vertical wheeled type. Each gate consists of three tiers having flexible joint between them
5	Size of intake gates	6m x 7.2m
6	Weight of the gate	30 Tonnes
7	Nos. of stop log gates	1 No. (in 4 tiers) operated through electrically operated gantry crane
8	Gate by pass arrangement	Through single by–pass gate valve for penstock filling priming before gate lifting
9	Operating mechanism of the intake gates	Each intake gate is equipped with 58T electrically operated hoist for remote (control room) site as well as local operation of the intake gates. The operating mechanism enables closure of intake gates in case of "catastrophic shutdown" conditions
10	Type of fixed hoist	Rope-drum type with 8 fall system through one continuous steel wire rope.
11	Lift of the gate	a) Normal Operation – 9m b) Emergency fall – 9m c) Maintenance operation by short circuiting the limit switch terminals and taking the gate above pier for repair etc. – 17.9m
12	Manual Operation of the gates	Lifting / lowering speed of 30mm/ minutes by engaging four men.
13	Normal operation of gates	3-Ø, 415V AC power supply to 50HP, 100 rpm "Kirloskar" make motor providing lifting/ lowering speed of 3m/ minute.

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14	Emergency Lowering of gates	By applying 220V DC for releasing electromagnetic brakes resulting in fall of gate under gravity within 2 minutes.
E	**Penstocks**	
1	No. of Penstocks	4 Nos., 1 feeding each unit.
2	Size of Penstocks	6.0m diameter each
3	Length of Penstocks	59.95m each
4	Material of Penstock liners	Steel with nominal thickness 16mm
5	Structures in the exposed portion of the penstock (i.e. between upstream wall & spiral casing)	Expansion joint, Manhole for inspection, tapping for pressure gauge and Tapping for feeding raw water cooling water system.
F	**Chilla Powerhouse**	
1	Type	Surface Powerhouse
2	Existing Installed Capacity	4x36 MW
3	Manufacturer of Hydro-generating plant	BHEL
4	Existing Generator type	Vertical suspended type
5	Existing turbine type	Vertical Kaplan type
6	Minimum Tail water level	El. 295.25m (1 unit at running full load @ 141.25 m^3/s)
7	Maximum Tail water level	El. 296.78m (4 units running; each @110% load @155 m^3/s)
8	Extreme Minimum Tail water level	El. 294.85m (1 unit running at 5% load)
9	FRL & MDDL at fore-bay intake	El. 330.00m

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10	FRL at Virbhadra Barrage, Pashulok	El. 337.00m
11	Maximum Net Head	33.91 m
12	Minimum Net Head	32.23 m
13	Rated design net head	33.35m
14	Centreline of spiral casing	El. 290.60m
15	Centreline of runner	El. 289.016m
	Floor	
16	Generation Voltage	11kV
17	Transmission Voltage	132kV
18	Switchyard	Open Outdoor type
19	Existing Generator Step Up Transformers	4 Nos. 3-Ø, 42.5MVA, 11/132kV, BHEL make
20	Existing bus-dust from Generator to Generator Step Up Transformer	Non-segregated phase bus duct.
21	Mode of connection between transformer and outdoor switchyard	132kV Overhead link line
G	**Draft Tube gates**	
1	No. of Draft Tube Gates	8 Nos. (2 Nos. in each unit)
2	Type of gate	Vertical lift type
3	Size of the Draft Tube Gates	5mx5.25m each
4	Gate operating system	Through single common gantry crane
5	Manufacturer of gates	Irrigation Workshop, Roorkee

1.4 PRIORITY OF THE DOCUMENTS

The documents forming the Technical specifications are to be taken as mutually explanatory of one another. In case there is an ambiguity or discrepancy in the document, the Employer shall issue necessary clarification or instruction to the contractor. As a general rule, SCC shall prevail over GCC or ITB in commercial portion of the tender while in the technical portion of the tender, GTP (TDS) shall prevail over GTS and PTS shall prevail over both GTS & GTP.

1.5 RESPONSIBILITY OF THE CONTRACTOR FOR COORDINATION AND INTERFACING

It will be obligatory for the contractor to coordinate between various supplies & related work as per the contract agreement. The contractor shall be fully responsible for following interfacing/ coordination of work in addition to the normal work as stipulated under the contract:-

A) Layout Engineering:

Layout Engineering as per applicability, particularly related to work covered under the contract agreement incorporating interfacing & coordination with existing legacy cut-outs, equipment, spaces etc., maintaining aesthetic ambience & technical harmony shall be responsibility of the contractor.

B) Functional & Physical Compatibility:

The contractor shall ensure the functional & physical compatibility of all the E&M equipment under the scope in order to maintain efficient, reliable and safe operation of entire plant as a whole. Additional contacts for signal/ pulse multiplication along with auxiliary relays & potential free contacts as decided during detailed engineering, (in order to meet the functional compatibility with entire system), shall be made available in marshalling kiosk/common marshalling kiosk without any extra cost to the Employer.

C) Grounding System

Connection of various equipment for body earthing, neutral earthing as well as earthing bus in panels to the nearest available risers shall deemed to be included in the scope of this contract. For carrying out the same, the contractor shall utilise the earth mat risers as available nearby the existing equipment at various levels of powerhouse complex.

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D) Cables & Cabling Works

All cables, cable termination work (including thimbles, glands, lugs, insulating kits etc.), cable laying work including covered perforated cable trays from & in between individual equipment supplied under this contract to their respective individual marshalling kiosks as well as to any other legacy panel/equipment is deemed to be included in the scope of the Contractor. Further cabling from Local control cubicle/marshalling kiosk of any other equipment to various LCBs/UCBs/Plant SCADA/power supply boards shall also be the responsibility of Contractor.

E) Cable Schedule

Preparation of cable schedule for interconnection of their respective equipment of Local control cubicle etc. or any other panel/equipment supplied under this package is deemed to be included in the scope of the Contractor.
Preparation of cable schedule (power, control and instrumentation) of entire scope of work for successful commissioning of plant as a whole with proper co-ordination and inputs/data/details/drawing etc. including legacy equipment/ panel is included in the scope of the Contractor.
Further is would be mandatory that all necessary detail/inputs are received by the Contractor from its suppliers/ sub-vendors etc. for preparation of overall cable schedule.

F) Use the Hoist/Crane

Contractor shall be allowed to use the Hoist/Crane in the Chilla HEP complex when UJVN Limited is not required to use the same. However, the contractor shall ensure that hoist/ crane is not damaged during such usage, further if the damage happens during such usage, the contractor shall repair the same to the satisfaction of UJVN Limited, at his own cost. Operator shall not be provided by UJVN Limited.

G) Commissioning

Testing & commissioning of all equipment in coordination with all the legacy equipment/ panel supplied under this contract shall be included in the scope of the contract.
Before charging of the equipment(s), Contractor shall satisfy itself about the adequacy of protection of equipment. A protocol shall be signed by Contractor to give "go ahead" for energising of system (s) to avoid any complication at a later date.

1.6 AUXILIARY VOLTAGE

The electrical equipment like switchboards, MCCB, motors, contactors, relays, luminaires, heaters, switches, sockets, power outlets etc. should be rated for any of the following voltages:

A) A.C. Power - 415V(3-Ø)/ 240V(1-Ø)±10%, 50 Hz ± 5%, with grounded neutral.

B) D.C. Power – Ungrounded 220 V ± 20% and 48 V ± 20% with earth fault detection. Any other voltage system if required shall be generated from 220V system by means for DC-DC convertor. Capacity of the battery banks shall be considered accordingly.

1.7 PERFORMANCE GUARANTEE

The contractor shall guarantee that the equipment offered shall meet the ratings and performance requirements stipulated for various equipment/ systems/ work covered in the tender specification. The contractor shall demonstrate all the guarantees covered herein during functional guarantee/ acceptance tests. The contractor shall conduct the guarantee tests at site in presence of Employer.

1.8 COMPLETENESS & FULFILMENT OF SYSTEM/EQUIPMENT/ITEM/WORK

The supply as well as work to be carried under this tender shall be carried out by the contractor as per the tender specifications. It is not the intent to specify herein all aspects of design and construction; nevertheless, the supplied equipment and installation/ work shall conform in all aspects to high standard of engineering, design and workmanship and shall be capable of performing in continuous commercial operation in a manner acceptable to the "Employer", who will interpret the meaning the tender specification and drawings and shall have a right to reject or accept any work or material which in his assessment is not complete to meet the requirements of the tender specification and/ or applicable Indian Standard and/ or International Standards.

All such systems/equipment/items work/ services, which are not specifically mentioned in the tender specification but are functionally necessary for smooth operation of powerhouse along with fulfilment of the contract as per this tender specification , shall be deemed to be included in the scope of contractor and shall be furnished/ carried out by the Contractor without extra charges. Thus the contract shall achieve complete fulfilment. No extra claim will be entertained by the Employer later on this account.

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1.9 REMOTE TRANSMISSION OF DATA

It is required to transmit various data pertaining to generation to the remote ends of transmission lines by PLCC for their use at Regional Load Despatch Centre. For this purpose, spare contacts are to be provided in all 145 kV circuit breakers, isolators and earth switches. Information of three-phase currents, voltages, MW and MVAR of each generator and line are also required to be transmitted to remote end.

1.10 DEVIATIONS

Any deviation from the technical specifications should be clearly brought out by the bidder. All deviations from the tender Specifications should be at one place in the stipulated schedule. The contractor shall fulfil all the technical requirements of the specification except for those deviations clearly spelt out and accepted by the Employer.

1.11 STANDARDS

All equipment shall be in accordance but not limited with standards as cited throughout these Bid Documents. Any other applicable Indian Standard shall also be considered or its equivalent International standards (viz. IEC, ASTM etc.) in precision, quality, acceptability, tolerances, etc.

1.12 MATERIALS

Materials shall be new and of high grade/quality, suitable for the purpose/ application, free from defects & imperfections and of the classifications & grade listed herein, or their equivalents subject to acceptance by the Engineer. Material specifications, including grade or class shall be shown on the appropriate Contractor's detailed drawings submitted for review. Materials not listed herein but equivalent in their basic properties may be used subject to the Engineer's review of their acceptability.

S. No.	Material	Standards
1	Carbon-steel castings	Carbon Steel castings (Plain Carbon Structural Steel) for general application: i) DIN-1681(Grade GS-45 / GS-60), ii) ASTM A27 (Grade 65-35(450-24))

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2	Iron castings viz. nodular graphite iron casting for servomotor piston	Grey cast iron for General Engineering use: i) DIN EN 1561 ii) DIN 1693 iii) ASTM A48 iv) IS:3896-2
3	Corrosion-resistant stainless steel castings for runner blades, guide vanes, discharge ring, Top cover & pivot ring liner plates etc.	i) "Stainless & Corrosion Resistant Steel- Martensitic, Quenched & tempered type": DIN EN 10283 a) Type GX7Cr Ni Mo 12-1 (1.4008) b) Type GX5Cr Ni 19-10 (1.4308), c) For runners GX4 Cr Ni 13-4 (1.4317/ J91540) ii) "Corrosion Resistant Castings for General Application": ASTM A 743 CA 6NM.
4	Corrosion-resistant stainless steel plate, bars, pipes	i) Stainless & Corrosion resistance steel specifications: DIN-17440 - a) X 2 Cr Ni Mo 1810 (1.4404)/ ASTM 316L b) X 6 Cr Ni Ti 1810 (1.4541)/ ASTM 312 c) X 6 Cr Ni Mo Ti 17-2-12 (1.4571)/ ASTM 316 Ti d) X 20 Cr Ni 17-7 (1. 4057)/ ASTM 431 ii) Seamless stainless steel tubes dimensions, tolerances and weights: DIN EN ISO 1127, ASTM A269, ASTM A 511 iii) ASTM A240 - S41500 (Chromium and Chrome Nickel Stainless Steel Plate, Sheet and strip for pressure vessels and for General Applications)
5	Hardened corrosion resistant steel	Stainless steel quality specifications: DIN-17440, X 12 Cr 13 (1.4006) hardened condition.

6	Carbon steel forging (turbine/generator shaft, servomotor piston rod, rotor poles & pole plates, other important parts)	i) Quenched and tempered carbon steels DIN EN 10083-1, C35E/C45E or "Steel Forgings, Carbon & alloy, for general industrial use" ii) ASTM A 668 Grade D (Normalized & annealed or Normalized & tempered) iii) BS: 970-I (Part-I) "Wrought Steels for Mechanical & allied Engineering Purposes"– Manganese steel Forging (GR:150 M28) iv) IS: 2004
7	Carbon steel forging, structural steel (pipe flanges, fittings, regulating ring, draft tube cone, rotor spider, brackets, stator frame, Generator Brake ring, slip rings, Cooler Tube Plates, water boxes & other structural parts etc.)	i) DIN EN 10025, Steels for general structural purposes: quality specifications grade S235JRG2/ S355J2G3. ii) IS 2062 "Hot Rolled Medium & High Tensile Structural Steel" iii) ASTM A 572
8	Guide vane servomotor piston rings	i) ASTM A 516 Grade 70 (Pressure vessel plate, carbon steel, for Moderate and Lower-Temperature Service)
9	Guide vane servomotor piston	i) ASTM A 537 Grade 70 (Pressure vessel plate, heat treated, Carbon-Manganese-Silicon Steel)
10	Carbon steel plates (for low-stressed parts and piping): application for bearing housing	i) DIN EN 10025, Steels for general structural purposes: quality specifications, gradeS235JRG3 (1.0116) ii) ASTM A 283 Grade B "Low & intermediate Tensile Strength Carbon Steel Plates"

11	Carbon steel plates (for important stress carrying parts such as bottom/ pivot ring, top cover, draft tube cone)	i) DIN EN10025, Steels for general structural purposes: quality specifications, grade S355J2G3 (1.0841), normalized. ii) ASTM A 516 "Pressure Vessel Plates, Carbon Steel, for Moderate & Lower Temperature Service".
12	Intermediate and high strength steels (for important stress carrying parts and structures under hydraulic pressure)	i) DIN-17102, weldable fine grain steels, normalized, grades TStE ii) ASTM 514 "High Tensile Strength, Quenched & Tempered Alloy Plates"
13	Bronze casting	i) DIN1705 EN1982, Copper and Copper alloys- Ingots & Castings ii) ASTM B427 "Gear Bronze Alloy Castings"
14	Bronze (for bolting)	i) DIN-17672, Rod, bar of wrought copper and copper alloys: mech. Properties non-leaded copper-zinc alloys with min. U.T.S of 370 N/mm^2 ii) ASTM B124 "Copper and Copper Alloy Forging Rod, Bar, and Shapes"
15	Copper Tube (For condensers & heat exchangers etc.)	i) DIN-1754, Tube of copper: seamless drawn, material type SFCu F30 according to DIN-17671. ii) ASTM B251 "General Requirement of Wrought Seamless Copper & Copper-Alloy Tubes" iii) IS 1545 "Solid Drawn Copper and Copper Alloy Tubes"
16	Bolts and fasteners and Guide vane Servomotor body	i) DIN-13 "ISO General Purpose metric screw threads ii) DIN-267, Fasteners and similar parts: technical Delivery Conditions. iii) ASTM A 434M (Steel bars, Alloy, Hot-wrought or cold finished, quenched and tempered)

17	Steel pipes (Cooling water, Drainage & dewatering, drinking water system, mulsifyre system, sprinkler system etc.)	i) DIN-2448, Seamless steel tubes: dimensions and weights. ii) DIN-2458, Welded steel tubes dimensions and weights. iii) ASTM A53 "Pipe, Steel, Black & Hot Dipped, Zinc Coated, Welded & Seamless", iv) ASTM A 106 "Seamless Carbon Steel Pipes for High Temperature Services" v) IS 1239 Grade HFS (Hot Finished Seamless) "Steel Tubes, Tubular & Other Wrought Steel Fittings"
18	Steel pipe flanges and flanged fittings	i) IS-13159-1 ii) ASTM A105/ A105M iii) ASTM A 181/A 181M iv) ASTM A 182/A 182M v) Equivalent DIN
19	Carbon brushes	IS 13586 "Definition & Nomenclature of for carbon brushes, brush holders, commutator & slip rings for electrical machinery"
20	Copper for connection & Copper for field winding	ETP (Electrolytic Tough Pitch) copper as per IS-191 "Copper Specification"
21	Stator winding Copper	IS 4685 "Specification for Varnish Bonded Glass Fibre Covered Copper Conductors"
22	Stator Core, Rotor Pole and rotor rim punchings	Low Loss CRGO electrical steel as per IS-3024 "Grain Oriented Steel Strips" ASTM A 664 -15 for NGO BS 6404-8-8.5 & IEC 60404-8.5
23	Guide vane bushes	Thordon "ThorPlas" make Self-lubricating Polymeric Bushes
24	Cup seals for guide vane bushes (middle & lower)	Thordon "Thorseals"
25	Top Cover & bottom/ Pivot/ Lower Ring and guide apparatus servomotor cylinder	IS 2002 "Boiler Quality Steel"

26	Bushes for movable joint between regulating ring & link and links & straps	Thordon "ThorPlas" make Self-lubricating Polymeric Bushes
27	Bushes for movable joint between regulating ring & Servomotor pistons	Thordon "ThorPlas" make Self-lubricating Polymeric Bushes

All materials or parts used in the equipment shall be tested in conformity with the standards specified herein or other applicable standards approved by the Engineer.

"Certified Material Test Report for the materials of major/important components and/or materials for special application shall be furnished to the Engineer-in-Charge as soon as possible after the tests are performed. Each test certificate shall identify the components for which the materials are used and shall contain all information necessary to verify compliance with the Contract Documents."

1.13 CORROSION RESISTANT BOLTS AND NUTS

Corrosion resistant steel or bronze shall be used for bolts and nuts when either or both are subjected to frequent adjustment or frequent removal, such as adjusting bolts for packing glands on removable screens or strainers, on adjustable bearings, rubber seal holders, etc. Bolts on manholes shall be of high-strength stainless steel. Protective measures against electrolytic corrosion shall be ensured where necessary.

1.14 STEEL CASTING

1.14.1 GENERAL

Castings shall be sound and free from blow holes, porosities, shrinkage holes, cracks or any other defects, Surfaces of castings which do not undergo machining and which are exposed to view in the installation shall be dressed for good appearance and for painting. The location of existing defects shall be determined, and all defects, which impair the strength or utility of the casting, shall be removed to achieve a sound metallic part. The structure of the castings shall be homogeneous and free from excessive non-metallic inclusions. An excessive concentration of impurities or separation of alloying elements at critical points in a casting will lead to its rejection.

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1.14.2 INSPECTION

Castings shall be inspected visually at the foundry after they are cleaned and while defects are being removed. Castings shall also be inspected after repairs and after heat treatment. Radiographic or other non-destructive tests will be required as specified under clause 1.7.6. and as directed by the Engineer when granting permission to repair major defects. The Engineer reserves the right to require conducting non-destructive tests at the Contractor's expense to determine, the full extent of defects, readiness of the area for welding and the quality of repairs to satisfaction.

1.14.3 GENERAL REPAIR WELDING

Minor defects that will not impair the strength or serviceability of the castings may be repaired by welding in accordance with accepted foundry practices without the review of the Engineer. Defects shall be considered minor when the depth of cavity properly prepared for welding is not greater than 24% of the actual wall thickness but in no case greater than 24 mm and when the area to be welded is smaller than 0.016 m^2.

However, an accumulation of minor defects, which in the opinion of the Engineer casts doubt as to the general quality of the casting, shall be considered as a major defect. A complete descriptive report of major defects, supplemented with sketches, photographs, and metallurgical test reports, as the case may warrant, and the proposed repair procedure shall be submitted to the Engineer for review prior to any repair of major defects. If removal of defects reduces the stress-resisting cross-section of the casting by more than 50% or if the calculated stress in the remaining metal exceeds the allowable stress by more than 50%, the casting may be rejected. All castings having a major defect repaired after heat treatment, or any defects which will impair the strength of the stress-resisting cross-section or the dimensional stability of the finished part repaired after heat treatment, shall be re-heat treated.

1.14.4 DIMENSIONS

Dimensions of castings shall not be reduced by shop or foundry practices by an amount sufficient either to impair the strength of castings by more than 10% (calculated from drawing dimensions) or to cause the stresses to exceed those allowed under these Tender Documents. Dimensions shall not be oversized to the extent that the castings interfere with processing operations or proper fit with other parts. Warped or otherwise distorted castings shall not be used in the Work.

1.15 WELDING

1.15.1 PREPARATION OF BASE MATERIAL

Members to be joined by welding may be cut to shape and size by mechanical means such as shearing, machining, grinding, or by gas or arc cutting, to suit the conditions. Edges shall be shaped according to DIN 8551 "Edge Preparation; Grooves of The Weld of Steel; Submerged Arc Welding". Design of welded joints and selection of weld filler metal shall be in accordance with approved standards and shall allow thorough penetration and good fusion of the weld with the base metal. The edges of surfaces to be welded shall be sound and free from visible defects such as laminations or defects caused by cutting operation at least 30 mm back from the edge of the weld, and free from rust, oil, grease, and other foreign matter.

1.15.2 WELDING QUALIFICATIONS

The qualification of welding procedures, welders, and welding operators for all welding, including weld repairs, shall conform to DIN 8560 "Welding Personnel; Approval testing of welding Personnel for fully mechanized and automatic welding of metallic materials", DIN 8563 "Quality Assurance of Welding Process", BS EN 287 "Quality Test For Welders", or to the requirements of the ASME Boiler and Pressure Vessel Code Section VIII and IX. The Contractor shall arrange conducting of qualification tests of his welders and welding operators and submit evidence of this to the Engineer.

1.15.3 WELDED CONSTRUCTION AND STRESS RELIEVING

Weld-fabricated pressure-containing parts subject to constant and varying pressure shall be designed, fabricated, inspected and tested, unless otherwise specified, in accordance with approved standards and shall be stress relieved as a unit prior to final machining.

1.15.4 FIELD WELDING

Filler material required for field-welded joints shall be furnished by the Contractor. The Contractor shall select the proper filler material with respect to parent material for all field welded connections and shall specify it on the applicable drawing, together with the detailed design of the field weld joint. Field welding shall be done only when

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weather is clear and there is little or no wind unless the welders, welding operator and the Work are properly protected.

1.15.5 IMPACT AND BEND TESTS

Steel products for all principal turbine and shut-off valve parts shall be tested for impact resistance using the ISO V-notch specimen and shall have an impact resistance of not less than 27 J for steel castings and forgings and not less than 30 J for plate steel for each of 3 specimens tested at - 10°C. Both longitudinal and transverse impact tests shall be performed on plate steel. Bend tests shall be performed on specimens of all major steel castings and forgings in accordance with the applicable DIN designation. The nil ductility transition temperature shall be the temperature at which the impact resistance is at the values specified above.

1.16 MAXIMUM ALLOWABLE STRESSES

1.16.1 GENERAL

Adequate factors of safety shall be used throughout the design, especially in the design of parts subject to alternating stresses, vibration, impact, or shock, short circuit. The design of the equipment shall include seismic loads as specified in the General Technical Specifications, clause 4.4.2. Under the most severe conditions of loading expected in normal operation, stresses in the materials shall not exceed the values listed below except that appropriately lower values shall be used where loading characteristics could cause fatigue failure or excessive deflections. The design stresses for materials not listed herein shall be selected by the Contractor, but the maximum stresses in tension or compression shall not exceed one-third of the yield strength or one-fifth of the ultimate strength.

The turbine parts shall also be designed to withstand safely for not less than 30 minutes operation at the maximum runaway speed and the bearings shall safely withstand the temperature and wear caused by such operation.

B) Direct or combined steady stresses

1) For materials used in the construction of the equipment, unless otherwise specified, the maximum stress due to maximum normal rated load operating conditions shall not exceed one-third of the minimum yield point or one-fifth of

the minimum ultimate strength of the material, whichever is lower.

2) Maximum unit stresses in rotating parts of the turbine due to maximum runaway speed or in parts under hydrostatic test conditions shall not exceed two-thirds of the minimum yield point.

3) Maximum unit stresses in rotating parts of the generator due to maximum runaway speed shall not exceed three-quarters of the minimum yield point.

4) Maximum unit stresses in parts of that equipment which is subject to the maximum normal operating conditions, shall not exceed the values in the following table.

Material	Maximum allowable stresses	
	In Tension	In Compression
Grey cast iron	1/10 U.T.S	70Mpa
Carbon cast steel and alloy cast steel	The lesser of 1/5 U.T.S. or 1/3 Y.S.	The lesser of 1/5 U.T.S. or 1/3 Y.S.
Carbon or alloy steel forgings	1/3 Y.S.	1/3 Y.S.
Carbon or alloy steel plates for principal parts	**1/4 UTS**	**1/4 UTS**

U.T.S. = Ultimate Tensile Strength

Y.S. = Yield Strength

5) Maximum stresses in shear shall not exceed 21 MPa in cast iron, nor 60% of the allowable stresses for other materials, except that the maximum shear stresses in the turbine / generator main shafts and shut-off valve stems shall not exceed 50 % of the allowable stress in tension.

6) Thermally or hydraulically pre-stressed bolts such as coupling bolts, bolts for connecting of Butterfly valve body halves, bolts for pre-tensioning of Generator-stator metal sheets etc. are exempted from the limitations imposed and stresses up to 80 % of Y.S. are allowed in such cases.

7) Parts subject to water pressure shall be designed to the applicable provisions of ASME Code and welding shall be as specified herein and in accordance with ASME Boiler and Pressure Vessel code Section 8, Division 2. These parts are the following:

- Shut-off valve upstream & downstream connection pipes.
- Shut-off valve housing & servomotor Pressure vessels.

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1.16.2 STRESSES IN STANDARD PRODUCTS

Standard products are not subject to the above conditions i.e. will not be custom designed. Such products are, for example-

- Drainage water pumps,
- Cooling water pumps,
- Air compressors,
- Fans, etc.

1.17 NON-DESTRUCTIVE TESTING

1.17.1 EXAMINATION OF WELDS

Unless otherwise indicated in these Contract Documents, non-destructive tests shall be in accordance with approved standards. Radiographic examination of welds shall be in accordance with the technique and acceptance standards of IIW (International Institute of Welding). The Contractor's Drawings shall indicate the type and extent of non-destructive examination as it applies to each component or weld.

Weld examination shall be conducted by ultrasonic, dye penetration or magnetic particle methods, supplemented by radiographic examination. Supplemental radiographic examination shall include examination of critical high-stressed areas where interpretation of other methods is unclear, or where the integrity of the weld is doubtful. The Engineer shall have the right to request the Contractor to make random spot-check examination of welds, including radiographic examination, as part of his inspection of the equipment. The Contractor's detailed program for non-destructive examination of welds shall be submitted for review.

1.17.2 EXAMINATION OF CASTING

The turbine runner casting shall be given complete non-destructive examination including radiographic examination of the most critical areas. The Contractor shall submit Quality Sheets (Specification for inspection of steel casting for hydraulic machines), with his recommendation and specify special precautions to be taken of the casting of the turbine runner and other important casting components. The Quality Sheets submitted shall define the area and extent of the various non-destructive examinations to be performed on castings.

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17 (c) Examination of Forging

Shafts, stems and coupling bolts made of forgings shall be given complete ultrasonic examination and other applicable non-destructive test, to determine that they are sound. Non-destructive examination of other forgings shall be in accordance with accepted good practice to assure their soundness. The structure of forgings shall be homogeneous and free from excessive non-metallic inclusions. An excessive concentration of impurities or separation of alloying elements at critical points in a forging will be a cause for its rejection.

1.18 WORKMANSHIP

1.18.1 ELECTRIC WELDING

i) Minimum Weld Requirements

All welds shall be made continuous and watertight. The minimum size of fillet welds shall be 6 mm measured on the leg. All butt welds shall be full penetration welds welded from both sides.

ii) Weld Finish

Welds shall in general be treated so that they will display good appearance and a surface suitable for painting. Structural welds shall be grinded and blended to avoid stress raisers. All welds, which require non-destructive examination, shall be dressed by chipping and grinding as required for good interpretation by the selected weld examination method.

iii) Weld Tests

All butt welds in the flanges and webs of beams and girders shall be radio-graphically inspected. The fillet welds between flanges and webs shall be tested by the magnetic particle method. Butt welds shall be classified according to IIW (International Institute of Welding). They shall meet grade 4 (blue), except that bubbles in welds shall meet grade 3 (green), unless otherwise noted.

At least 20% of pipe welds shall be radio-graphically inspected. They shall meet grade 3 (green).

All cost of making the initial radiographic and magnetic particle tests of shop welds as well as the cost of any additional radiographic and magnetic particle testing to prove the acceptability of repaired welds shall be borne by the Contractor.

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All cost of initial field-weld testing will be borne by the Contractor. Any additional testing required by the Engineer to prove the acceptability of repaired welds shall also be borne by the Contractor.

1.18.2 STRUCTURAL WORK

Design and fabrication of structural parts shall conform to the applicable provisions of the DIN standards, including DIN 19704 - Hydraulic steel structures: criteria for design and calculations and DIN 4114 - Stability of steel structures, unless otherwise prescribed elsewhere in these Specifications. All embedded metal shall be at least 12 mm thick and all other metal shall be at least 10 mm thick. Dimensions without tolerances shall be according to DIN 7168 - Deviations for dimensions without tolerances, class "mittel", unless otherwise specified.

1.18.3 MACHINE WORK

i) General

All tolerances, allowances, and gauges for metal fits between plain (non-threaded) cylindrical parts shall be indicated according to DIN ISO 286-1:2010-11. Sufficient machining stock shall be allowed on parts to be machined to ensure true surfaces of solid material. Finished contact or bearing surfaces shall be true and exact to secure full contact. Journal and sliding surfaces shall be polished, and all surfaces shall be finished with sufficient smoothness and accuracy to ensure proper operation when assembled. No machining shall be done on working surfaces of self-lubricating bushings or washers.

ii) Finished Surfaces

All surfaces that are so indicated on the drawings or those that require machining for their intended function, or those that are usually machined according to good workshop practice shall be machined. Surface finish qualities shall be adequate for the intended use and shall be indicated on the Contractor's Drawings. Suitable measuring device such as scatter meter or other acceptable measuring device will be used to determine compliance with specified surface finish.

iii) Unfinished Surfaces

So far as practicable, all works shall be laid out to secure proper matching of adjoining unfinished surfaces. Where there is a large discrepancy between adjoining unfinished surfaces they shall be chipped and grinded smooth, or

machined, to secure proper alignment. If surfaces not designated as finished in the Contract Documents require machining to obtain the tolerances or straightness specified or needed for correct function, such machining shall be performed by the Contractor.

iv) Pin Holes

Pinholes shall be bored true to gauges, smooth and straight, and at right angles to the axis of the member. The boring shall be done after the member is securely fastened in position.

1.19 PAINTING AND SURFACE TREATMENT

1.19.1 SCOPE

All the equipment furnished and installed by the Contractor shall be completely painted for final use, with the exception of those parts or surfaces that are expressly designated as unpainted. Surfaces to be painted shall receive the preparatory treatment and number of coats prescribed in the General Technical Specifications, Section-VIII, Annex 1, Painting schedule. The Contractor shall perform all painting works in the shop, before shipment, followed by a field touch-up during or after installation. If accepted by the Employer, the Contractor may apply the last coat of paint at the site instead of applying it in the shop.

1.19.2 STANDARD PRODUCTS

All materials, supplies, and articles furnished shall be the standard products of recognised reputed manufacturers, and shall be subject to Engineer's review for acceptance.

1.19.3 CLEANING AND PREPARATION OF SURFACES

Refer to the General Technical Specifications.

1.19.4 COLOUR SCHEDULE

Colour Standard references to major equipment/ system shall be as per the details given below: -

S. No.	Equipment	Colour	Colour Code
1	Governor Cubicles	Oyster White	RAL 1013
2	Local Control Cubicle for Governor	Oyster White	RAL 1013
3	Generator Cover Plates	Oyster White	RAL 1013
4	Braking Control Cubicle	Oyster White with blue band	RAL 1013 & RAL 5012 for band
5	LAVT/NGT/Transformers including Marshalling Box	Light Grey	RAL 7035
6	Bus Duct	Light Grey	RAL 7035
7	HS Oil Unit	Light Grey	RAL 7035
8	Oil Sump Tank	Light Grey	RAL 7035
9	Oil centrifuging & purification system	Light Grey	RAL 7035
10	Turbine (top cover & other equipment in the turbine pit)	Pebble Grey	RAL 7032
11	HS Oil Unit	Light Grey	RAL 7035
12	Oil Pressure Tank	Yellow Orange	RAL 2000
13	Cooling water pumps, cooling water filters & strainers.	Mint Green	RAL 6029
14	Cooling water, conveniences water & drinking water pipelines	Mint Green	RAL 6029
15	Local Control Cubicle for cooling water system, Drainage & dewatering system and emergency flood dewatering pumps	Oyster White with green band	RAL 1013 & RAL 6029 band

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16	compressed air pipelines	Light Blue	RAL 5012
17	Air Compressors	Sky Blue	RAL 5015
18	Fire Fighting water Pipelines	Traffic Red	RAL 3020
19	Pressure oil & lubrication oil Pipelines	Yellow Orange	RAL 2000
20	Transformers	Pebble Grey	RAL 7032
21	Outdoor switchyard equipment, junction box, Outdoor Marshalling Kiosk (ODMK) etc.	Pebble Grey	RAL 7032
22	Unit Control Board/ Local Control Boards/ Excitation Panel/ Protection & Control Panels/ indoor marshalling boxes etc.	Oyster White	RAL 1013
23	Power Auxiliary Boards, Distribution Low Voltage Boards	Oyster White with Melon Yellow band	RAL 1013 & RAL 1028 band

The interior of all the cubicles & panels shall preferably have a matt finish unless specified otherwise. The colour scheme shall however be got reconfirmed & approved by the Employer during detailed engineering

1.20 FLUIDS AND LUBRICANTS

1.20.1 GENERAL

The Contractor shall deliver to the Employer all equipments complete with initial fill of fluids, grease or lubricants, transformer oil, SF_6 gas in non-returnable drums / containers and replace any quantity used up or lost during installation and testing.

1.20.2 COMPATIBILITY

The oil used for the lubrication and oil pressure systems for the turbine, governor, penstock, intake gate and generator shall be ensured to be of the same type. In case of any deviation, approval

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of the Employer shall have to be obtained by giving full justification, as the above deviation cannot be allowed in normal case.

The Contractor shall co-ordinate with the Employer for the type of fluids and lubricants used in the bearings.

Upon completion of the design, the Contractor shall furnish a tabulation confirming the quantities and types of fluids and lubricants required for each item of equipment.

1.20.3 SUPPLY

The Contractor shall furnish the following:

- All oil for initial filling of all equipment supplied, plus 10% additional.
- Grease if required for initial filling of all of the equipment, plus 10% additional.
- SF6 gas for initial filling of all equipment supplied, plus 10 % additional quantity.
- Flushing fluids to flush and clean all systems.

1.21 PIPE CONNECTIONS

External connections for all equipment shall be in accordance with the applicable standards.

Internal connections shall be in accordance with standards selected by the Contractor and accepted by the Engineer.

Adequate pipe supports and mounting hardware shall be provided for all piping in the Contractor's supply.

1.22 PRESSURE TESTS

Unless specifically mentioned otherwise in the Contract Documents, equipment, vessels and tanks under internal pressure during service shall be subject to hydrostatic pressure testing. The test pressure shall be 1.5 times the maximum design pressure of the respective equipment, vessel or tank.

The test pressure shall be applied for a period of 8 hours without showing leaks or drop in pressure.

1.23 DIMENSIONAL CHECKS AND VISUAL INSPECTION

Dimensional checks shall be performed on all major parts, components and partial assemblies, especially when close

tolerances and fits are involved (tolerance of shafts, between stationary and moving parts, connecting dimensions for the assembly with other supplies, etc.). If the dimensional checks show discrepancies in measurement, which may affect the fit, assembly or dismantling of the respective part or component, the same have to be corrected correspondingly. Such correction or modification shall, however, in no way lead to sacrifices with respect to reliability of operation or inter-changeability, and shall be performed only after the agreement of the Engineer has been obtained. If the correction or modification cannot be carried out in accordance with the terms mentioned above, the part or component concerned may be subject to rejection. Faulty machine parts or equipment shall by no means be delivered.

1.24 FUNCTIONAL TESTS

Functional tests on partial assemblies and/or complete assemblies shall be carried out as much as possible already in the manufacturer's workshops. Such tests shall be performed as far as possible under operation-like conditions.

When requested by the Engineer, the functional tests shall be repeated until it is established that the functioning of the assemblies will comply with the requirements of the Contract Documents.

1.25 EMBEDDED PARTS AND ANCHOR BOLTS

All embedded anchor bolts, rods, welding plates and support plates shall be provided. Anchor bolts shall consist of a threaded steel rod installed inside a pipe sleeve to provide lateral adjustment after the sleeve is embedded. The embedded end of the rod shall be provided with a steel plate, which shall be welded to the rod and sleeve to provide anchorage and to prevent entry of concrete into the sleeve during installation.

The threaded end of the rod shall be provided with two steel nuts and two steel washers to permit levelling and anchoring the equipment prior to grouting.

Approved types of expansion or chemical anchors shall be used where practicable for small equipment.

1.26 ELECTRICAL EQUIPMENT

1.26.1 GENERAL

The electrical equipment delivered under this contract shall be new and of high quality, suitable for the purpose it is intended for, free

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from defects and imperfections, and it shall be of the classifications listed herein, or their equivalents, subject to acceptance by the Engineer.

The equipment shall meet the applicable IEC Recommendations, international standards such as ANSI - IEEE – DIN - SEN or others that can be shown to be comparable to these. The IEC and IEEE recommendations for approval of equipment and tools are applicable.

The equipment design shall be suitable to render satisfactory operation under the conditions prevailing at the site, and the equipment shall operate satisfactorily under normal load and voltage variations. The design shall further include all necessary provisions ensuring the safety of the operating and maintenance personnel.

Each equipment assembly, or unit containing electrical devices and wiring, shall be completely wired in the shop. Wiring shall be neatly arranged and protected against mechanical damage, terminating in terminal blocks located in a connection box or cubicle, on or near the unit.

1.26.2 AUXILIARY SUPPLY VOLTAGE

i) AC Power

Three-phase system with grounded neutral for feeding three-phase and single-phase consumers (connected between phase and neutral), type TN-C 415/240 V ±10%, 50 Hz ± 5%. All motors and other electrical apparatus should be designed to work continuously under ± 5% frequency variation and ± 10% voltage variation.

ii) DC Power

D.C. Systems, ungrounded, with earth fault detection

- -220 V±20% for the supply of main control circuits for high and medium voltage switchgear, protection circuits and to other larger essential loads.
- ± 48V+20% for the supply of PLCC and EPBAX etc.
- Other voltage systems eventually needed, shall be generated from the above systems by means of dc/dc converters, inverters etc.

1.26.3 PERMISSIBLE TEMPERATURE RISE

The permissible temperature rise for the major electrical components is cited in the respective chapters of these Contract

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Documents. Wherever, temperature rise is not specifically mentioned, it shall be understood that the temperature rise is in accordance with the IEC recommendations.

1.26.4 SYSTEM PARAMETERS

Parameter	Normal	Variation under worst condition
Voltage	132 kV	110 – 145kV
Frequency	50 Hz	47.5 – 52.5 Hz

1.26.5 ELECTRIC MOTORS

As per relevant clause of "General Technical Specifications"

1.27 UNIT MODEL

A scaled model of section through a unit depicting the details of turbine generator set resembling as closely as possible shall be supplied & installed by the Contractor in the powerhouse.

The model shall primarily have following features:

a) The turbine runner and generator rotor rotating at slow speed using 220V, 1-Ø, AC motor.

b) Flow of water in cut section part of the spiral casing and DT cone/elbow or cone only with blue coloured LEDs using dedicated electronics interfaces.

c) Red light Effect in part of generator stator.

d) Red light on top of the brush gear casing.

The model should have high quality of craftsmanship to ensure the inclusion of all major details of the unit set. The details of model may be discussed during detailed engineering and should be approved by the Employer before acceptance of the same.

1.28 ELECTRICAL EQUIPMENT ENCLOSURES

1.28.1 GENERAL

All electrical equipment, apparatus and devices shall be of suitable design for satisfactory operation under the conditions prevailing at

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the Site. The equipment shall operate satisfactorily under normal load and voltage variations in accordance with IEC Publications.

The design shall also include all necessary provisions ensuring the safety of the operating and maintenance personnel.

All electrical connections and contacts shall be of ample cross section and capacity for carrying continuously the specified currents without undue heating and shall be secured by bolts or setscrews of ample size, fitted with locknuts or lock-washers of approved types.

Unless otherwise expressly stated conductors and all other current carrying parts shall be made from electrolytic grade copper in accordance with approved applicable standards.

Cubicles and other enclosures containing electrical equipment shall be especially treated to prevent corrosion. All cubicles shall be provided with a door switched lighting fixture and a single-phase socket for power outlet.

All interior surfaces of electrical apparatus, enclosures etc. including contactors, relays, and coils, etc., shall be treated in an approved manner to prevent mold growth. Such treatment shall in no way interfere with the proper operation of the equipment either electrically or mechanically.

Bigger assemblies such as switchboards, etc., shall be designed to present suitable transportation devices adapted to the local conditions within the plant.

Unless otherwise specifically called for or described in these Contract Documents all electrical appliances shall conform to the applicable IEC Publications.

1.28.2 CONSTRUCTION REQUIREMENTS

All cubicles and enclosures shall be of good quality standard production subject to approval by the Engineer. Cubicles shall be free floor standing type, of rigid frame covered with removable steel sheets. The frame shall be bolted to the floor. Cubicles mounted in rooms with computer floors shall have their own supporting structures made of steel profiles, being fixed to the concrete floor. There shall be provision and enough space for entrance of cables from above or below as necessary. The cubicles shall be ventilated if needed; in this case, removable filter inserts shall be fitted to the air entrance openings. Provision for cable fastening shall be inside the cubicles and enclosures, and sufficient space from cable fastenings to nearest terminal.

All control and indicating devices such as contactors, circuit breakers, auxiliary relays, indicating instruments, switches etc.,

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shall be functionally displayed in appropriate location. All indicating devices shall be visible with the door closed. The layout is subject to the approval of the Engineer.

If required, flush mounted hinged steel doors with latches shall be available: doors shall be with approved locks. The locks shall be of the same type throughout the plant. All panels and cubicles shall have a uniform appearance.

The indoor cubicles and enclosures shall be of protection class IP42 or higher according to their location. For outside installation, the ingress protection class of cubicles shall be IP65. Cubicles housing electronic cards/ modules such as of unit control boards, control & protection panels, digital governor etc. shall be of protection IP 5X except static excitation equipment (SEE) cubicles shall be IP31. If necessary the cubicles shall be equipped with automatically controlled heating elements for protection against internal condensation and moisture especially in the outdoor cubicles such as circuit breaker mechanism & other ODMKs.

All panels/cubicles shall have approximately 20% space for mounting of future devices.

Door operated interior illuminating lamps, power socket for 240V 5 / 15A and communication socket shall be provided in all panels.

1.28.3 WIRING

Unless and otherwise specifically called for or described in these contract documents all electrical appliances shall conform to the applicable IEC standards.

Wiring within cubicles and equipment enclosures shall conform to requirements of this section unless otherwise specified. Control wiring shall be stranded copper and shall be not smaller than 1.5 mm^2, except as otherwise agreed by the Engineer.

Larger size wiring shall be used where needed for the current carrying capacity requirements.

LT Cables shall have at least 1100 V grade PVC insulation except for 110V DC and telemetering or communication system equipment for which 650V and 300 V ratings respectively are acceptable. Cables shall conform to IEC 60331/ IEC 60332/ IS 1554/ IS 7098 as per applicability. LT power cables single or multicore (2/3/3.5 cores) shall be 1100V grade, heavy duty, FRLS, stranded Aluminium/ Copper conductor, cross linked polyethylene (XLPE) insulated and PVC inter sheathed. Cables for DC system shall be copper only. The control & instrumentation cables shall be multi core, FRLS, colour coded/ numbered, Annealed stranded high

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conductivity Copper, insulated with PVC & PVC sheathed. The outer sheath shall be specially formulated PVC compound.

For current and potential transformer secondary circuits the minimum cross section of the conductors shall not be less than 2.5 mm^2.

Wiring shall terminate at terminal blocks at one side only. Where tap connections are required, they shall be made on terminal blocks. Wiring shall be neatly arranged and laid in plastic conduits accessible from the front door. The conduits shall not be filled more than 70 %.

Each cubicle shall be provided with an earthing bar (PE) of sufficient cross section carrying any possible fault current without undue heating. All metallic parts of the cubicle not forming part of the live circuits, all instrument transformer terminals to be earthed and other earthing terminals as well as all cable screens and PE-wires shall be connected to the earthing bar.

All internal equipment and wiring shall be neatly and clearly marked as indicated on the schematic and wiring diagrams. Internal wiring and cables shall be marked with sleeve type engraved marking. Marking system and marking material shall be subject to approval by Employer. Identification of the respective conductors shall be in accordance with the requirements of IEC publication 60204. In cables having five conductors or more the individual conductors shall be numbered throughout the entire length. In cables having less than five conductors colour coding in accordance with IEC 60204 shall be applicable.

1.28.4 TERMINAL BLOCKS

Control circuits & power circuits shall be completely separated by use of divided or separate Terminal Blocks (TB).

The screw type modular Terminal block should be manuifactured as per IEC-60947-7-1. The insulating material of terminal block should be of polyamide 6.6 meeting V0/V2 flammability Class as per UL94. All metal parts including screws should be of copper alloy. The terminal block should be suitable for mounting on both "DIN" as well as "G" type rail . All metal parts shall be captive & touch proof. The TB shall have screw locking design so that it can withstand vibration level up to 5g and also prevent accidental, loosening of conductors. The terminal blocks shall also have necessary accessories like end clamp, separation plates etc. Unlewss otherwise specified terminal blocks shall be suitable for connecting following conductors on each side:-

1	All circuits except CT/PT circuits	Minimum of two of 2.5 mm^2 copper flexible
2	All CT/PT circuits	Minimum of two of 2.5 mm^2 copper flexible

The terminal blocks shall be located to allow a neat and easy connection work and shall be safely accessible while the equipment is in service. Control circuits and power circuits shall be completely separated by use of divided or separate terminal blocks. Power terminal blocks shall be rated in accordance with applicable standards, and shall be provided with covers.

Control wiring terminal shall be equipped with facilities for opening the circuit. It shall be possible to interchange a single terminal block for a new one without dismantling a whole row. Current transformer terminal blocks shall have provisions for short-circuiting and disconnecting. Not more than two wires shall be connected to any one terminal. Terminal blocks using screws acting directly on the wire will not be accepted. At least 20% spare terminals shall be provided on each panel/ cubicle/ box and these spare terminals shall be uniformly distributed on all terminals rows. Terminals shall be marked with printed labels.

1.28.5 GROUNDING

The Contractor shall connect all equipment included in the scope of delivery to the grounding system as described in chapter on Grounding System.

In addition to the grounding through cable screens, all equipment such as cubicles, motors, etc. shall be connected directly to the grounding system using copper wire of area not less than 50 mm^2 at two different points. In general, all iron parts such as supports, covers, railing, etc. shall be connected to the grounding system. Each conductor shall have its own separate connection point. Pressed on closed shoes shall be used for connections to bars.

1.28.6 PROTECTION DEVICES

For short circuit and overload protection of power and control circuits, moulded case circuit breakers or MCBs shall be used.

Outlets from AC (and DC) distribution panels are protected in their respective panels.

Power supply system shall be provided with three stage of surge protection (First stage with class A type, Second stage with class B type and third stage with class D type of lightning arrestors) to protect electrical & electronic devices.

1.29 MARKING OF EQUIPMENT AND WIRING

All internal equipment and wiring shall be neatly and clearly marked as indicated on the schematic and wiring diagrams. Internal wiring and cables shall be marked with sleeve type engraved marking. Marking system and marking material shall be subject to approval by Engineer. Identification of the respective conductors shall be in accordance with the requirements of IEC publication 60204. In cable, having five conductors or more the individual conductors shall be numbered throughout the entire length. In cables having less than five conductors colour coding in accordance with IEC Recommendations 60204 shall be used.

i) Colour Coding For Electrical Connections

Live parts of electrical connections shall be colour coded as follows:

Conductor Designation	Coding Alphanumeric	Symbol	Colour
A.C. network 3 phase	Phase 1	R	Red
	Phase 2	Y	Yellow
	Phase 3	B	Blue
	Neutral	N	Black
A.C. single phase	Phase	P	Red
	Neutral	N	Black
	Earth	E	Green-Yellow
D.C. Network	Positive	a	Red
	Negative	b	Black

ii) Colour Coding for Mimic Diagrams

Mimic diagrams to be arranged on switchgear cubicles, control panels/desks, etc., shall be colour coded as follows:

S. No.	Voltage Level	Colour	Colour Code
1	HVDC	Crimson Red	No. 540 as per IS - 5
2	400 kV	Signal Red	RAL 3001/ No. 537 as per IS - 5

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3	220 kV	Yellow Orange/ Light Orange	RAL 2000/ No. 557 as per IS - 5
4	132 kV & 110 kV	Lemon Yellow	RAL 1012/ No. 355 as per IS - 5
5	66 kV	Golden Brown	No. 414 as per IS - 5
6	33 kV	Olive Green	RAL 6003/ No. 220 as per IS - 5
7	11 kV	Sea Green	RAL 6017/ No. 217 as per IS - 5
8	6.6 kV	Aircraft Blue	No. 108 as per IS - 5
9	3.3 kV	Sky Blue	RAL 5015/ No. 101 as per IS - 5
10	415V & 220V AC	Dark Violet	No. 796 as per IS - 5
11	220V & 110V DC	Graphite Black	RAL 9011

Note: Above colours shall be finally agreed upon during detailed design.

1.30 COMPATIBILITY

Equipment serving similar or same purpose shall as far as possible be of same make and type. All indicating lights shall use same type of light bulbs.

1.7.18 Cable Laying

Wiring between equipment enclosures shall be made with cables, laid in trenches and/or cable trays and in cable conduits. The Contractor shall submit for review to the Engineer a cable route layout-showing location of trenches, conduits and trays. All material for cable laying such as cable trays supports and fastening material shall be furnished and placed by the Contractor. Cables shall be properly fastened and marked where they enter enclosures by either cable clamps or nipples.

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Cables in horizontal cable trays shall be fastened properly with clamps or plastic strips. Power and control cables shall be placed in separate trays or conduits. Cables shall be clearly marked at each terminal point.

1.31 HANDLING & TENSIONING DEVICES

Lifting lugs, brackets, eyes, and other items required for attaching lifting devices shall be provided on all of the major components of the equipment weighing more than 24kg. All slings and lifting devices required for attachment to the components and assemblies and to a crane hook for handling during erection and later disassembly shall be furnished. Nylon slings shall be provided for lifting of various components up to 100 Tons. Wire rope slings may be provided for lifting loads more than 100 Tonnes. Hydraulic tensioners shall be provided for tightening of bolts.

1.32 CONTROL CONCEPT

1.32.1 GENERAL

The operations, control procedures, monitoring and protective devices for the plant shall be as described in chapter "Computerized Control and Monitoring system - SCADA" and "Protection system" of PTS (Volume-III(B)). The Contractor shall provide all equipment required for affecting the intended method of operation and control, within the plant.

Primarily, control of equipment shall be automatic, but manual control and/or local control of the various components shall also be possible from control boards during operation, testing and maintenance of the respective components.

Interlocking devices shall be incorporated in the control circuits in the quantity needed to guarantee correct sequence of operation of the equipment. Protective devices shall be supplied and the particular needs of equipment furnished with the aim of ensuring a safe and reliable operation of the plant in the event of electrical and mechanical disturbances or in case of mal-operation by the plant personnel.

In the design of the control system for different parts of the plant the Contractor shall take care of standardizing the components used.

Where programmable logic controllers are used these shall to the extent possible be compatible. Where control systems are based on relays, sufficient information on the operating status shall be provided through potential free changeover contacts connected to outgoing terminals for comfortable connection.

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1.32.2 CONTROL SWITCHES, INDICATING LAMPS AND INSTRUMENTS

Control switches, indicating lamps and instruments shall be arranged so that all parts are readily accessible for servicing without the necessity to remove other devices, terminal blocks or excessive amount of wiring.

All control switches and indicating devices mounted in cabinets and enclosures shall be visible with the doors closed.

Identification nameplates shall be provided for all control switches, indicating instruments and lamps, in accordance with clause .

Instruments and controls shall be located so that their dials, indicators and nameplates are clearly readable. Data for all instruments to be provided, including type, size, scale range, electrical ratings, nameplate and name of manufacturer, shall be furnished. Steel panels shall be provided for group mounting of the instruments. All instruments shall be of an approved type and shall match, insofar as practicable, the other instruments with which they are associated; their dial type, scaled markings and units, type of connection and mounting, shall be co-coordinated. All piping and tubing required for instruments shall be furnished and installed.

All instruments and control switches shall be furnished with necessary auxiliaries, i.e. resistors, shunts etc.

i) Control Switches

The switches and push buttons shall be provided with ample contact ratings, suitable cam or block arrangements necessary for the control functions on 240 V AC or 220 V DC circuits. The control switches used in mimic diagrams shall be of discrepancy type with built in lamp indication.

ii) Indicating and Signalling Lamps

Each indicating and signalling lamp shall have a removable cap, which can be inscribed with wording and shall not be affected with the heat of the lamp. Light bulbs shall be replaceable from the front of the panel. The indicating and signalling lamps shall be of the same size and type.

iii) Indicating Instruments

Refer to the General Technical Specifications, Section-VIII, clause 7.

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iv) Integrating Instruments

The Wh and VArh meters shall be of the semi-flush-mounted type. Each meter shall be connected to terminal blocks suitable for opening and short-circuiting for testing purposes. The meter cases shall be dust-tight and with removable covers. The meters shall be three-phase, three element, equipped with an impulse contact mechanism, potential free for remote metering purposes, and shall be suitable for continuous operation from secondary of potential transformers and from secondary of current transformers, with transformer ratios and connections indicated on the contract Drawings.

The meters shall be provided with primary-rated, direct reading registers, with five or more digits and a suitable multiplier. The meters for the outgoing lines shall be of the two-way type and all meters shall have mechanism to prevent negative registration.

The meters shall have built in over-voltage protection and isolation according to IEC Publication 60521. The tolerance ambient temperature range of the meters shall be 0 to 45 degrees C.

The class of the Wh meters shall be 0.2 and the VArh meters 0.2 according to IEC Publication 60687.

v) Measuring Converters

The converters shall be suitable for direct connection to the secondary circuits of the potential and current transformers used, or other sensors, each as they apply. The converters shall be static type, having all accessories to provide an output signal of 4-20 mA, filtered DC.

For the measuring converters the following minimum requirements shall be fulfilled:

a) Current transducers shall be single-phase, of accuracy class 0.5 or better.

b) Voltage transducers shall be single-phase of accuracy class 0.5 or better.

c) W and VAR transducers shall be two elements, three-phase. Accuracy class of the transducers shall be 0.5 or better.

vi) Measuring Transformers

Potential transformer secondary windings shall be rated 110/ √3 V Current transformer secondary windings shall have a rated current of 1A / 2.5A / 5A as per the design requirements.

1.33 NAMEPLATES

Name plates shall be scribbled with important rated parameters related to equipment as confirmed in the "Guaranteed Technical Particulars" and as defined in the relevant clause 4.9 of "General Technical Specifications.

1.33.1 GENERAL

Each major and auxiliary item of equipment shall have a nameplate permanently affixed thereto, or as directed, showing in a legible and durable manner the serial number, name and address of the manufacture, rated capacity, speed, electrical characteristics, and other significant information, as applicable.

Nameplates of distributing agents only will not be acceptable. Nameplates shall also be provided for identification of all panels, cubicles and other enclosures as well as for panel-mounted devices, dials, gauges instruments and control devices. Nameplates shall be marked with the nomenclature and units of measurement used in the metric system (SI- units), and a schedule of such markings shall be submitted for review. Type of nameplates and wording on identification nameplates shall be submitted in English for approval. The Employer will translate the text if needed and the Contractor shall furnish and attach the nameplates.

1.33.2 CAUTIONARY SIGNS

English along with Hindi shall be used as prime languages on nameplates required for caution or warning signs, identification plates for control devices, and instruction plates etc.

1.33.3 OTHER NAMEPLATES

Nameplates which are not required for the operation of the equipment and are not of a cautionary or warning nature required for the safety of personnel, i.e. showing motor speeds, horse-powers, electrical characteristics, name and address of

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manufacturer and other information necessary for maintenance and repair work shall be in English.

1.33.4 LIST AND DRAWINGS

The above nameplate requirements are general for use in preparing nameplate lists and drawings to be submitted for review. Nameplates shall be submitted for review, as they will appear on the finished equipment.

1.34 PREPARATION FOR FIELD WELDING

All cutting, chamfering, and other shaping of metals necessary for the field connection shall be done as far as possible in the shop. Adequate temporary bolted field connections shall be provided to hold the assemblies rigidly and in proper alignment during shop and field assembly.

To assure proper alignment during field erection, a minimum of two dowels shall be provided for each field connection between subassemblies. The holes shall be drilled and the dowels fitted at shop assembly after the subassemblies have been satisfactorily aligned. All stipulations for welding, structural work and other, shall be applied to fieldwork as well as to shop work, except where otherwise stated.

1.35 SPARE PARTS

Supply of spares shall be as per the details provided in relevant clauses of "General Technical Specifications" & "Technical Specifications".

In addition, the Contractor shall supply sufficient number of erection and commissioning spares based on their experience so that erection, testing and commissioning work progresses smoothly and is not hampered for want of such spares.

The spares parts provided by the Contractor shall be of the same quality and have the same mechanical and/or electrical properties as the original parts and be fully interchangeable with them. If modification is made to equipment during erection, the Contractor shall ensure that these modifications are also made to all spare parts.

Condition for tests, surface treatment, painting, etc., stipulated for the main items/equipment in the GTS/GTR/PTS, shall also apply for their spare parts.

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Spare parts shall be conditioned, packaged, shipped and stored to ensure long term storage without degradation.

The complete set of the spare parts for the works or a section shall be delivered prior to taking over.

1.36 WITNESSING OF SHOP ASSEMBLY AND TESTS

Witnessing of shop assembly as well as shop tests shall be as per the relevant clause of "General Technical Specifications"

1.37 EQUIPMENT SERVICE CONDITIONS

All equipment and material supplied against the contract shall be suitable for operation under the following service conditions

1.37.1 WATER

In order to ascertain characteristics of the water of Ganga River in the power channel of Chilla Hydro Electric Project at powerhouse site, three samples were collected and petrographic analysis of the same was carried out by Indian Institute of Technology, New Delhi through M/s SNC Lavalin Inc. The results of the petrographic analysis are as follows:-

PETROGRAPHIC ANALYSIS DATA (TEST DATE: 28.07.05)

Estimation of total Sediments

S. No.	Parameters	Sample 1	Sample 2	Sample 3
1	Ambience Temperature	35°C	35°C	35°C
2	pH of the sample	7.55	7.5	7.5
3	Volume of sample (ml)	942	971	930
4	Weight of sample (g)	930	964	920
5	Weight of silt in sample	1.113	1.473	1.3037
6	Density of water (g/cc)	0.9873	0.9928	0.9892
7	Density of sample (g/cc)	0.9885	0.9943	0.9906
8	Sediments present (g/l)	1.1815	1.5169	1.4018
9	Sediments present (ppm)	1181.5	1516.9	1401.8

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10	Sediments present (%)	0.1181	0.1516	0.1402
11	Sediments present (cc/l)	0.8439	1.0835	1.0013

Petrographic Composition

S.No.	Mineral Nomenclature	Composition (%)		
		Silt Fraction >150µ	Silt Fraction > 62µ	Silt Fraction <150µ
1	Quartzite	92.21	93.16	94.53
2	Muscovite	0.86	1.02	1.00
3	Biotite	1.04	0.87	0.5
4	Feldspar/ Pyroxene/amphibole	1.94	1.00	0.92
5	Coal/ Vegetative Matter	1.44	0.98	-
6	Clay Minerals	2.00	2.44	2.67
7	Iron Oxide	0.5	0.52	0.38

Shape of Particles

S. No.	Shape Nomenclature	Shape (%)		
		Silt Fraction >150µ	Silt Fraction > 62µ	Silt Fraction <150µ
1	Angular	35	32	26
2	Sub-angular	20	26	27
3	Sub-round	22	20	25
4	Round	11	14	16
5	Prismatic/ Flaky	8	6	5
6	Fibrous/ Woody	4	2	1

1.37.2 SEDIMENTS

The project is situated in Himalayan region where the silt content during high flow period is excessive and peaks abnormally during high flood. Sediments of Himalayan Rivers contain high quartz content having hardness 7-9 on Mho scale. The underwater components may be expected to operate under silt concentration of 3000 ppm. These components **(runner, facing plates of top cover and pivot rings, guide vanes and their respective spares)** shall be designed and provided with erosion resistant coating **(full HVOF)** to minimize the damages due to silt erosion.

Contractor shall critically study the silt data and chemical analysis of water as provided above and take the same into account while designing the turbines, valves and other auxiliary equipment susceptible to abrasive effect of silt, making all such specific provisions and measure including selection of materials, coatings and paintings which will help to resist silt abrasion and enable easy and quick maintenance / replacement of worn out components.

1.37.3 ATMOSPHERIC CONDITION

The temperature and humidity in the area of the project are as follows:

-	Maximum temperature	=	**46.9^{0}C**
-	Minimum temperature	=	**2^{0}C**
-	Annual Mean Rainfall (Project Area)	=	**2136.7mm**
-	Maximum relative humidity	=	**86%**
-	Minimum relative humidity	=	**46%**
-	Basic Wind Speed in area	=	**39m/s**

1.37.4 SEISMICITY

The project is situated in a seismic zone and falls within Zone IV of the seismic zoning Map of India. Value of peak ground acceleration has been recommended as 0.36g for maximum Credible Earthquake (MCE) and 0.18g for Design basis Earthquake (DBE).

The forces being caused by earthquake including hydraulic loads, which may occur additionally, shall be taken in to account for the computations. Stress resulting after including these loads shall not exceed permissible stress limits as per relevant clause of this chapter.

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Sector-142, Noida U.P.

The contractor shall design all equipment supplied, including related erection work under this contract to seismic criteria. The contractor shall submit to the employer the method of seismic design calculation and conformity to IS 1893.

1.38 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 respective 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 code, design and selection criteria, equipment data, material specification, major technical features, basic arrangement layouts etc.

Design memorandum of all the equipment/ system shall be prepared and first draft shall be submitted within six (6) months from the date of award of the contract.

1.39 TECHNICAL DOCUMENTATION

All the technical documents and drawings required to be furnished under this contract as per clause 2 of Section-VIII "General Technical Specifications" shall be prepared in internationally accepted software of latest version used for preparation of documents and drawings. Layout shall be prepared preferably in 3-D form and the Contractor shall furnish software with minimum 10 (ten) user license to Employer's designated office to study/review/approve the drawings during detailed engineering stage. The contractor shall also furnish software proposed to be used for documentation and scheduling with minimum 10 (ten) user license to design office. The software shall be compatible with the Windows 8 and 10 and MS Office programs.

The Contractor shall submit six copies of drawings along with two reproducible and one copy in electronic form media (editable) for approval / review as per clause 20.3 of General Conditions of Contract. At the time of completion of contract, the Contractor shall submit ten copies along with two reproducible and five copies in electronic form in CD media of approved and as built drawings together with operation and maintenance manual as specified in Clause 8 of Special Conditions of Contract.

All the drawings and documents shall be submitted in presentable folders properly bound and catalogued for easy retrieval / reference. Drawings shall be submitted in A0 / A2 /A3 and all documentation in A4 size. Besides, the hard copy and electronic

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media (editable) specified above, all these documents and drawings shall also be incorporated in "Powerhouse Intranet" as specified in Chapter-7 of PTS "Computerised Control and Monitoring system-SCADA".

1.40 DOCUMENTATION / RECORD OF THE WORK/ACTIVITIES

The preparation and submission of the work under this contract for future reference shall be included in the scope of work.

The contractor shall document all the major activities, milestones related to installation of powerhouse from commencement of work under this contract and shall maintain the documentation/record in chronological order till the completion of the job specified under the contract. The Contractor shall prepare an elaborate documentary film/movie titled "Renovation Modernization & Up-gradation" of the Chilla HEP highlighting the panorama of all the major activities in chronological order.

The Contractor shall submit ten copies of above documentation/records and documentary film/movie to the Employer after completion of work under this Contract. The Contract shall be deemed as completed only after the Contractor submits the same.

1.41 DELIVERY, INSTALLATION AND COMMISSIONING

1.41.1 TRANSPORTATION LIMITATIONS

For shipments, the Manufacturer shall pack the items to meet size and weight restrictions of the Indian railways and road systems.

Shipments from Manufacturer's work (in case of foreign manufacturer) shall travel to the Port of entry in India, from where these will be transported, after necessary port clearances etc., by the Contractor to Haridwar , which shall be the nearest rail head for the Project, and further transported to site. However, in certain cases the Contractor may be required to transport the materials from Port of entry to Haridwar and further to Chilla HE Project site directly by road transport. However, Indian contractors shall be responsible in all respects for transportation of all materials and equipment up to the project site.

The contractor shall consult with the concerned authorities of railways and highways to ensure that their packaging will be such as to permit them to transport the plant and equipment within such imposed limits. Manufacturers shall arrange to deliver the maximum size sub-assemblies consistent with safe and convenient transport.

All materials and equipment etc. arrived at Haridwar will be unloaded from rail wagons and reloaded on to road transport for shipment to project site by the Contractor.

The roads and bridges en-route shall be made suitable for loading capacity.

All components shall be so designed and constructed as would enable easy assembly of components at works and at the same time permit easy transportation. The weights and sizes of the components/packages shall be within the permissible transport limits for the project site.

1.41.2 PACKAGING, HANDLING AND SITE STORAGE

The Contractor shall follow the general requirement of Packaging, Handling and Storage as elaborated in "General Technical Specification (GTS)".

The Contractor shall pack all the consignment in sea worthy packaging, wherever required, strong enough to withstand rough handling during transit. Machine surface shall be suitably protected against scratches, corrosion, shocks, impact etc. Packages shall be suitably and distinctly identified for type of handling and kind of storage.

The packaging and storage of electronic equipment shall be strictly in accordance with internationally accepted standards. Electronic equipment shall be packaged, shipped and stored in anti-static packing. All packages shall be stored indoor. Packages containing electronic equipment shall be stored in humidity controlled environment.

1.41.3 INSTALLATION PROCEDURE

The contractor shall submit six copies of all detailed programs and the procedures to be adopted for disassembly, erection/installation, testing and commissioning well in advance, before start of erection activates/installation, for approval of the Employer.

The installation procedure shall also have a section "site quality assurance plan" containing erection data sheets for various components. These sheets should specify site measurements/inspection required to be made for ensuring proper installation.

1.41.4 INSTALLATION & FIELD TESTING

The Contractor shall follow the requirements of installation elaborated in "General Technical Specification (GTS)".

record shall clearly show the achieved erection tolerances vis-à-vis the allowable limits. The installation records shall be submitted to Employer for approval/acceptance to establish completion of installation milestones as per program of performance. All installation records shall be compiled and submitted to the Employer before taking over the respective unit. Completion certificate for any work shall be issued only after approval/acceptance of complete installation records.

1.41.6 FIELD WELDING

The Contractor shall select the proper filler material with respect to parent material for all field welded connections and shall specify it on the applicable drawing, together with the detail design of the field weld joint.

All cutting, chamfering, and other shaping of metals necessary for the field connection shall be done as far as possible in the shop. Adequate temporary bolted field connection shall be provided to hold the assemblies rigidly and in proper alignment during shop and field assembly.

1.41.7 CABLE LAYING

Wiring between equipment enclosures shall be made with cables, laid in trenches and/or cable trays and in cable conduits. The Contractor shall submit for review to the Employer a cable route layout-showing location of trenches, conduits and trays. Material for cable laying such as cable trays supports and fastening material shall be furnished and placed by the Contractor. Cables shall be properly fastened and marked where they enter enclosures by either cable clamps or nipples.

Cables in horizontal cable trays shall be fastened properly with clamps or plastic strips. Power and control cables shall be placed in separate trays or conduits. Cable shall be clearly marked at each terminal point.

1.41.8 FIELD INSPECTION

The Contractor shall permit Employer to perform inspection of the assembly which will include a complete verification of the assembly of all parts as to their levels, clearances, pertinent fits, alignments and quality of workmanship. The field supervisor of the Contractor shall provide Employer with three (3) copies of all the clearances, tolerances and data of all pertinent fits, alignments and levels, so that the latter may repeat the Contractor's measurement, if desired.

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Unless otherwise specified, any rejection based on the inspection will be reported to Contractor within fifteen (15) days and injurious defects subsequent to assembly and acceptances will be rejected.

1.42 SPECIAL TOOLS

Special tools shall be supplied by the Contractor as necessary for erection, installation, operation and maintenance, etc. of each item of equipment supplied under this Contract.

Special tools shall be clearly marked to identify their use and shall be made available for the erection to be undertaken by the Contractor. Special tools shall be shipped with the first consignment of equipment to be erected.

The tools shall be delivered to the Employer prior to taking over, in perfect condition or be replaced, if necessary, with new tools of equal or better quality than the original ones.

The tools and plants like mobile crane, trailer, truck, hydraulic jacks, welding generators, hydraulic test pumps, drill machines, torque wrenches, chain pulley blocks dewatering pumps, HV testing kit, Drying out transformer, brazing equipment etc. shall be arranged by the Contractor and shall be allowed to take away with him

Apart from the tools specifically mentioned in the tender, any other speciality tool not mentioned specifically but is required for routine and capital maintenance of the unit shall be supplied by the contractor without any extra charge.

1.43 MODEL, ROUTINE & TYPE TESTS:

Model, test shall be performed on turbine as specified in chapter of turbine in the "Particular technical specifications". Prices quoted for turbine therefore, shall, be inclusive of the cost of performing the model test.

For **all the** items of equipment, for which carrying out of type tests have been specified/indicated in various chapters of "Particular Technical Specifications" or elsewhere contractor shall furnish copies of Type Tests Certificates for the equipment of the type and ratings similar to those specified. Type Tests Certificates furnished shall be as per the provisions of relevant standards for such equipment. In case the contractor is not in position to furnish, such type tests certificates or the type tests certificate furnished by him are not as per the relevant standard for such equipment and, therefore, not acceptable to the Employer, Type Test for such items and equipment will have to be got conducted by the contractor at his cost.

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The contractor at his own cost shall carry out all tests during manufacturer and/or on site and/or during inspection of Plant and Equipment and part thereof at the place of manufacturer and/or the site based on the provisions contained in the relevant standards for such equipment and/or good engineering practice.

1.44 TRAINING TO EMPLOYER'S PERSONNEL

The Contractor shall arrange training to familiarize the employer's personnel about constructional and O&M aspects of equipment wherever need of specialized training is felt during detail engineering. Cost of such training shall be borne by the Contractor. Travelling expenses, of the personnel deputed on such training, however shall be borne by the Employer. The Contractor shall arrange for necessary living, accommodation, boarding & lodging and other facilities such as food & local conveyance etc. at the site of training for trainee or resident representative of the Employer free of cost.

Besides above, the Contractor shall hold training sessions to familiarize the Employer's Personnel with all aspects of operation and maintenance of the plant and sub-systems before the beginning of the dry tests on site. The technical documentation used in the training sessions shall include the Contractor's draft operation and maintenance manuals and test procedure descriptions approved by the Engineer. Employer shall, in writing, intimate the names and designation of persons to be trained by the contractor for training during the tenure of the contract. The contractor shall provide suitable training for each phase of work as per the details agreed at the time of award.

a) General Requirement of training

The contractor shall provide suitable instructors, training material and facilities (instruments, apparatus, simulators, documents, drawings, protective clothing, rooms, office supplies etc.) for the personnel made available by the Employee for training.

On month before the start of the training, the employer shall send the list of the trainees and comments (if any) on the training program proposed by the contractor. This program shall be adapted to the design aspect and varied nature of the work such as plant operation as well as plant maintenance so as to cover the trainees coming from various fields.

The contractor shall supervise and provide direction to, and be liable for the acts or omissions, other than negligent or wilful misconduct of such personnel, of the Employer's trainees.

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The contractor shall provide the training described hereafter in accordance with any further specific requirements stated in the Employer's requirements.

The contractor shall assist the Employer in obtaining any visas/ permissions and any other formalities for entering or leaving the foreign territory at which the training is being provided.

The contractor shall bear responsibility for ensuring the safety of the trainees during their stay in the foreign or domestic territory for the training. On their part, the trainees shall comply with the laws, regulations and customs of the country bin which training is being provided.

b) Training of employer's personnel

The scope of service under training of Employer's engineers shall include a training module covering the following:

i) **Training during engineering/ manufacturing phase:**

This shall cover all disciplines viz. Mechanical, Electrical, Hydro engineering, hydro mechanical, installation & commissioning and Quality Assurance etc. and shall include all the related areas like design familiarisation, training on product design features, and product design software of major equipment and systems, engineering, manufacturing, erection, commissioning, training on operating features of equipment, quality assurance and testing, plant visits and visits to the manufacturer's works/ design office, exposure to various kinds of erection problems which may be encountered in fabrication, manufacturing, erection, welding etc. The training in areas of operation & maintenance shall take place preferably during end of manufacturing and related tests. The proposed training for various equipment and systems shall be minimum 21 man-months.

ii) **Training during erection/ installation/ testing & manufacturing phase:**

Independently from the supervision and inspection functions of the Employer's Representative, the contractor shall authorize the Employer's personnel to follow the erection/ installation/ testing & commissioning and site work at his site.

The Employer's start – up Personnel shall take no part in the equipment erection and / or installation work, which shall be exclusively carried out by the contractor and under his entire responsibility.

This onsite training shall cover each phase of erection/ installation/ testing & commissioning and shall be of sufficient duration.

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The contractor shall supply the information or measurements concerning the erection requested by the Employer's Representative or/and by Employer's personnel.

The contractor shall also provide on the job training in the operation and maintenance of the works to the Employer's Operating Personnel. Such training shall start at least 30 days prior to the commencement of Tests on Completion and continue until Taking Over. It scope and quality shall be such as to provide the trainees with comprehensive understanding of all operational and maintenance aspects of the work. Such training shall also include safety and environmental protection aspects applicable to the work.

The proposed training for various equipment and systems shall be minimum 11 man-months.

A tentative breakup of the training schedule is briefed up hereunder: -

S.No.	Name of Packages	Training during engineering/ manufacturing phase (mandays)	Training during ETC Phase (mandays)
1	Turbine and Digital Governor System and any other Associated Auxiliaries etc.,	240	130
2	Generator and Associated System and Auxiliaries etc.,	150	65
3	Power Transformers and Auxiliary dry type Transformers	20	10
4	Plant Computerized control & monitoring system -SCADA	75	45
5	Protection System	75	60
6	Switchyard Equipment ,HT and LT Switchgears System , DC system and Associated Auxiliaries etc.,	50	10
7	Electrical Testing and Measurement System	0	5

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8	Other system such as Fire Fighting System, Illumination System, DG Set, HVAC, Cooling water System, Low Pressure Compressed Air system, and other equipment specified in Tender Document.	20	5
Total Man Days		**630**	**330**
Total Man-Month (1months=30 working days)		**21**	**11**

1.45 MODEL QAP

i) It is clearly understood that all the Routine Tests and type Test (where ever mentioned) are to be performed in the presence of the Employer's Representative, whether specifically mentioned or not.

ii) Provisions contained in various chapters and respective Model Quality Assurance Plan (QAP) for conducting the Type Test / furnishing Type Test reports shall be read in conjunction with the stipulations of relevant clause of this chapter.

SECTION: I

SUB-SECTION: C-3

TECHNCIAL SPECIFICATION

(ELECTRICAL PORTION)

`

TECHNICAL SPECIFICATION

FOR

HVAC

(ELECTRICAL PORTION)

1.0 EQUIPMENT & SERVICES TO BE PROVIDED BY BIDDER:

a) Services and equipment as per "Electrical Scope between BHEL and Vendor".

b) Any item/work either supply of equipment or erection material which have not been specifically mentioned but are necessary to complete the work for trouble free and efficient operation of the plant shall be deemed to be included within the scope of this specification. The same shall be provided by the bidder without any extra charge.

c) Supply of mandatory spares as specified in the specifications.

d) Erection and Commissioning spares

e) Erection & Maintenance tools & tackles

f) Electrical load requirement for **HVAC.**

g) All equipment shall be suitable for the power supply fault levels and other climatic conditions mentioned in the enclosed project information.

h) Bidder to furnish list of makes for each equipment at contract stage, which shall be subject to customer/BHEL approval without any commercial and delivery implications to BHEL

i) Various drawings, data sheets as per required format, Quality plans, calculations, test reports, test certificates, operation and maintenance manuals etc shall be furnished as specified at contract stage. All documents shall be subject to customer/BHEL approval without any commercial implication to BHEL.

j) Motor shall meet minimum requirement of motor specification.

k) LT switchgear panels shall meet minimum requirement of LT switchgear specification.

l) LT power & control cables shall meet minimum requirement of LT power & control cables specification.

m) Cabling, earthing & lightning protection shall meet minimum requirement of cabling, earthing & lightning protection specification

2.0 EQUIPMENT & SERVICES TO BE PROVIDED BY PURCHASER FOR ELECTRICAL & TERMINAL POINTS:

Refer "Electrical Scope between BHEL and Vendor".

3.0 DOCUMENTS TO BE SUBMITTED ALONG WITH BID

3.1 Bidder shall confirm total compliance to the electrical specification without any deviation from the technical/quality assurance requirements stipulated. In line with this two signed and stamped copies of the following shall be furnished by the bidder as technical offer:

a) A copy of this sheet ”Electrical equipment Specification for HVAC” and sheet “Electrical Scope between BHEL and Vendor” with bidder’s signature and company stamp.

b) List of Erection & Maintenance tools & tackles.

c) Electrical load requirement

3.2 No technical submittal such as copies of data sheets, drawings, write-up, quality plans, type test certificates, technical literature, etc, is required during tender stage. Any such submission even if made, shall not be considered as part of offer.

List of enclosures :

a) Electrical scope between BHEL & vendor

b) Technical specification, datasheets & quality plans for 415V Electric motors

c) Technical specification, datasheets & quality plans for 415V LT Switchgear

d) Technical Specification, datasheets & quality plans for LT power & control and screened control cables.

e) Technical Specification, datasheets & quality plans for cabling, earthing & lightning protection

f) Electrical Load data format

g) List of mandatory spares and special tools and tackles

ELECTRICAL SCOPE BETWEEN BHEL AND VENDOR

PACKAGES : HVAC

SCOPE OF VENDOR: SUPPLY, ERECTION & COMMISSIONING OF VENDOR'S EQUIPMENT

PROJECT: CHILLA HEP (RM&U) 4X36 MW

S.NO	DETAILS	SCOPE SUPPLY	SCOPE E&C	REMARKS
1	415V MCC	Vendor	Vendor	1. 415 V AC (3 phase 4 wire) /240 V AC supply (1ph) shall be provided by Vendor. BHEL shall provide 2 incomer feeders of Maximum rating up to 630A. Bidder to take care of further power distribution.
2	Local Push Button Station (for motors)	Vendor	Vendor	Located near the motor.
3	Power cables, control cables and screened control cables for a) both end equipment in vendor's scope b) one end equipment in vendor's scope	 Vendor Vendor	 Vendor Vendor	1. Finalisation of cable sizes shall be done by Vendor meeting specification requirements. Vendor shall provide lugs & glands accordingly. 2. Laying of cables by Vendor. 3. Termination at equipment terminals by Vendor.
4	Any special type of cable like compensating, co-axial, prefab, MICC, optical fibre etc.	Vendor	Vendor	
5	Cable trays, accessories & cable trays supporting system	Vendor	Vendor	
6	Cable glands, lugs and bimetallic strip for equipment supplied by Vendor	Vendor	Vendor	1. Double compression Ni-Cr plated brass cable glands 2. Solder less crimping type heavy duty tinned copper lugs for power cables 3. Solder less crimping type heavy duty copper lugs for control cables.
7	Conduit and conduit accessories for cabling between equipment supplied by vendor	Vendor	Vendor	Conduits shall be medium duty, hot dip galvanised cold rolled mild steel rigid conduit as per IS: 9537. Makes of conduits shall be subject to customer approval at contract stage.
9	Lighting	BHEL	BHEL	
10	Equipment grounding & lightning protection	Vendor	Vendor	
12	LT Motors with base plate and foundation hardware	Vendor	Vendor	Makes shall be subject to customer approval at contract stage.
13	Mandatory spares	Vendor	-	Vendor to quote as per specification.
14	Recommended O & M spares, E & C spares, erection & maintenance tools & tackle.	Vendor	-	As per specification
15	Any other equipment/material/service required for completeness of system but not specified above (to ensure trouble free and efficient operation of the system).	Vendor	Vendor	

ELECTRICAL SCOPE BETWEEN BHEL AND VENDOR

PACKAGES : HVAC
SCOPE OF VENDOR: SUPPLY, ERECTION & COMMISSIONING OF VENDOR'S EQUIPMENT
PROJECT: CHILLA HEP (RM&U) 4X36 MW

S.NO	DETAILS	SCOPE SUPPLY	SCOPE E&C	REMARKS
16	a) Input cable schedules (C & I) b) Cable interconnection details for above c) Cable block diagram	Vendor Vendor Vendor	- - -	Cable listing & cable routing for C & I systems for vendor supplied equipment shall be furnished during detail engineering by vendor in soft copies.
17	Electrical Equipment & cable tray layout drawings	Vendor	-	For ensuring cabling requirements are met, vendor shall furnish Electrical equipment layout & cable tray layout drawings (both in print form as well as in AUTOCAD) of the complete plant (including electrical area) indicating location and identification of all equipment requiring cabling, and shall incorporate cable trays routing. Electrical equipment layout & cable tray layout drawing shall be subjected to BHEL/ customer approval without any commercial implications to BHEL.
18	Electrical Equipment GA drawing	Vendor	-	For necessary interface review.

NOTES:

1. Make of all electrical equipment's/items supplied shall be reputed make & shall be subject to approval of BHEL/customer after award of contract.
2. All QPs shall be subject to approval of BHEL/customer after award of contract without any commercial implication.
3. Supply and E & C of LT cables, Cable tray and tray support system for incomer to HVAC switchgear shall be in vendor's scope. Route Length from source PMCC shall be approx. 150m.

Chapter 10 – 415V LT System

Table of Content

10.1. SCOPE

10.1.1. This section/ chapter of the specification covers the provision of all labour, plant and materials and performance of all work necessary for dismantling, transportation & storage of items at Employer's store, reverse engineering & site measurements on existing legacy structures & equipment in order to determine site limitations & constraints, detail design and engineering, manufacture, quality assurance, quality control, shop assembly, shop testing, transportation, delivery at site, site storage & preservation, erection, testing and commissioning including performance testing, field acceptance test, training of employer's personnel, handing over of plant to the Employer and guarantee of Twenty Four (24) months from commissioning of "415V Low Tension (LT) System" complete with all accessories such as panels, circuit breakers, MCCBs, MCBs and including supporting structures and cubicles for making the equipment complete and for warranting a trouble free safe operation.

10.1.2. Dismantling of existing 415V system components shall be done in such a way that dismantling allows operation of remaining units without any trouble while one of them is under comprehensive RMU.

10.1.3. The control and relay panel shall form integral part of 415V LT system (i.e. shall be physically integrated into one unit). In addition to this remote closing, tripping, ON/OFF status, annunciation, indication and fault logging of every switchgear panel shall be part of computerized control and monitory system scheme such that 415 V switch gear supervisory control shall be done through main control room of plant.

10.1.4. Tolerances on all the dimensions shall be in accordance with provisions made in the relevant Indian/IEC standards and in the specification. Otherwise the same shall be governed by good engineering practice in conformity with required quality of the product.

10.1.5. The protection scheme and specification of protection system for "415V Low Tension (LT) System" and "Cabling System" are defined in chapter 14:"Protection System".

10.1.6. The specification shall be read and construed in conjunction with General technical requirement and chapters of PTS of bidding document. In the event of any discrepancy with listed documents, the stipulation of this specification shall govern.

10.2. SCOPE OF WORK

The scope of work shall be a comprehensive functional system complete in every respect including but not be limited to following:

10.2.1. The "415V Low Tension (LT) System" shall be consisting of:

S.No.	Description	Unit & Quantity
1	Unit Auxiliary Boards (UABs) of indoor metal enclosed 415V switchgear type, complete with cubicles, protection, metering, bus bar system, draw out type electrically operated air circuit breakers, fixed MCCBs, instrument transformers, instruments, cabling, communication ports for integration with plant SCADA system, wiring, and other accessories for making the system functional.	Four (4) sets
2	Station Auxiliary Boards (SABs) of indoor metal enclosed 415V switchgear type, complete with cubicles, protection, metering, bus bar system, draw out type electrically operated air circuit breakers, fixed MCCBs, instrument transformers, instruments, cabling, communication ports for integration with plant SCADA system, wiring, and other accessories for making the system functional.	Two (2) sets
3	Secondary Station Supply Boards (SSSBs) complete with cubicles, protection, metering, bus bar system, draw out type electrically operated air circuit breakers, draw out type MCCBs, instrument transformers, instruments, cabling, communication ports for integration with plant SCADA system, wiring, and other	1 (One) Lot

	accessories for making the system functional.	
4	All cabling, conduit/ cable racks laying, interconnections etc. for making the system functional.	One(1) lot

10.2.2. The insulating mat (Class-A (0 to 3.3 kV), at least 2.0 mm thick) of appropriate length and width shall be provided in front of LT switchgear panels such as SABs, UABs, at LT room and SSSBs throughout the powerhouse complex including powerhouse building and adjoining areas such as draft tube deck, fore bay intake, switchyard etc.

10.2.3. Coordination and provision of necessary contacts and/or ports for integration with plant SCADA system as per Chapter-7 of PTS: Plant computerized control and monitoring system/SCADA

10.2.4. Other items not specified above but are necessary for satisfactory operation of the system and as decided during detailed engineering.

10.2.5. All special devices, tools, maintenance equipment etc., required for installation, testing commissioning and maintenance of the transformers and the distribution systems.

10.2.6. Spares

10.3. DESIGNATION OF LT SWITCHGEAR

The following abbreviations for the LT supply boards shall be used:

S.No.	Board Nomenclature	Acronym
1	Unit Auxiliary Board	UAB
2	Station Auxiliary Board	SAB
3	Unit Auxiliary Transformer	UAT
4	Station auxiliary Transformer	SAT
5	Switchyard Switch Board	SSB
6	HVAC Switch Board	HVACSB
7	Drainage & Dewatering Switch Board	DDSB
8	Erection Bay Switch Board	EBSB
9	Fore-bay Intake Switch board	FISB
10	Workshop Switchboard	WSB
11	Isolated Phase Bus Duct	IPBD

10.4. DESCRIPTIVE DATA

10.4.1. Existing electrical auxiliary system:

Requirement of auxiliary loads of power station operated at 3-Ø, 415V AC or 1-Ø, 230V AC is catered through existing SABs & UABs and Secondary Station Supply Boards (SSSBs). The existing SABs & UABs are located at the LT room at generator floor while the SSSBs are located at various places near the load centres within the Chilla HEP complex. The SAB-1 & 2 are fed from respective SAT-1 & 2 and two Nos. Diesel Set respectively while UAB-1,2,3 & 4 shall be normally charged through UAT-1,2,3&4 which are in turn charged through 11kV IPBD. UABs & SABs are also interconnected for interconnectivity & redundancy.

10.4.2. Requirement:

All existing LV auxiliary boards and secondary station switchboards are to be replaced with new state of art panels and boards complete in all respect equipped with automatic transfer system. Hence Air Circuit breakers shall be selected for adequate communication & operation compliance and each shall be properly integrated with computerized control and monitoring system /SCADA by the contractor thus enabling remote automatic operation of the boards in various combinations. Thus automatic transfer of supply between SABs and UABs shall be established.

10.4.3. Location:

10.4.3.1. The location of existing LT equipment, LT board and its secondary switch boards are as follows:-

S.No.	Name of Boards	Location	Elevation
1	SAT	GSU deck	El.303.00M
2	UAT	GSU deck	El.303.00M
3	D.G. set	Truck turning area	EL.303.00M
4	UAB	LT room	El.299.6M
5	SAB	LT room	El.299.6M
6	SSB	132 Switchyard	El.306.00 M
7	HVAC Board	AC room	El.295.30 M
8	DDSB	Turbine floor	El.295.10 M
9	EBSB	Erection bay	El.298.60 M
10	WSB	Workshop room	El.298.00 M
11	FISB	Fore bay	El.330.00 M

10.4.3.2. Space/ Area

S.No	Name	Elevation	Dimension
1	LT room	El.299.6M	19250X9000 mm
2	Control Room	El.299.6M	19050X9000 mm

10.4.4. Operation Philosophy:

10.4.4.1. During normal operation of the unit, each UAB shall be fed electrical power through its respective Unit auxiliary Transformer (500 kVA, 11/0.415 kV) which in turn shall be fed from the 11 kV IPBD. The UABs thus shall cater the loads of the respective units.

10.4.4.2. The common Station load shall be catered through SAB-1 & 2 being fed through respective 1000kVA, 11/0.415 kV SAT–1 & 2. Each SAT shall be charged from 11kV bus panels at switchgear room in the switchyard complex and inter connection between the 11kV bus panels & the SATs shall be through 11 kV cables of suitable capacity. 11kV bus panels shall be charged from two sources viz. 5MVA, 132/11kV Station Transformer and 33kV 3MVA 33/11KV Transformer at the Chilla colony substation.

10.4.4.3. The two SABs, in addition to feeding the station auxiliary loads, can also back feed the UAB of each unit for black starting purposes and also feed the adjacent SAB in case of its supply failure. An electrical interlock shall prevent simultaneous feeding of UAB from unit and from SSB.

10.4.4.4. Supply to feed essential loads in the event of loss of power from both SATs shall be ensured through Emergency Diesel sets on Auto start mode. The DG sets circuit breaker will close on the condition that both the two incomer breakers fed from the respective SATs are open and the Diesel set is running. In case both the DG sets are require to be operated, the bus coupler between SAB – 1 & 2 shall also be required to be opened. The SCADA system shall be capable of carrying out above operations automatically from remote location i.e. powerhouse control room, however, exact philosophy shall be finalized during detailed engineering.

10.4.4.5. The UABs, in addition to feeding their own unit auxiliaries can also feed the UABs of its adjacent unit as well as respective SAB in case of its supply failure. The arrangement is required for emergency purpose only where utmost care shall be taken during operation so that the load catered through the UAB does not exceed the load being fed through SAB.

10.4.4.6. The UABs, SABs and secondary station service switchboards shall be equipped with necessary instruments, such as digital voltmeters, ammeters, CTs, PTs, 220 V dc operated circuit breaker controls and indicating lamps for breaker position and power status, single phasing preventer, thermal overload relays, over current and under voltage relays.

10.4.4.7. Each UABs, SABs, secondary station service switchboards shall be provided with protection relays and programmable logic controller to achieve the required automatic changeover logic from unit supply to station supply and vice-versa. The PLC's shall be interfaced with the powerhouse auxiliary control unit, which in turn shall interface with the Digital Distributed Control System (DCS).

10.4.4.8. The 415/240V Secondary Station Service Switchboards and motor control centres (MCC) consisting of the Switchyard Board (SSB), Heating Ventilation Air Conditioning Switch Board (HVACSB), Drainage & Dewatering Board (DDSB), Erection Bay Board (EBB) etc. shall be fed through either of the two SAB- 1&2. The incomer circuit breakers of each secondary service board shall be essentially inter-locked, controlled locally, in order to prevent the occurrence of common fault on SAB-1 and SAB-2. The upstream Gate Control Board (FISB) shall be fed from SAB-1, and the Workshop Board (WSB) shall be fed from the Erection Bay Board (EBB) or from the SAB-2. Exact connection shall be decided during detailed engineering.

10.4.4.9. All the equipment shall be so designed & selected so as to ensure easy & proper integration of the complete system with the Powerhouse control system i.e. Plant SCADA.

10.5. ELECTRICAL SYSTEM DATA:

10.5.1. System particulars:

Unless otherwise agreed upon the rating, insulation levels and test voltages of equipment and devices in the system shall be as follows:

S.No.	Parameters	Values
A	**System Parameters**	
1.	Highest System voltage	440V
2.	Nominal system voltage	415V
3.	Rated frequency	50 Hz

4.	Rated power frequency withstand voltage 60s for main circuits	2.5kV(r.m.s)
5.	Rated power frequency withstand voltage 60s for control circuits	2.0 kV(r.m.s)
6.	Steady state voltage Variation	± 10 %
7.	Steady state frequency Variation	± 5 %
8.	Combined Voltage Frequency	± 5 %
9.	System fault level at rated voltage	50 KA for 1s
10.	System Earthing	Solidly Earthed
B	**Control supply for Electrical System**	
11.	Spring Charging Motors for 0.415kV LT Air Circuit Breakers	220V DC
12.	Closing Circuit	220V DC
13.	Trip Coil :	220 V DC
14.	Alarm :	220 V DC
15.	Indication :	220 V DC
16.	Relay Auxiliary Supply :	220 V DC
17.	Heaters in Panels :	240V AC (Single phase neutral(SPN))
18.	LT Motor Starters	
19.	Control Voltage :	110V AC, SPN derived through control transformer
20.	Indications	240V AC, SPN
21.	Space Heater Circuit :	240V AC, SPN

10.5.2. Basic Dimensions and Minimal Ratings

S.No.	Parameters	Values
A	**Unit Auxiliary Boards & Station Auxiliary Boards**	
1.	Rated current of bus bars of UABs	1200 A
2.	Rated current of bus bars of SABs	1600 A
3.	Rated short time withstand current bus bar and boards for 1 s	25 kA

4.	Rated circuit breaker short circuit breaking capacity for UAB and SSB	25 kA
5.	Rated circuit breaker short circuit breaking capacity for UAB and SSB	25 kA
B	**Secondary Station Service Switchboards**	
6.	Rated Voltage	415 /240 V
7.	Rated current	800 A
8.	Rated short time withstand current bus bar and boards, 1 s	25 kA
9.	Rated circuit breaker short circuit breaking capacity	25 kA
10.	Rated circuit breaker short circuit breaking capacity	25 kA

10.5.3. Switchboards

Unit Auxiliary Boards and Secondary Station Service Switchboards shall have at least following feeders for catering power distribution requirement of various loads, however exact requirement shall be finalized during detailed engineering. Any other switchboard/ number of feeders, not mentioned here but essential for completeness of system shall be supplied and commissioned by contractor:-

S.No	Description	Nos.
1	**Unit Auxiliary Switchboards (each)**	
a	32 A feeders	**10**
b	63 A feeders	**3**
c	125 A feeders	**2**
2	**Drainage & Dewatering Board**	
a	150 A feeders	**3**
b	125 A feeders	**3**
c	100 A feeders	**3**
d	63 A feeders	**2**
e	32 A feeders	**2**
3	**HVAC Board**	
a	100 A feeders	**4**
b	63 A feeders	**4**
c	32 A	**24**
4	**Switchyard Board**	

a	63 A feeders	**4**
b	32 A feeders	**4**
5	**Erection Bay Board**	
a	63 A feeders	**5**
b	32 A feeders	**4**
c	200 A feeders	**2**
d	250 A feeders	**2**
6	**Workshop Board**	
a	100 A feeders	**2**
b	63 A feeders	**6**
c	32 A feeders	**6**
7	**Fore-bay Intake Control Board**	
a	200 A feeders	**1**
b	100 A feeders	**6**
c	63 A feeders	**3**

10.6. CODE AND STANDARDS

10.6.1. The design, manufacture and performance of the equipment shall comply with all currently applicable statutes, regulations and safety codes. Nothing in this specification shall be construed to relieve the tenderer of this responsibility.

10.6.2. Unless otherwise stated hereafter, ratings, characteristics, tests and test procedures, etc. concerning to equipment under this chapter shall comply with the provisions and requirements of the latest approved recommendations of the Bureau of Indian Standards (BIS) or International Electro-technical Commission (IEC), each as they apply and in particular ,to the following:

S.No.	Standard	Description
1.	IS:60947-1/2007	Low-Voltage Switchgear and Control gear Standards Part1: general rule.
2.	IS:60947-2/2003	Low-Voltage Switchgear And Control gear - Part 2: Circuit Breakers.
3.	IS:60947-3/1999	Low-Voltage Switchgear And Control gear - Part 3: Switches, Disconnections, Switch-Disconnections And Fuse Combination Units.
4.	BIS IS/IEC 60947-4-1:2000	Low-voltage Switchgear And Control gear - Part 4: Contactors And Motor-starters - Section 1: Electromechanical Contactors

		And Motor-starters.
5.	IS 13947-5/1993 (R2004)	Control circuit devices and switching elements.
6.	IS 8623-3(R2004)	Specification for factory built assemblies of switchgear and control gear for voltage up to and including 1000 V ac and 1200 V dc.
7.	IS 10118-4	Code for practice for selection installation and maintenance of conductors and apparatus terminals.
8.	IS 12021	Specification of control transformers for switchgear and control gear for voltage not exceeding 1000V ac.
9.	IS 3043/ IEC60364-3	Code of practice for earthing.
10.	IS 3072	Code of practice for installation and maintenance of switchgear.
11.	IS 3231	Electrical Relays for power system protection.
12.	IS 5	Colours for ready mixed paints and enamels.
13.	IS 5578	Marking of insulated conductor.
14.	IS11353	Guide for Uniform System of Marking and Identification of Conductors and Apparatus Terminals.
15.	IS 1248	Indicating instruments.
16.	IS13779 &CBIP-88	Energy meters
17.	IS 6875	Control switches.(amended up to date)
18.	IS 4794/68 & 86	Push button.
19.	IS 8085	Interconnection bus bar for AC voltage up to 1KV up to and including 36KV
20.	IS 3156	Voltage transformers
21.	IS 2705	Current transformers

10.7. PERFORMANCE CRITERIA AND GUARANTEE

The 415V LT system equipment with all accessories shall be capable of performing all intended duties and it is the responsibility of the Contractor to supply the equipment as per guaranteed technical particulars.

10.8. DESIGN AND CONSTRUCTION

The Contractor shall try to accommodate the new equipment in the space vacated on account of dismantling of the existing equipment, however final call shall be taken as per the design adequacy during detailed engineering.

10.8.1. LT switchgears

10.8.1.1. UABs, SSBs and Secondary Station Service Board

a) Each Unit Auxiliary Board will normally be powered by respective 500 kVA Unit Auxiliary Transformer. Each Station Auxiliary Board shall be catered through respective Station Auxiliary Transformer. In the case of a grid failure, the diesel engines shall be started automatically and power automatically switched to the power house through Station Auxiliary Boards. However, it is the responsibility of the Contractor to complete the work in all respect and to make the scheme functional.

b) The interconnection between transformers and the switchgear assembly shall be made through cables or bus bar as per the adequacy of design.

c) The 415V LT system shall be solidly grounded through powerhouse grounding mat, four wires (3 phases + neutral), according to IEC Publication 60364-3. In case risers in the existing mat are not available in the new locations, grounding electrodes or satellite grounding mat shall be supplied and installed by the contractor for fulfilment of the design requirement.

d) The rated continuous current of any circuit connection or component shall correspond to the maximum current for which that connection or component is designed to carry continuously during operation, under the most unfavourable service conditions.

e) The LT switchgear shall be compatible with plant SCADA, regarding input and output needed for operation, control and monitoring of LT switchgear and SCADA. The Contractor shall comply with provisions of ‘computerised Control and Monitoring’ scheme of the power house

f) Local Control switches and instruments shall be mounted on the circuit breaker compartment doors / front side of the panel.

10.8.1.2. Construction of Switchgears

a) The switchgear related to UABs, SABs and Secondary Station Service Board (SSSBs) shall be totally enclosed, metal clad, sheet steel fabricated, dust & vermin proof, free standing, floor mounted type with self-supporting structure and provided with integral base frame at bottom. Cable entry shall be provided from bottom with un-drilled gland plate. All doors shall be fastened to the vertical section by means of concealed hinges. The sides, top & bottom of each vertical section shall be covered with removable screw-on plates with formed edges all around.

b) The cubicle assemblies/panels shall be designed in accordance with the recommendations of IEC Publication 60439-1 with protection class IP 42 according to IEC Publication 60529.

c) The assemblies must be built to suit the equipment shown on the single line diagram.

d) The frame of the cubicles shall be sufficiently sturdy and the metal sheeting of sufficient thickness to ensure safe transport, mounting and operation without deformation or bulging.

e) Bus bars shall not be exposed when Air Circuit Breaker module is removed. Insulated and isolated vertical bus bars shall be provided for keeping accidental flashover due to rodents at bay. Barriers shall be provided to separate the bus compartment from wiring space at top, bottom and sides of each section and shall be adequate to prevent accidental contact and restrict propagation of unit originated arc into the bus bar compartment.

f) Air Circuit Breaker shall be “Siemens/Schneider/ABB/GE” make and shall be draw-out type. Each CB compartment door shall be interlocked with door mechanically so that it cannot be opened unless the Switch operating handle is moved to the "OFF" position. However, the handle mechanisms of the Switch shall be so designed that a qualified person can defeat the door interlock for purpose of inspection without interrupting power.

g) Natural ventilation as required shall be provided. Provision for future expansion of cubicles shall be made in end cubicles.

h) Continuous lifting angle or lifting hooks shall be provided to facilitate the installation of the cubicles.

10.8.1.3. Major equipment

The 415V LT system shall contain the following major equipment

including the necessary bus bars and wiring.

a) Four (4) Unit Auxiliary Boards.
b) Two (2) Station Service Boards.
c) Minimal Seven (7) Secondary Station Service Boards.

The details of some of the equipments to be provided in the above-mentioned boards are indicated below. However, the quantities are to be worked out by the Contractor and shall be approved by Employer during detail engineering.

a) Draw out type, motor charged spring operated Air Circuit Breakers with magnetic short circuit over current and instantaneous trip as well as protection defined in Chapter -14 according to single line diagram. The ACBs shall have communication ports for integration with plant SCADA

b) Required number of Moulded Case Circuit Breakers (MCCBs).

c) Required No. of single phase, single core current transformers as per details provided above.

d) Required Nos. of ampere meters, rated 1200A with selector switches for UAB

e) Required Nos. of ampere meters, rated 1600A with selector switches for SABs

f) Required Nos. of ampere meters, rated 800A with selector switches for Secondary Station Service Boards.

g) Required Nos. of voltmeters with selector switches rated 500V and required Nos. of under voltage relay.

h) Local control switches.

i) Indicators as specified.

j) Winding temperature alarm and trip along protection relays for the auxiliary transformers. (Other transformer protections like UAT, SAT, over current and REF etc shall be supplied under chapter "Protection system").

k) All necessary auxiliaries for control and supervisory circuits.

l) Other feeder units necessary to fulfil the requirements of the specification and sockets etc.

m) All secondary wiring, terminal blocks, labelling and nameplates, sockets etc.

n) All necessary AC bus bars. (including N- bus bar)

o) Cubicle LED lighting including lighting fixtures and power and communication sockets

p) Cubicle space heating including heating elements

q) Energy meters in incoming panels of UAB, SSB and Secondary Station Service Board.

10.8.2. Bus Bars

The bus bars of UABs, SSBs and SSSBs shall have a continuous current carrying capacity of minimum 1200A, 1600 A and 800 A respectively. Bus bar conductors shall be made of electrolytic copper. All connections shall be in accordance with the best modern practice.

A continuous PEN bus of the same cross section as the main bus shall be furnished and connection of ample size shall be brought to each feeder compartment, for bolted connection of the feeder PEN wire.

Phase arrangements shall be R-Y-B from top to bottom, from back to front and from left to right when facing the front of the equipment. All bus bars shall be clearly marked by engraved letters.

Adequate provisions must be made for the expansion and contraction of the bus bars and other bus bar connections with variation in temperature. Bus bars shall be so arranged that they can be extended in length without difficulty.

All field connections shall be bolted. The connections shall be kept as short and straight as possible. Bus bars, connections and their insulating supports shall be of approved construction, mechanically strong and shall withstand all the stresses, which may be imposed upon them under ordinary working conditions due to vibration, temperature fluctuations, short circuit or other reasonable causes.

10.8.3. Air Circuit Breakers

10.8.3.1. The Contractor shall provide “Siemens” make Air Circuit Breakers (ACBs) in accordance with schedule of equipment of this

specification and the single line diagrams. The air circuit breakers shall be designed in accordance with the recommendations of IEC Publications 60947.1 and 60947.2. All circuit breakers shall be of the draw out type, housed in individual metal-enclosed compartments. Each air circuit breaker shall be mounted on a carriage assembly with wheels running on tracks secured to the inside of the compartment. The carriage shall have self-engaging definite position stops for disconnected, test and connected position. Means shall be provided for easy removal and handling of the breakers.

The air circuit breakers shall be three pole electrically operated with motor driven spring stored-energy operating mechanism. The motor for operating the spring loading device shall be for 220V D.C. supply. The closing and tripping coils shall be for 220V DC. The closing mechanism shall be trip-free and wired so that "pumping" is not possible. Manual charging and operation of the breakers shall be possible. The provision for remote indication and operation shall be made.

The operating handle shall be located so that the air circuit breakers can be operated without opening the compartment door.

A mechanical interlock shall prevent moving of the air circuit breaker from the connected position, while the breaker is closed, and prevent the access door being opened unless the circuit breaker is in test or withdrawn position.

The frame of the air circuit breakers shall be solidly grounded in both test and connected positions. In the test position, it shall be possible to operate the breaker and perform complete functional tests.

The air circuit breaker shall be equipped with shutters, which automatically cover live parts when the breaker is withdrawn. Provision shall be made for padlocking the circuit breaker in the disconnected and test position.

10.8.3.2. The main circuit breaker contacts shall be of the self-cleaning type, made from an arc resisting material and provided with auxiliary arcing contacts as a protection against burning during the operation of the breaker. All contacts shall be self-aligning, and shall be readily replaceable.

Main and secondary disconnecting contacts shall be silver plated with springs, which will ensure high-pressure contacts. Secondary contacts shall be engaged both in connected and test position.

Auxiliary contacts for position indication, control, interlocks, etc., showing whether the breaker is in open, closed or tripped position and whether the operating spring is locked, shall be provided and

wired to terminals. Mechanical position indicators, visible from the outside without opening the circuit breaker compartment door, shall also be provided. At least 2 NO and 2 NC auxiliary contacts shall be provided for each breaker as spares.

10.8.3.3. The air circuit breakers shall be equipped with adjustable magnetic short circuit over current and instantaneous trip mechanism/ relay, with auxiliary magnetic short circuit contacts for indication of tripped condition. The protection equipment shall be interchangeable.

10.8.3.4. Each air circuit breaker shall be equipped with facilities for remote operation. Each air 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 air 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 the control circuits.

Auxiliary contacts for the following remote indications of the circuit breakers shall be wired to terminal blocks:

a) Main contact position
b) Test and connected /service position.
c) Trip condition
d) Fault condition
e) Spring charging condition

10.8.3.5. Each Air circuit breaker shall have provision for remote operation via communication bus using IEC61850 Protocol for SCADA and shall be electrical and process interlock Hardwired from closing and tripping circuit and interlocking logic.

10.8.4. Moulded Case Circuit Breakers

10.8.4.1. The Contractor shall provide MCCBs in accordance with Schedule of equipment of this specification. The MCCBs shall be designed in accordance with the IEC Publications 60947.1 and 60947.2. All MCCBs shall be manually operated and shunt trip type.

All MCCB shall be of the fixed type, housed in individual metal-enclosed compartments. Each MCCB shall be mounted on a carriage assembly with wheels running on 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. ON, OFF TRIP position of MCCBs should be indicated.

A mechanical interlock shall prevent moving of the MCCB from the connected position, while the breaker is closed, and prevent the access door being opened unless the breaker is in withdrawn position.

10.8.4.2. The MCCB contacts shall be of the 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.

10.8.4.3. MCCBs shall be operable by means of push button switches/ handle.

10.8.5. Current Transformers

The Contractor shall provide following single phase current transformers manufactured in accordance with IEC Publication 60044-1

The ratings for CTs of UAB's, SSB's of air circuit breakers shall be decided during detailed engineering and shall be provided in accordance with IEC 60044.

Other air circuit breakers connected to UAB and SSB shall have single core CTs of suitable rating (based on capacity of breaker) for protection of 5P20 class.

10.8.6. Transformer Burden and Connections

The burden rating of all current transformers shall not be less than 200% of the overall computed burden of apparatuses connected to each transformer.

The secondary windings of all current transformers shall be grounded at one point only and means shall be provided to facilitate the secondary windings to be short-circuited.

10.8.7. Voltage Transformers

Required No. of voltage transformer shall be provided for metering and interlock. Accuracy class for voltage transformer should be as following

- Protection cores 3P
- Metering 0.2

The contractor shall use single-phase 240V supply available in switchgear for metering and indication.

10.8.8. Cubicles

10.8.8.1. Each cubicle shall be divided into sections, or compartments, housing the incoming, interconnecting or out going feeder air circuit breaker units and moulded case circuit breaker units respectively. Each ACB and MCCB unit shall be mounted on a 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 the unit.

10.8.8.2. Cable Compartments

All feeders to and from the cubicle assemblies will be cables. The assemblies shall be accessible for the cables from bottom to each feeder circuit breaker via separate cable compartment. Solder less connectors shall be furnished for each power conductor entering the equipment. Provisions shall be made to clamp and fasten cables in the cable compartment.

10.8.9. Wiring

All secondary and control wiring shall be done with stranded copper wires, of size 1.5mm2, with voltage rating 1.1 kV, except that current transformer secondary leads shall not be less than 2.5 mm^2. All control wiring within the assembly housing shall be installed at the manufacturer's premises.

All connections shall be made with solder less lugs. All wires and connections to remote equipment shall be wired to terminal blocks. The terminal block shall be according to IEC Publication 60947-7-1.

All spare compartments shall be completely wired. All terminals and terminal blocks shall be marked according to an approved system. Terminal blocks shall have approximately 10% extra terminals as spare and for future circuits.

10.8.10. Metering

All instruments, relays and control switches mounted in the switchgear shall be in accordance with chapter “Control and Monitoring” and “Protection system”. Instruments shall be furnished with all necessary resistors, shunts etc.

For each Air circuit breaker, one number of “3-Ø Electronic static power metering equipment (single units) shall be provided for measurement of voltage, current ,PF, kW, KVA, KVAr, kWh, KVAh, Maximum demand in KVA for 15/30 minutes interval. Metering

equipment is not required for bus coupler. All power metering equipment shall be SCADA Compatible IEC 103 or MODBUS.

Energy meter, ampere meters and ammeter selector switches, voltmeters and voltmeter switches shall be located in the respective Circuit Breaker compartment doors.

All metering circuits shall be terminated in terminal blocks for remote metering purposes.

10.8.11. Interlocks

The breakers connecting the UAB's to the unit auxiliary transformers shall be interlocked mutually in order to prevent paralleling of the supply during normal operation. Interlocking scheme to prevent parallel operation of UAT supply to SAT supply and DG set supply shall also be provided by Contractor. All breakers shall also be equipped with mechanical lock with key. In case of sustained voltage drop at the UABs, an automatic changeover to the other Station service boards shall be provided.

10.8.12. Name Plates

Each feeder shall be clearly identified with suitably located nameplate(s). Nameplates shall be furnished for all instruments, control switches, etc. Each section of an assembly shall have an identifying nameplate placed near the top edge.

10.8.13. Annunciators

Suitable numbers of 9-12 Window Annunciators suitable for the visual and audible alarm annunciation shall be provided for SAT`s and UAT`s. These shall be micro processor based units using bright LEDs. Annunciator facia units shall have translucent plastic windows for each alarm point and shall be suitable for flush mounting on panels. Replacement of individual facia inscription plate and LED shall be possible from front of the panel. Each annunciator shall be provided with 'Accept', 'Reset' and 'Test' push buttons, coloured red, yellow and blue respectively. In case 'RESET' push button is pressed before abnormality is cleared, the LEDs shall continue to glow steady and shall go out only when normal condition is restored. Any new annunciation appearing after the operation of 'Accept' for previous annunciation, shall provide a fresh audible alarm with accompanied visual, even if the process of "acknowledging" or "resetting" of previous alarm is going on or is yet to be carried out. Provision for testing healthiness of visual and audible alarm circuits of annunciator shall be available.

10.9. QUALITY CONTROL AND ASSURANCE

The contractor shall follow the quality assurance and testing requirements specified separately in Volume-III-D: Model Quality Assurance Plan.

10.10. DRAWINGS, DOCUMENTS AND DESIGN CALCULATIONS

10.10.1. Drawings

Successful tenderer shall minimally furnish following drawings for approval before commencement of supply.

a) Foundation details for SABs, UABs
b) Single line schematic diagram for SAB, UAB Switchgear.
c) General arrangement (GA) of indoor LV Switchgear.
d) DC control circuit diagram
e) Name Plate & Connection diagram of Current Transformer* Voltage diagram
f) Metering circuit Diagram for SAB, UAB and Secondary Station Service switchboards.
g) Annunciation and Alarm scheme.
h) P.T. supply change over scheme.
i) Terminal block details for incomer, bus coupler & feeder section.
j) Cross section view for CTs.
k) Cross section view for PTs.
l) Any other scheme/ drawings.

10.10.2. Documents

The Contractor shall submit all relevant documents such as equipment and component O&M manual

10.10.3. Design Calculation

The Contractor is required to submit the design calculation for following to the Engineer for approval during detail engineering.

a) Design memorandum of complete scheme.
b) Fault level at each board taken in consideration for their design
c) Load on various transformers and burden on CTs

10.11. SHOP TEST

10.11.1. General

10.11.1.1. Cubicle Assemblies

The cubicle assemblies shall be tested in accordance with the IEC Publication 60439. Type test certificate of similar assembly shall be provided by the Contractor. Routine tests shall be done on all assemblies.

10.11.1.2. Circuit Breakers

The circuit breakers shall be tested in accordance with IEC Publications 60947-1 and 60947-2. Type test certificate of similar circuit breaker of each type shall be provided by the Contractor. Routine tests on all circuit breakers

10.11.1.3. Contactors

The contactors shall be tested in accordance with IEC Publications 60947-4-1 and IEC 61095. Type test certificate of contactor of each type shall be provided by the Contractor. Routine tests on all contactors

10.11.1.4. Current Transformers

The current transformers shall be tested in accordance with IEC Publication 60044-1. Type test certificate of current transformer of each type shall be provided by the Contractor. Routine tests on all current transformers

10.11.2. Operational Test:

All electrical equipment and installations shall be subject to a complete operational test to check the correct operation thereof in terms of the operational requirements specified in these Specifications.

10.11.3. Certificates

Instead of carrying out the type tests, the Contractor shall submit suitable certificates for tests made on equipment of the same type and same capacity. However, the Employer reserves the right to accept these certificates or to reject them partially or totally.

The Contractor shall prepare written documents, in a form agreed upon by the Contractor and the Employer, of all test results and hand over these documents to the Employer in due time.

10.12. INSTALLATION AND COMMISSIONING

The Contractor shall furnish all labour, tools, supplies, shims, and supports, and all other items or materials necessary to assemble, erect, and install the equipment in a thorough workmanlike manner following the best modern practices. The equipment and all 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 manufacture of modern equipment. The proper elevations and centrelines to which equipment is to be set shall be established by the Contractor.

All civil works required for foundation shall be carried by the Contractor. The contractor is required to submit all foundation drawings and supporting steels well in advance.

10.13. FIELD TESTS

All the equipment being supplied by the contractor shall comply with the requirements of type tests prescribed in the relevant IEC/IS standard. It shall be certified by the contractor that type test in accordance with the relevant standards have been successfully carried out for all the equipments.

The contractor shall furnish a complete outline of the proposed methods and procedures to be followed for auxiliary and station transformer, valve house transformer including 415 V switchgear testing. The list of equipment and instruments to be used, shall be included in the above and the list be submitted to Employer for review at least 60 days before schedule testing.

After installation and prior to putting the switchgear into operation, at least the following tests shall be made:

a) Power frequency withstand-voltage test
b) Functional and operational tests
c) Measurement of the insulating resistance of the different power and control circuits, including cables, instruments and apparatus, against earth.
d) Adjustment of the protection equipment
e) Calibration of relays.
f) Resistance measuring of all major circuits.
g) Other test as suggested by the Contractor and / or Employer at site.

The Contractor shall prepare written documents, in a form agreed upon by the Contractor and the Employer, of all test results and hand over these documents to the Employer in due time.

All necessary materials and labour for performing these tests shall be provided by the Contractor. All test equipment and instruments shall be furnished by the Contractor and will remain Contractor’s property after fulfilment of all tests.

10.14. SPARE PARTS

The following specified spare parts, which shall comprise the total requirement for 415V LT system under this Contract, shall be supplied.

S. No.	Description	Unit & Quantity
1	Complete Air Circuit breaker of each type used	1 No.
2	MCCB of each type used	2 Nos.
3	Current transformer of each type used.	3 Nos.
4	Supporting insulator of each type used.	6 Nos.
5	Bushing of each type used.	1 No.
6	Arcing chamber assemblies for each type of circuit breaker.	2 Sets
7	Main contacts for three poles, with spring, bolts, nuts etc. for each type of circuit breaker.	10 sets
8	Primary isolating contacts used.	10 sets
9	Coils for tripping and closing of each type used.	12 nos.
10	Complete motor drives, of each type.	4 nos.
11	Complete spring closing mechanism for the breakers. (If applicable)	13 nos.
12	Overload and instantaneous trip mechanism for circuit breakers of each type used.	3 nos.
13	Indication lamps used including assemblies	10 nos. of each type
14	Fuses of all type used	10 nos. of each type
15	Control and instrumentation switches	3 nos. of each type
16	Contactors of each type used	4 nos. of each type
17	Indicating instruments	2 nos. of each type
18	Under voltage relays	2 nos.
19	Over current and E/F relays	2 nos.

A set is defined as the total number required for one breaker.

10.15. SPECIAL TOOLS

The Contractor shall provide one set of all necessary special tools and maintenance equipment for repairs and maintenance of the LT switch gear equipment, as recommended by the manufacturer.

A list of such tools shall be approved during detail engineering.

However, it shall include at least following maintenance equipment for repairs and maintenance of the LT switchgear,

a) One portable hand operated hoist for lifting and moving the draw out type circuit breakers. The hoist shall be mounted on a trailer with rubber tires and ball bearings.
b) One relay test plug of each type.
c) One breaker test cable, with plugs for testing the breaker in disconnected position.
d) One hand lever or crank for manual closing of the electrically operated breakers. (or other means as applicable)
e) One complete set of all special wrenches, tools, etc. required for the installation, maintenance and repair of the equipment furnished under this chapter.

GENERAL NOTES, GA, SLD, SCHEMATIC DIAGRAM, BOM

FOR

WORKSHOP BOARD (WSB)

PROJECT - CHILLA RMU (4X39 MW)

CUSTOMER – UJVNL, UTTARAKHAND

BHARAT HEAVY ELECTRICALS LTD. BHOPAL (INDIA)
(A GOVERNMENT OF INDIA ENTERPRISE)

	NAME	SIGN	DATE
PREP.	S.SARKAR	-SD-	04.02.2025
CHD.	S.JUNEJA	-SD-	04.02.2025
APPD.	S.SHARMA	-SD-	04.02.2025

HPE (415)

TITLE: -	BHEL Doc. No:	REV.
GN, GA, SLD, SCHEMATICS, BOM FOR WORKSHOP BOARD (WSB)	**HPE/CHIL/LTAC/WSB**	**01**

समराट सरकार / Samrat Sarkar
वरिष्ठ प्रबंधक / Sr. Manager
एच. पी. ई. विभाग / H.P.E. Division
बी.एच.ई.एल., भोपाल / B.H.E.L., BHOPAL

GENERAL NOTES:-

1. DESIGN PARAMETERS AC SYSTEM

3PH, 4WIRE, SOLIDLY EARTHED

a. VOLTAGE : 415V AC ± 10%
b. FREQUENCY : 50HZ + 3% - 5%
c. COMBINED VARIATION IN VOLTAGE & FREQUENCY : ± 10% ABSOLUTE SUM
d. RATED INSULATION VOLTAGE : 1100V
e. FAULT LEVEL : 25KA/1SEC

2. ENCLOSURE

PRODUCT NAME : WORKSHOP BOARD (WSB)
TYPE : SINGLE FRONT DRAWOUT
MCCB - DRAWOUT TYPE
MCB/LINE PT/BUS PT - FIXED TYPE
CABLE ENTRY : BOTTOM
PANEL ACCESS : AS PER DRAWING
PAINT SHADE (EXTERNAL & INTERNAL) : RAL-7035 - LIGHT GREY
: MOUNTING PLATES-ORANGE
: MINIMUM THICKNESS 60 MICRONS
PAINT TYPE : POWDER COATING
DEGREE OF PROTECTION : INDOOR FLOOR MOUNTED
: IP42

3. BUSBAR

BUSBAR : 400A 25KA/1SEC TPN TINNED COPPER BUSBAR

HORIZONTAL BUSBAR :
PHASE : 1X30X10mm TINNED COPPER
NEUTRAL : 1X30X5mm TINNED COPPER
EARTH : 1X30X5mm TINNED COPPER

MIN. CLEARANCE:
PHASE TO PHASE : 25.4 MM
PHASE TO NEUTRAL : 19 MM
PHASE TO EARTH : 19 MM
NEUTRAL TO EARTH : 19 MM
BUSBAR SUPPORT : SMC/DMC INSULATORS

4. THICKNESS

STRUCTURE : 2 mm of CRCA
DOOR/OVER/PARTITION : 1.6 mm of CRCA
GLAND PLATE (REMOVABLE) : 3 mm of CRCA FOR MULTICORE CABLES & 4mm ALUMINIUM FOR SINGLE CORE CABLES (NON MAGNETIC)
BASE FRAME : ISMC 75 CHANNEL (75MMX40MMX5MM)

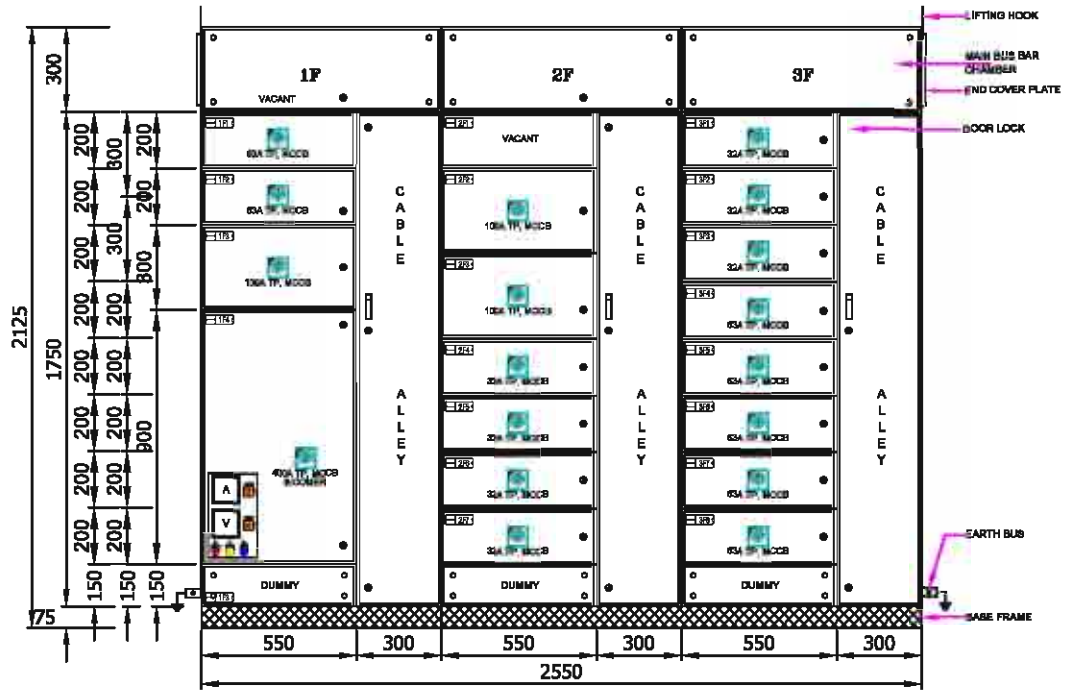
5. CONTROL WIRING

DC VOLTAGE CIRCUIT : 2.5 SQ. MM CU WIRE
AC VOLTAGE CIRCUIT : 1.5 SQ. MM CU WIRE
AC CURRENT CIRCUIT : 2.5SQ. MM CU WIRE
CT & PT WIRING : 2.5SQ. MM CU WIRE
OTHER AUX. AC CIRCUIT : 1.5 SQ. MM CU WIRE(BLACK)
EARTH WIRE CIRCUIT : 2.5 SQ. MM CU WIRE(GREEN)

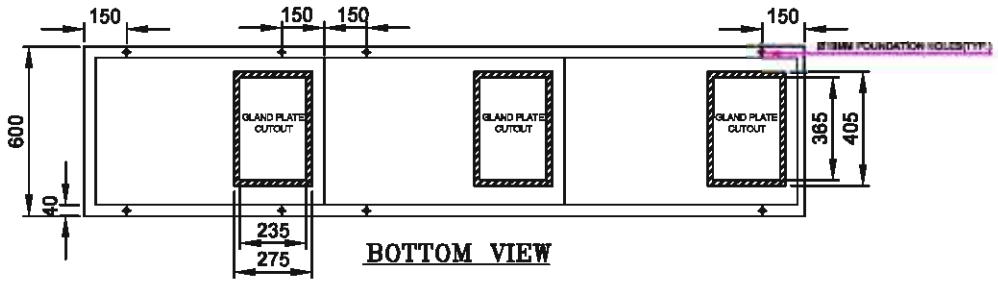
NOTE:- ALL CONTROL WIRES SHALL BE 1.1KV GRADE, PVC, CU FLEXIBLE TYPE.

6. ASSEMBLY

1) MINIMUM 10% TERMINALS IN SPARE SHALL BE PROVIDED.
2) CT's CONNECTION TO BE MADE WITH DISCONNECTING TYPE TERMINALS FOR METERS & RELAYS.
3) CT TERMINATION TO BE DONE WITH RING TYPE LUGS.
4) NAME PLATE SHALL BE PROVIDED.
5) BUSBARS SHALL BE COVERED WITH HEAT SHRINKABLE COLOURED PVC SLEAVE,RED,YELLOW & BLUE FOR PHASE IDENTIFICATION.
6) ALL DOOR SHALL BE EARTHED WITH Cu. WIRE.
7) ACCESSABLE LIVE PARTS SHALL BE SHAROUDED WITH FRP/ACRYLIC/POLYCARBONATE SHEET .
8) TPN MEANS TP SWITCHGEAR WITH REMOVABLE TYPE NEUTRAL LINK FOR MCCB.
9) GASKET SHALL BE PROVIDED INSIDE THE DOORS AND PANEL JOINTING TO MAKE THE PANEL DUST & VERMIN PROOF.
10) BUSBAR WILL BE INSULATED WITH HEAT SINK PVC SLEEVES.
11) OPERATING HEIGHT MINIMUM 300MM & MAXIMUM 1800MM.



FRONT VIEW

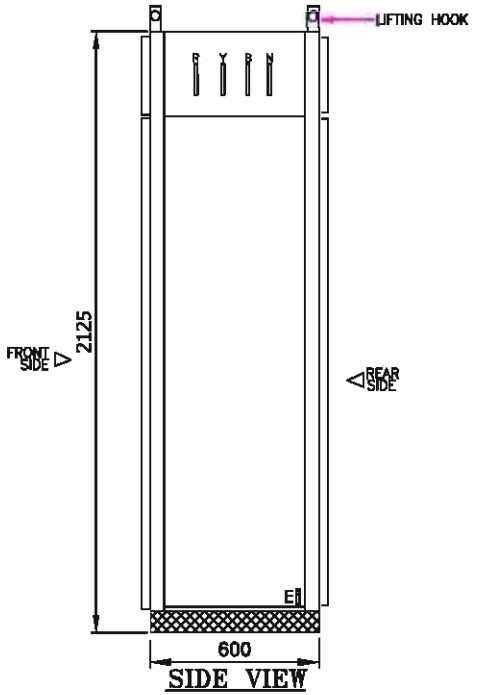


BOTTOM VIEW

GLAND PLATE SIZES

GLAND PLATE NO.	GLAND PLATE CUTOUT SIZE	GLAND PLATE SIZE
1F,2F & 3F	365X235MM	405X275MM

QTY. 01 No.



SIDE VIEW

LEGEND DETAIL	
LEGEND	DESCRIPTION
R	INDICATION R–PHASE 'RED'
Y	INDICATION Y–PHASE 'YELLOW'
B	INDICATION B–PHASE 'BLUE'
A	ANALOG AMMETER
ASS	AMMETER SELECTOR SWITCH
V	ANALOG VOLTMETER
VSS	VOLTMETER SELECTOR SWITCH

FABRICATION:– INDOOR TYPE FLOOR MOUNTED SINGLE FRONT DRAWOUT

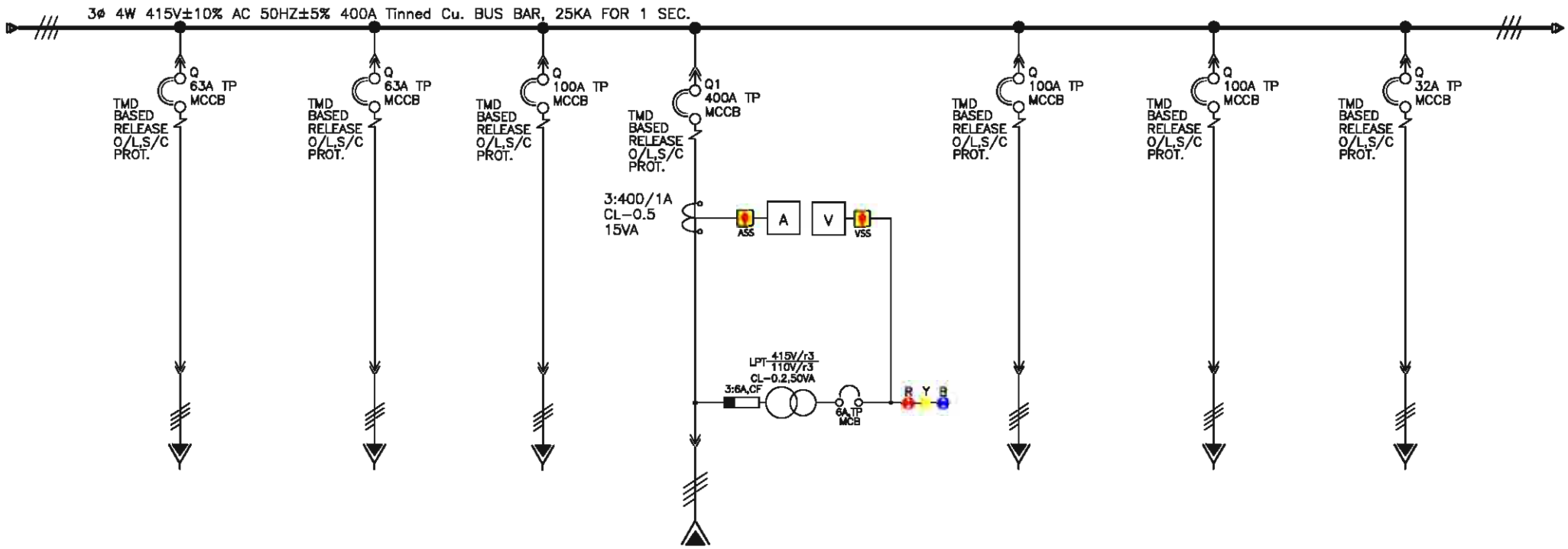
BUS BAR:– 400A TPN TINNED COPPER 25kA/1Sec.

HORIZONTAL BUSBAR:–

PHASE : 1:30X10 MM TINNED COPPER
NEUTRAL : 1:30X05 MM TINNED COPPER
EARTH : 1:30X05 MM TINNED COPPER

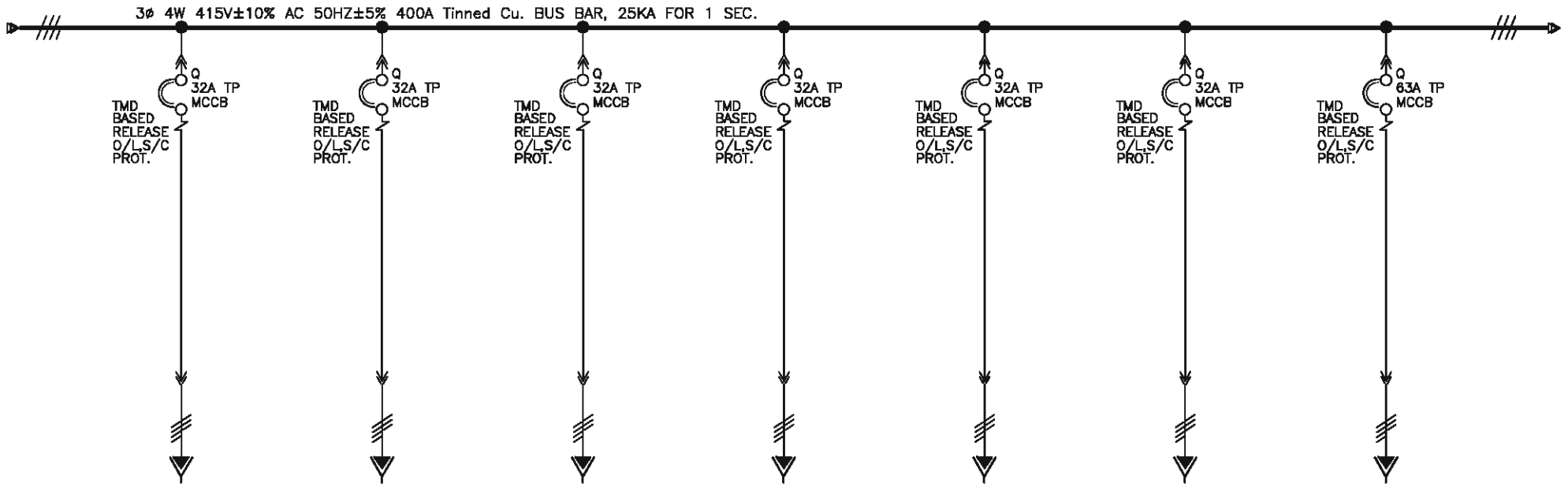
CABLE ENTRY : BOTTOM ONLY

QTY. 01 No.



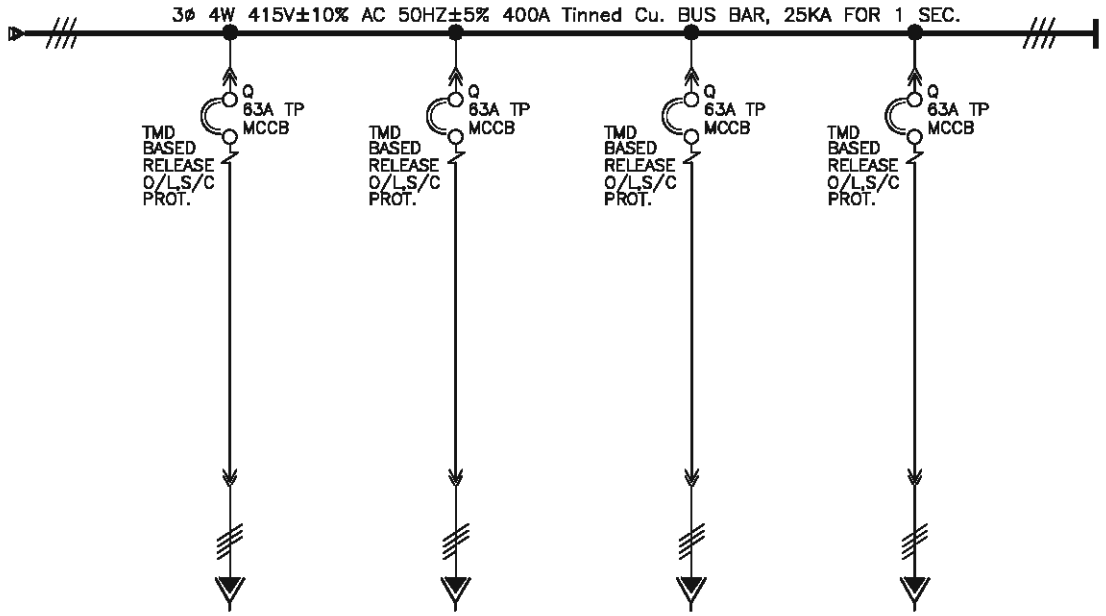
FEEDER No.	1F1	1F2	1F3	1F4	2F2	2F3	2F4
FEEDER RATING	63A	63A	100A	400A	100A	100A	32A
TYPE OF FEEDER/STARTER	PSF	PSF	PSF	PSF	PSF	PSF	PSF
FEEDER DESCRIPTION	W/B LOAD-3	W/B LOAD-4	SPARE	INCOMER FROM ERECTION BAY BOARD	W/B LOAD-1	W/B LOAD-2	W/B LOAD-9
SCHEME TYPE	E01	E01	E01	I02	E01	E01	E01
CABEL SIZE	--	--	--	--	--	--	--

-- PLEASE SPECIFY THE CABLE SIZE



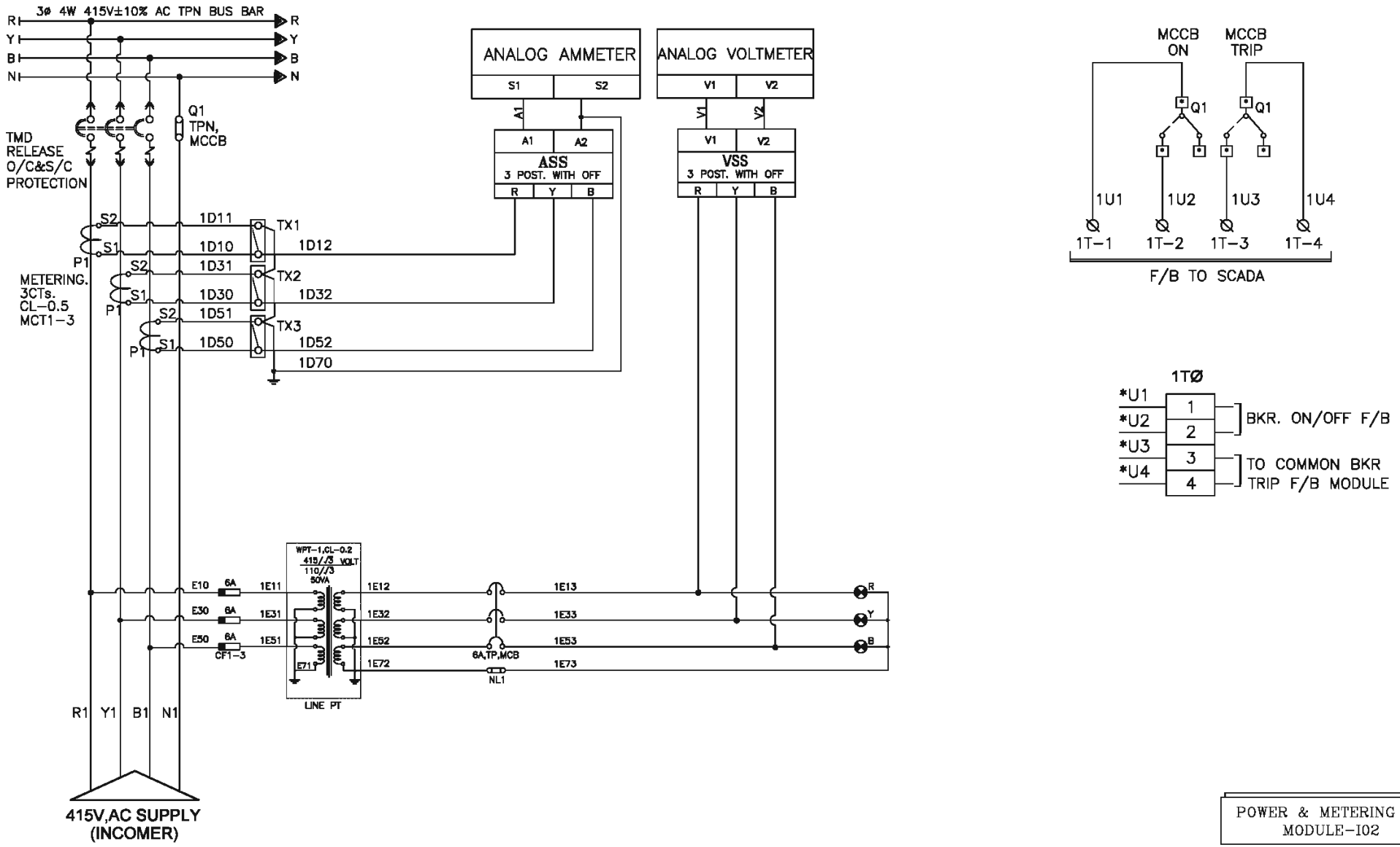
FEEDER No.	2F5	2F6	2F7	3F1	3F2	3F3	3F4
FEEDER RATING	32A	32A	32A	32A	32A	32A	63A
TYPE OF FEEDER/STARTER	PSF	PSF	PSF	PSF	PSF	PSF	PSF
FEEDER DESCRIPTION	W/B LOAD-10	W/B LOAD-11	W/B LOAD-12	W/B LOAD-13	W/B LOAD-14	SPARE	W/B LOAD-5
SCHEME TYPE	E01	E01	E01	E01	E01	E01	E01
CABEL SIZE	--	--	--	--	--	--	--

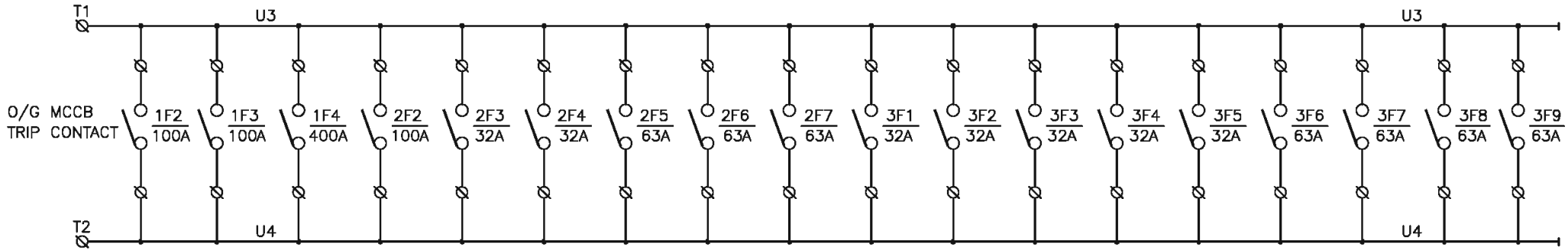
-- PLEASE SPECIFY THE CABLE SIZE



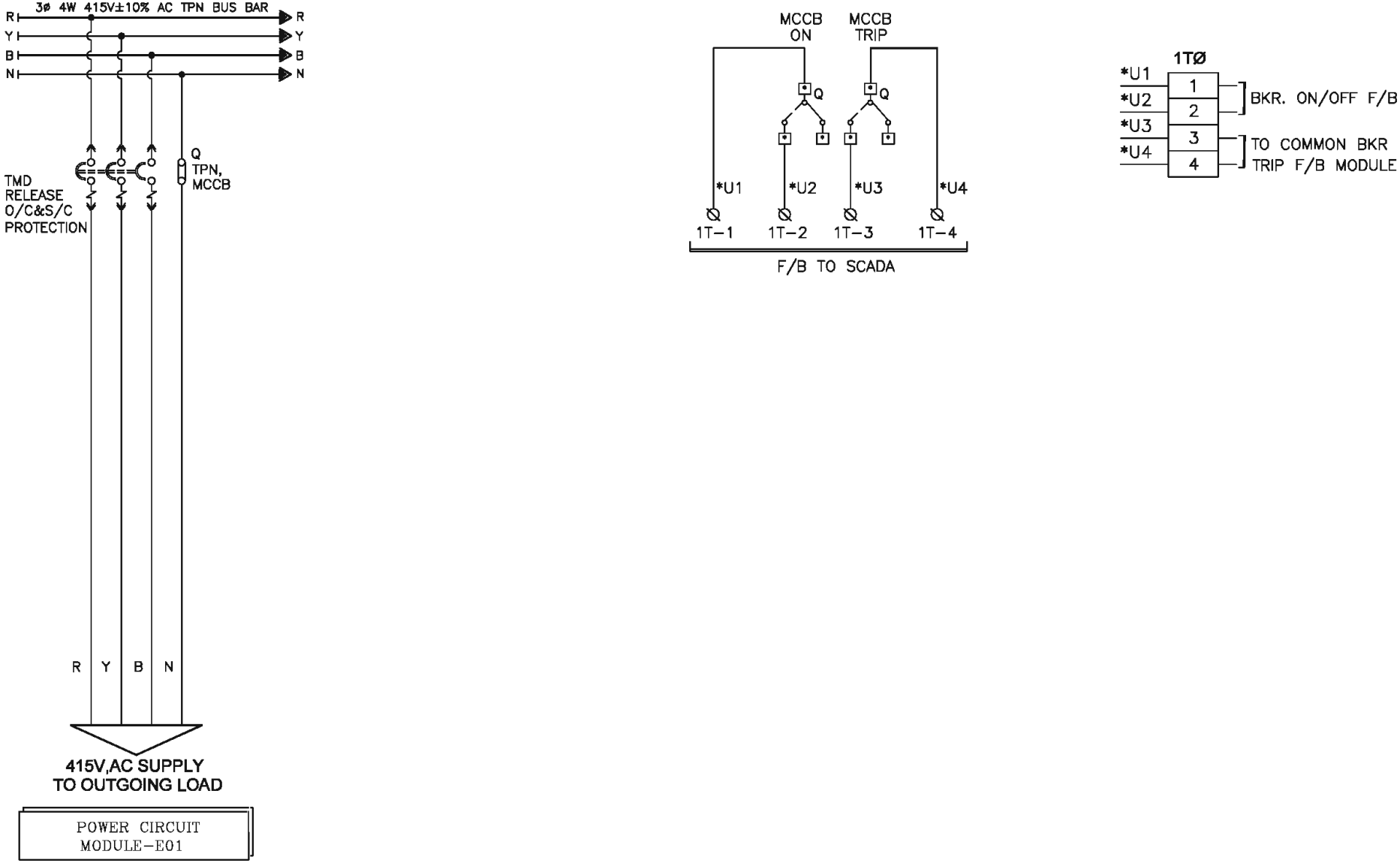
FEEDER No.	3F5	3F6	3F7	3F8
FEEDER RATING	63A	63A	63A	63A
TYPE OF FEEDER/STARTER	PSF	PSF	PSF	PSF
FEEDER DESCRIPTION	W/B LOAD-6	W/B LOAD-7	W/B LOAD-8	SPARE
SCHEME TYPE	E01	E01	E01	E01
CABEL SIZE	--	--	--	--

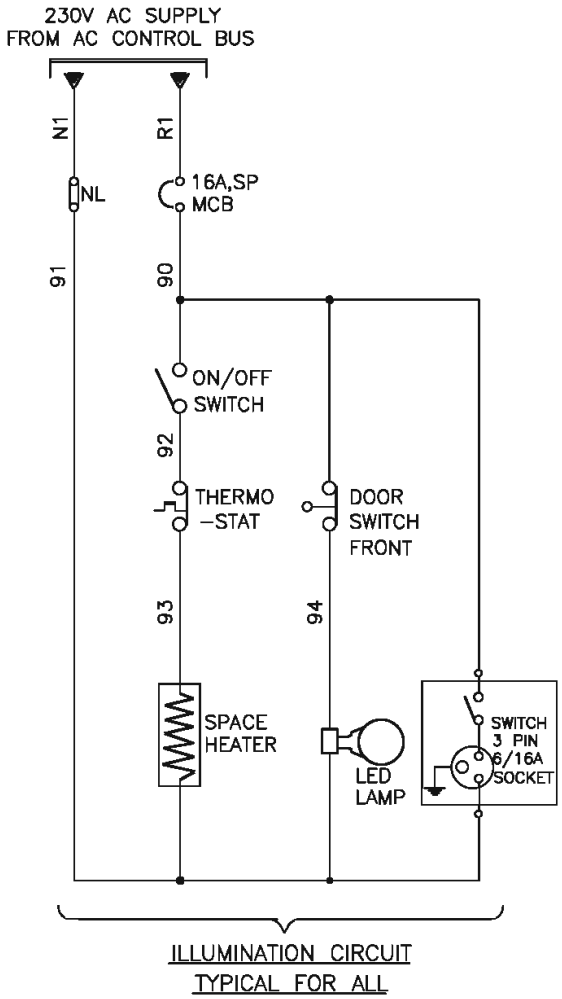
-- PLEASE SPECIFY THE CABLE SIZE


3ø 4W 415V±10% AC TPN BUS BAR
R
Y
B
N
Q1
TPN,
MCCB
TMD
RELEASE
O/C&S/C
PROTECTION
METERING.
3CTs.
CL-0.5
MCT1-3
P1
S1
S2
1D11
1D10
1D31
1D30
1D51
1D50
TX1
TX2
TX3
1D12
1D32
1D52
1D70
ANALOG AMMETER
S1
S2
A1
A2
ASS
3 POST. WITH OFF
ANALOG VOLTMETER
V1
V2
VSS
MCCB
ON
MCCB
TRIP
1U1
1U2
1U3
1U4
1T-1
1T-2
1T-3
1T-4
F/B TO SCADA
1TØ
*U1
*U2
*U3
*U4
BKR. ON/OFF F/B
TO COMMON BKR
TRIP F/B MODULE
WPT-1,CL-0.2
415/√3 VOLT
110/√3
50VA
E10
E30
E50
6A
CF1-3
1E11
1E31
1E51
1E12
1E32
1E52
1E72
1E13
1E33
1E53
1E73
E71
6A,TP,MCB
NL1
LINE PT
R1
Y1
B1
N1
415V,AC SUPPLY
(INCOMER)
POWER & METERING CKT.
MODULE-102



I/C & O/G MCCB'S COMMON TRIP
F/B TO SCADA
(1F4 MODULE)


3ø 4W 415V±10% AC TPN BUS BAR
R
Y
B
N
TMD
RELEASE
O/C&S/C
PROTECTION
Q
TPN,
MCCB
R Y B N
415V,AC SUPPLY
TO OUTGOING LOAD
POWER CIRCUIT
MODULE-E01
MCCB
ON
MCCB
TRIP
Q
Q
*U1
*U2
*U3
*U4
1T-1
1T-2
1T-3
1T-4
F/B TO SCADA
1TØ
*U1
*U2
*U3
*U4
1
2
3
4
BKR. ON/OFF F/B
TO COMMON BKR
TRIP F/B MODULE



ILLUMINATION CIRCUIT
TYPICAL FOR ALL

	▶	7	**Workshop Board (WSB)**	
Legend	**Qty**	**Unit**	**ITEM DESCRIPTION**	**Makes**
	1	Set	▶ **Incomer - 400A MCCB**	**Each with following**
MCCB	1	No.	400A 25kA TP MCCB Thermal - Magnetic Release for O/L, S/C Protection ▸Rotary Operated Handle (Extended) ▸Aux + Trip Contact ▸Spreader Links	Schneider / L&T
IL	1	Set.	R / Y / B Phase Indicating Lights (LED Type) 110 / √3 V AC	Esbee(L&T) / C&S / Werner
A	1	No.	Analog Ammeter ▸0 - 400A, CL: 1.0, 96sqmm Flush Mounted	AE / RISHABH /Selec
Ass	1	No.	6A Ammeter Selector Switch (Ass)	Salzer(L&T) / Kaycee
V	1	No.	Analog Voltmeter ▸0 - 500V, CL: 1.0, 96sqmm Flush Mounted	AE / RISHABH /Selec
Vss	1	No.	6A Voltmeter Selector Switch (Vss)	Salzer(L&T) / Kaycee
MCT	3	Nos.	Metering CT ▸400 / 1A, CL: 0.5, 15VA Resin Cast	Indcoil / Procom / Kalpa / Perfect / Trinity
LPT	3	Nos.	**Potential Transformer (Line PT)** **▸50VA, CL: 0.2, PT Ratio: 415/√3 / 110/√3V AC, 1-Phase**	Indcoil / Kalpa / Perfect / Reputed
Fuse	3	Nos.	6A HRC Control Fuse with base	L&T / C&S / Havells / Siemens
CMCB	1	No.	6A 3P 10kA, C-Curve MCB	Schneider / L&T
NL	1	No.	Neutral Link	Rept.
Cu Link	1	No.	TP+NL Copper Busbar Links	Rept.
D/O Module	1	No.	**Draw out module with male female contacts, cranking assembly, telescopic rails etc**	**Kandi Electrical**
Wir.	1	No.	Control Wiring	Rept.
			400A, 50kA/1 Sec, TP+NL Cu Busbar With PVC Heat Shrinkable sleeve	
	3	Set	▶ **Outgoing - MCCB - 100A**	**Each with following**
MCCB	1	No.	100A 25kA TP MCCB Thermal - Magnetic Release for O/L, S/C Protection ▸Rotary Operated Handle (Extended) ▸Aux + Trip Contact ▸Spreader Links	Schneider / L&T
Wir.	1	No.	Wiring	Polycab / Havells / RR Cable / KEI / HPL
D/O Module	1	No.	**Draw out module with male female contacts, cranking assembly, telescopic rails etc**	**Kandi Electrical**

	7	Set	▶ Outgoing - MCCB - 63A	Each with following
MCCB	1	No.	63A 25kA TP MCCB Thermal - Magnetic Release for O/L, S/C Protection ▸ Rotary Operated Handle (Extended) ▸ Aux + Trip Contact	Schneider / L&T
Wir.	1	No.	Wiring	Polycab / Havells / RR Cable / KEI / HPL
D/O Module	1	No.	**Draw out module with male female contacts, cranking assembly, telescopic rails etc**	**Kandi Electrical**
	7	Set	▶ Outgoing - MCCB - 32A	Each with following
MCCB	1	No.	32A 25KA TP MCCB Thermal - Magnetic Release for O/L, S/C Protection ▸ Rotary Operated Handle (Extended) ▸ Aux + Trip Contact	Schneider / L&T
Wir.	1	No.	Wiring	Polycab / Havells / RR Cable / KEI / HPL
D/O Module	1	No.	**Draw out module with male female contacts, cranking assembly, telescopic rails etc**	**Kandi Electrical**
	3	Set	Acessories (Space Heater & panel light)	Each with following
PS	1	No.	6/16A, Power Switch Socket Combine	Anchor / Havells / Reputed
Ther.	1	No.	Space Heater with Thermostat	Rept.
DS	1	No.	Door Limit Switch	Suraj / reputed
PL	1	No.	Panel illumination LED Batten 5W	Orpat / Eveready / Reputed
CMCB	1	No.	16A SP 10kA, C-Curve MCB	Schneider / L&T
Wir.	1	No.	Wiring	Polycab / Havells / RR Cable / KEI / HPL

GENERAL NOTES, GA, SLD, SCHEMATIC DIAGRAM, BOM

FOR

ERECTION BAY BOARD (EBSB)

PROJECT - CHILLA RMU (4X39 MW)

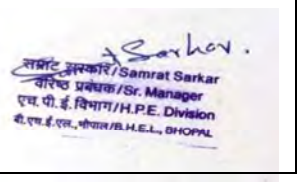
CUSTOMER – UJVNL, UTTARAKHAND

BHARAT HEAVY ELECTRICALS LTD. BHOPAL (INDIA)
(A GOVERNMENT OF INDIA ENTERPRISE)

	NAME	SIGN	DATE
PREP.	S.SARKAR	-SD-	04.02.2025
CHD.	S.JUNEJA	-SD-	04.02.2025
APPD.	S.SHARMA	-SD-	04.02.2025

HPE (415)

TITLE: -		REV.
GN, GA, SLD, SCHEMATICS, BOM FOR ERECTION BAY BOARD (EBSB)	**BHEL Doc. No: HPE/CHIL/LTAC/EBSB**	**01**



GENERAL NOTES:-

1. DESIGN PARAMETERS AC SYSTEM

3PH, 4WIRE, SOLIDLY EARTHED

a. VOLTAGE : 415V AC ± 10%
b. FREQUENCY : 50HZ + 3% - 5%
c. COMBINED VARIATION IN VOLTAGE & FREQUENCY : ± 10% ABSOLUTE SUM
d. RATED INSULATION VOLTAGE : 1100V
e. FAULT LEVEL : 25KA/1SEC

2. ENCLOSURE

PRODUCT NAME : ERECTION BAY BOARD (EBSB)
TYPE : DOUBLE FRONT DRAWOUT
ACB/MCCB - DRAWOUT TYPE
MCB/LINE PT/BUS PT - FIXED TYPE
CABLE ENTRY : BOTTOM
PANEL ACCESS : AS PER DRAWING
PAINT SHADE (EXTERNAL & INTERNAL) : RAL-7035 - LIGHT GREY
: MOUNTING PLATES-ORANGE
: MINIMUM THICKNESS 60 MICRONS
PAINT TYPE : POWDER COATING
DEGREE OF PROTECTION : INDOOR FLOOR MOUNTED
: IP42

3. BUSBAR

BUSBAR : 800A 25KA/1SEC TPN TINNED COPPER BUSBAR

HORIZONTAL BUSBAR :

PHASE : 1X50X12mm TINNED COPPER
NEUTRAL : 1X50X6mm TINNED COPPER
EARTH : 1X40X5mm TINNED COPPER
CONTRO BUS : 2X15X3mm COPPER

MIN. CLEARANCE:

PHASE TO PHASE : 25.4 MM
PHASE TO NEUTRAL : 19 MM
PHASE TO EARTH : 19 MM
NEUTRAL TO EARTH : 19 MM
BUSBAR SUPPORT : SMC/DMC INSULATORS

4. THICKNESS

STRUCTURE : 2 mm of CRCA
DOOR/OVER/PARTITION : 1.6 mm of CRCA
GLAND PLATE (REMOVABLE) : 3 mm of CRCA FOR MULTICORE CABLES & 4mm ALUMINIUM FOR SINGLE CORE CABLES (NON MAGNETIC)
BASE FRAME : ISMC 75 CHANNEL (75MMX40MMX5MM)

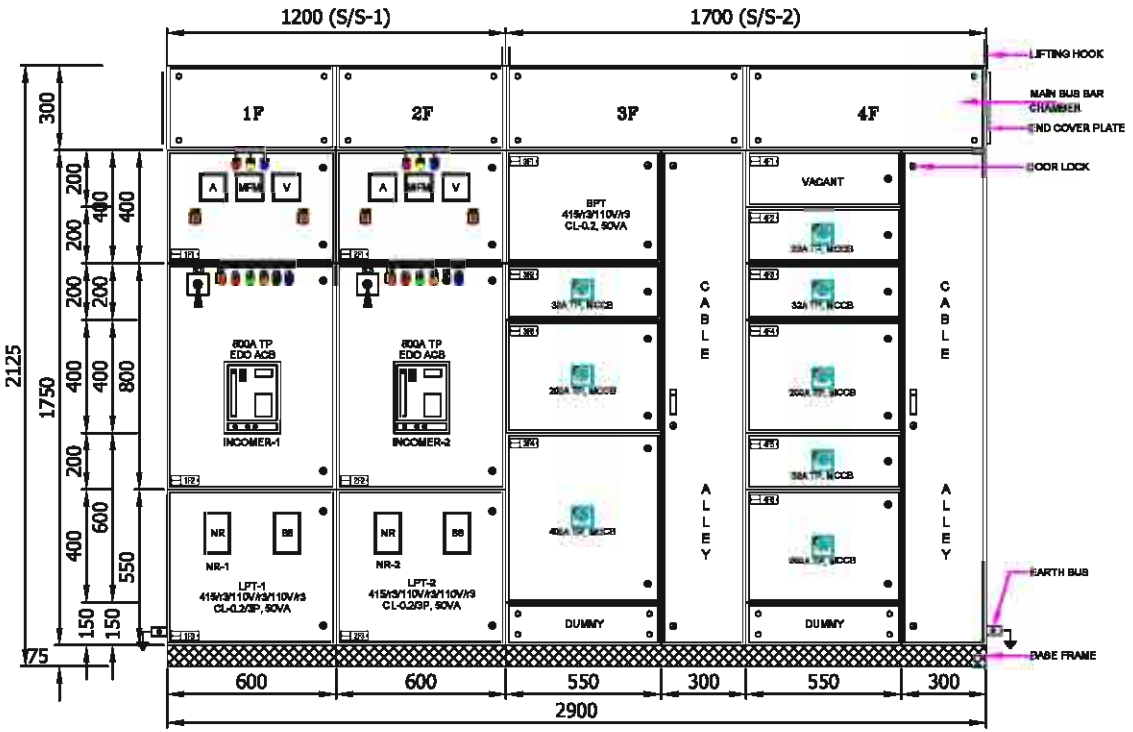
5. CONTROL WIRING

DC VOLTAGE CIRCUIT : 2.5 SQ. MM CU WIRE
AC VOLTAGE CIRCUIT : 1.5 SQ. MM CU WIRE
AC CURRENT CIRCUIT : 2.5SQ. MM CU WIRE
CT & PT WIRING : 2.5SQ. MM CU WIRE
OTHER AUX. AC CIRCUIT : 1.5 SQ. MM CU WIRE(BLACK)
EARTH WIRE CIRCUIT : 2.5 SQ. MM CU WIRE(GREEN)

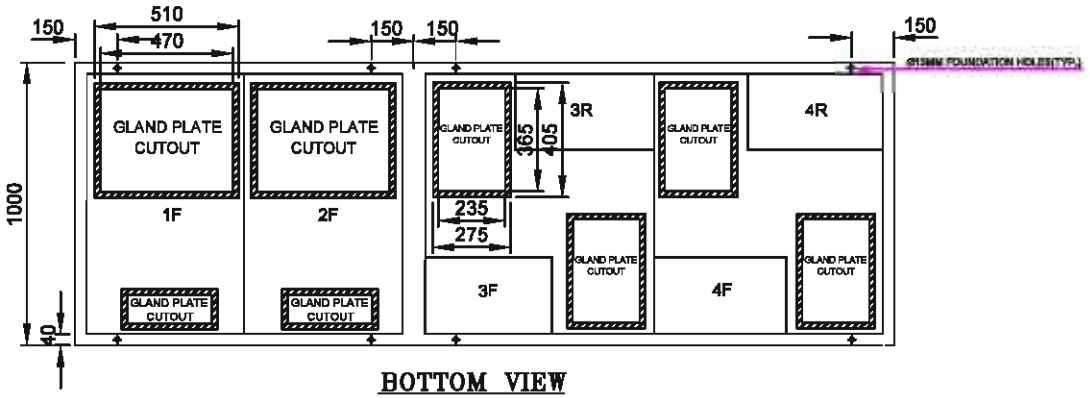
NOTE:- ALL CONTROL WIRES SHALL BE 1.1KV GRADE, PVC, CU FLEXIBLE TYPE.

6. ASSEMBLY

1) MINIMUM 10% TERMINALS IN SPARE SHALL BE PROVIDED.
2) CT's CONNECTION TO BE MADE WITH DISCONNECTING TYPE TERMINALS FOR METERS & RELAYS.
3) CT TERMINATION TO BE DONE WITH RING TYPE LUGS.
4) NAME PLATE SHALL BE PROVIDED.
5) BUSBARS SHALL BE COVERED WITH HEAT SHRINKABLE COLOURED PVC SLEAVE,RED,YELLOW & BLUE FOR PHASE IDENTIFICATION.
6) ALL DOOR SHALL BE EARTHED WITH Cu. WIRE.
7) ACCESSABLE LIVE PARTS SHALL BE SHAROUDED WITH FRP/ACRYLIC/POLYCARBONATE SHEET .
8) TPN MEANS TP SWITCHGEAR WITH REMOVABLE TYPE NEUTRAL LINK FOR MCCB.
9) GASKET SHALL BE PROVIDED INSIDE THE DOORS AND PANEL JOINTING TO MAKE THE PANEL DUST & VERMIN PROOF.
10) BUSBAR WILL BE INSULATED WITH HEAT SINK PVC SLEEVES.
11) OPERATING HEIGHT MINIMUM 300MM & MAXIMUM 1800MM.



FRONT VIEW

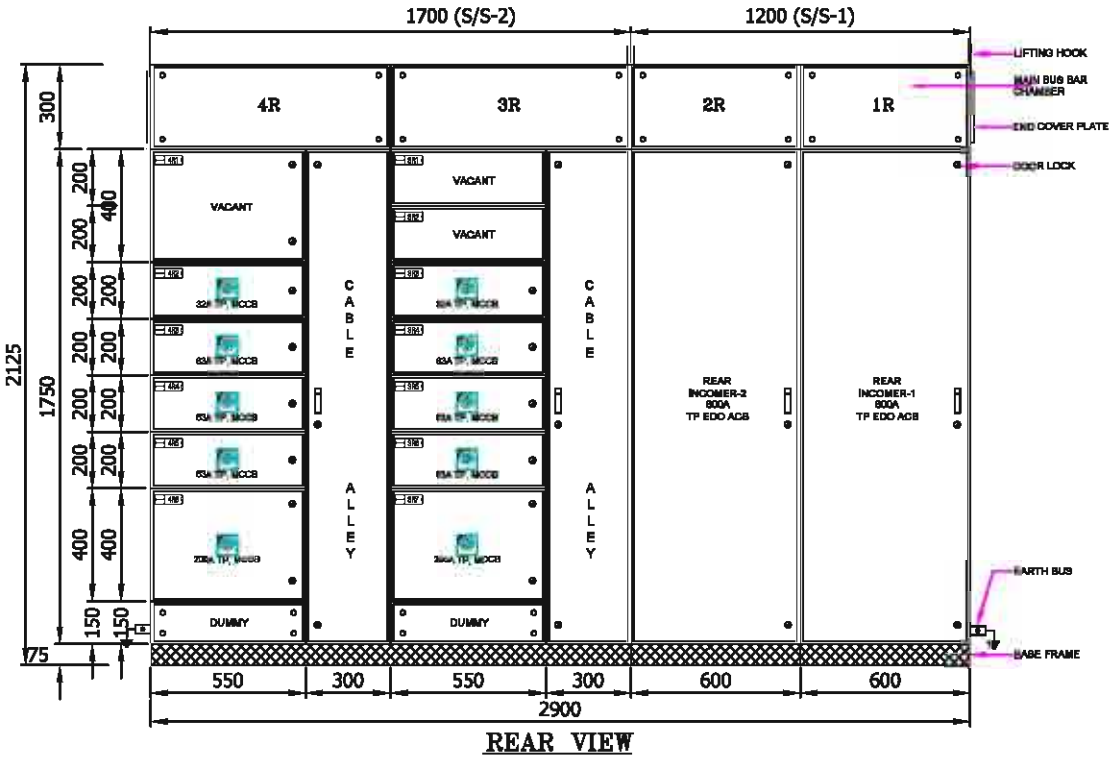


BOTTOM VIEW

GLAND PLATE SIZES

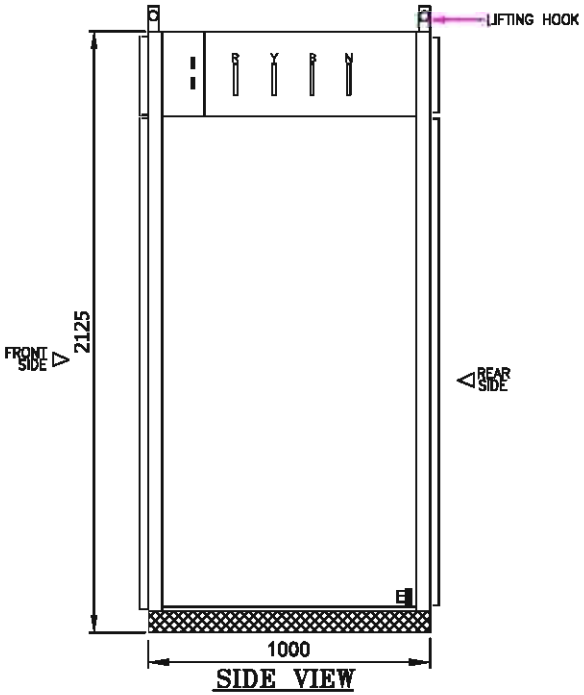
GLAND PLATE NO.	GLAND PLATE CUTOUT SIZE	GLAND PLATE SIZE
1F & 2F	470X365MM	510X405MM
3F & 3R	365X235MM	405X275MM
4F & 4R	365X235MM	405X275MM

QTY. 01 No.



REAR VIEW

QTY. 01 No.



SIDE VIEW

FABRICATION:– INDOOR TYPE FLOOR MOUNTED DOUBLE FRONT DRAWOUT

BUS BAR:– 800A TPN TINNED COPPER 25kA/1Sec.

HORIZONTAL BUSBAR:–

PHASE : 1:50X12 MM TINNED COPPER
NEUTRAL : 1:50X06 MM TINNED COPPER
EARTH : 1:40X05 MM TINNED COPPER

VERTICAL BUSBAR:–

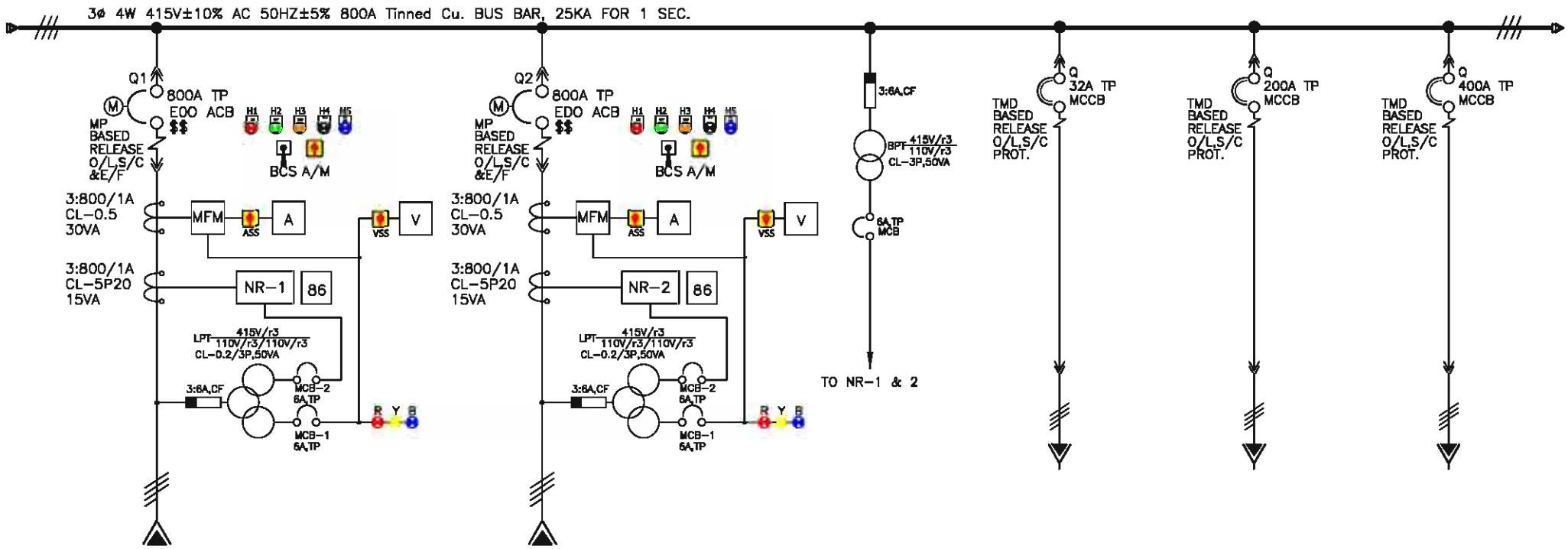
PHASE : 1:40X10 MM TINNED COPPER
NEUTRAL : 1:25X8 MM TINNED COPPER
EARTH : 1:20X05 MM TINNED COPPER

CONTROL BUSBAR :– 2:15X3 MM COPPER

CABLE ENTRY : BOTTOM ONLY

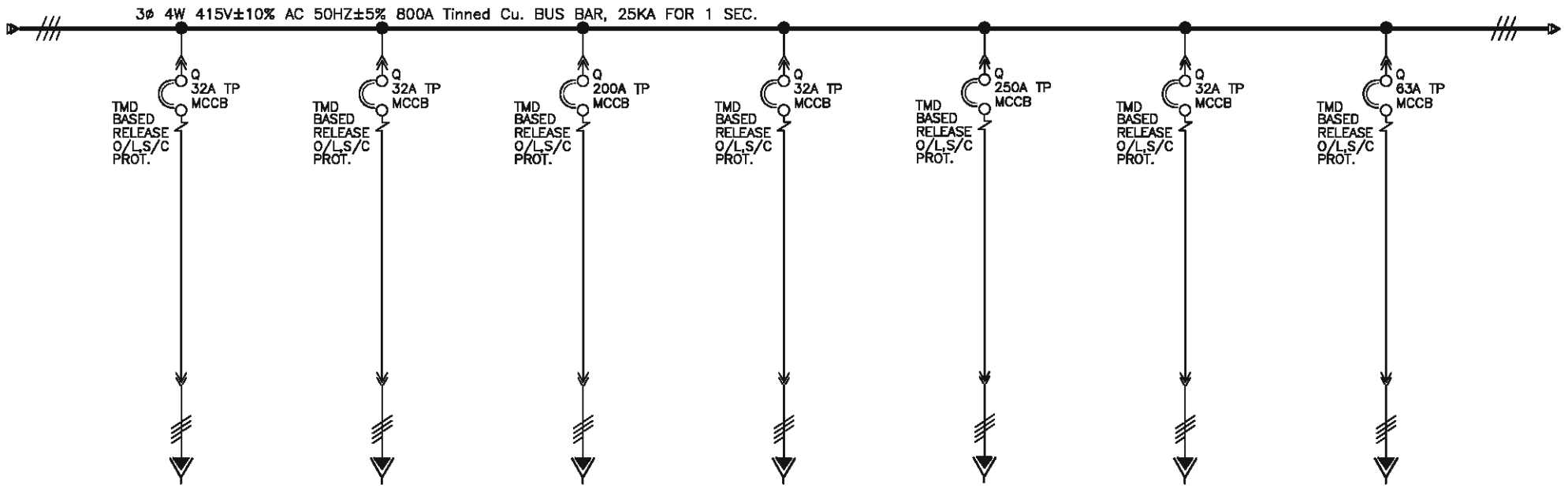
LEGEND DETAIL	
LEGEND	DESCRIPTION
R	INDICATION R–PHASE 'RED'
Y	INDICATION Y–PHASE 'YELLOW'
B	INDICATION B–PHASE 'BLUE'
H1	INDICATION ON 'RED'
H2	INDICATION OFF 'GREEN'
H3	INDICATION TRIP 'AMBER'
H4	INDICATION TRIP CKT. HEALTHY 'WHITE'
H5	INDICATION DC ON 'BLUE'
A	ANALOG AMMETER
ASS	AMMETER SELECTOR SWITCH
V	ANALOG VOLTMETER
VSS	VOLTMETER SELECTOR SWITCH
NR	NUMERICAL RELAY
86	MASTER TRIP RELAY
BCS	BREAKER CONTROL SWITCH (TNC)
L/R	LOCAL REMOTE SELECTOR SWITCH

QTY. 01 No.



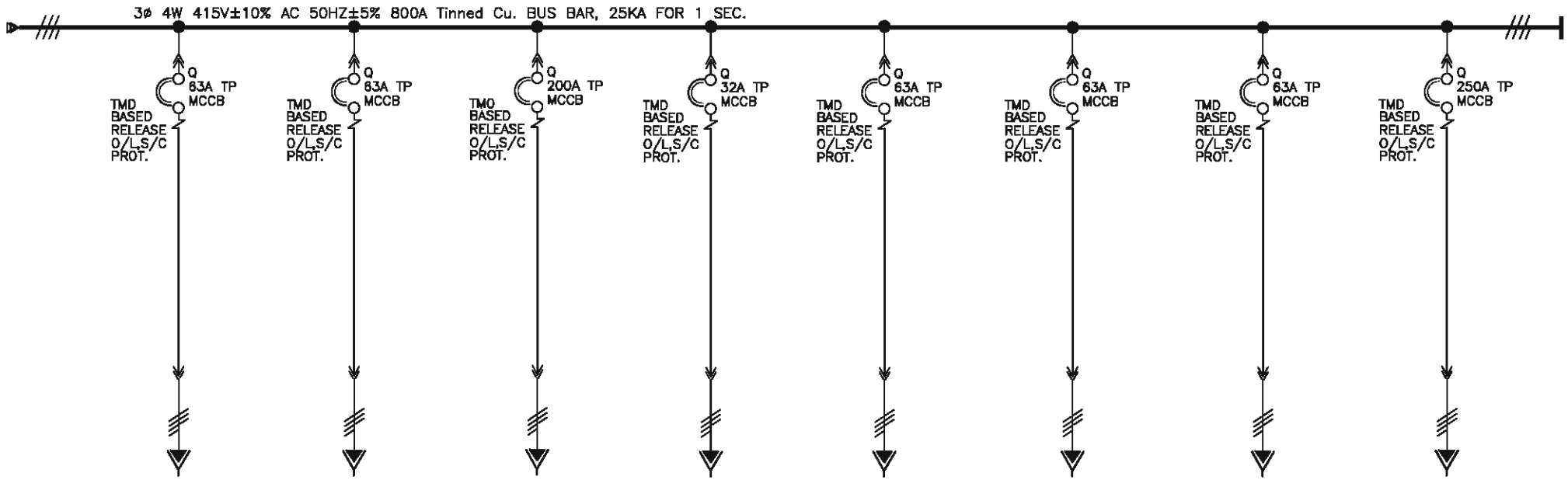
FEEDER No.	1F1, 1F2 & 1F3	2F1, 2F2 & 2F3	3F1	3F2	3F3	3F4
FEEDER RATING	800A	800A	50VA	32A	200A	400A
TYPE OF FEEDER/STARTER	PSF	PSF	PT	PSF	PSF	PSF
FEEDER DESCRIPTION	INCOMER-1 FROM SSB-1, BUS SECTION-2	INCOMER-2 FROM SSB-2, BUS SECTION-2	BUS PT	E/B LOAD	SPARE	TO WORKSHOP BOARD (WSB)
SCHEME TYPE	IC01 (52EA1)	IC02 (52EA2)	BPT	E01	E01	E01
CABEL SIZE	1R X PLT3.5C185ALXLPE	1R X PLT3.5C185ALXLPE	–	UJVNL Scope	––	1R X PLT3.5C185ALXLPE

$$ ELECTRICAL INTERLOCKING



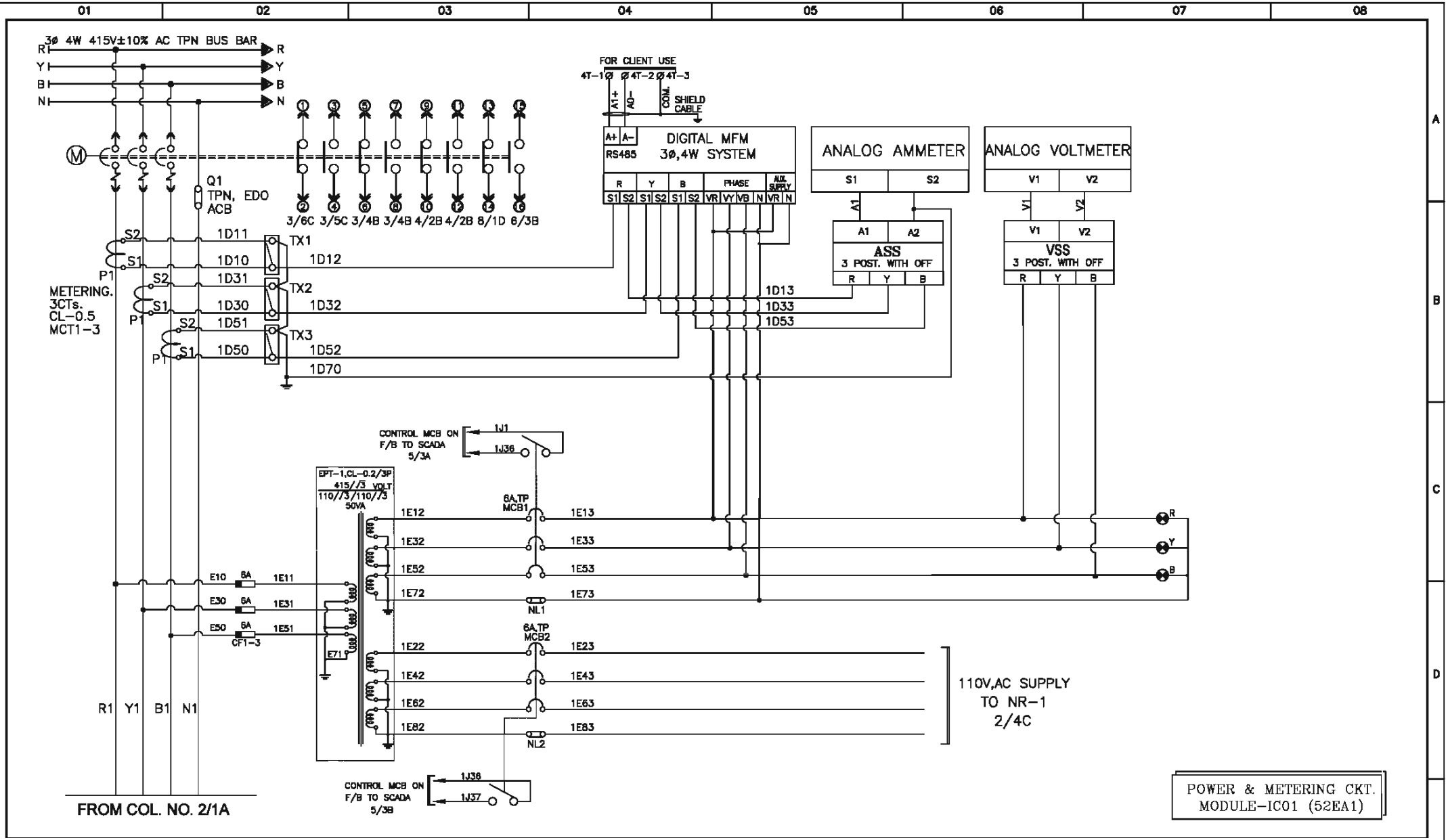
FEEDER No.	4F2	4F3	4F4	4F5	4F6	4R2	4R3
FEEDER RATING	32A	32A	200A	32A	250A	32A	63A
TYPE OF FEEDER/STARTER	PSF	PSF	PSF	PSF	PSF	PSF	PSF
FEEDER DESCRIPTION	E/B LOAD	E/B LOAD	GT OIL HANDLING FEEDER	E/B LOAD	E/B LOAD	SPARE	LUB. OIL HANDLING FEEDER
SCHEME TYPE	E01	E01	E01	E01	E01	E01	E01
CABEL SIZE	UJVNL Scope	UJVNL Scope	1R X PLT3.5C120ALXLPE	UJVNL Scope	UJVNL Scope	--	1R X PLT3.5C035ALXLPE

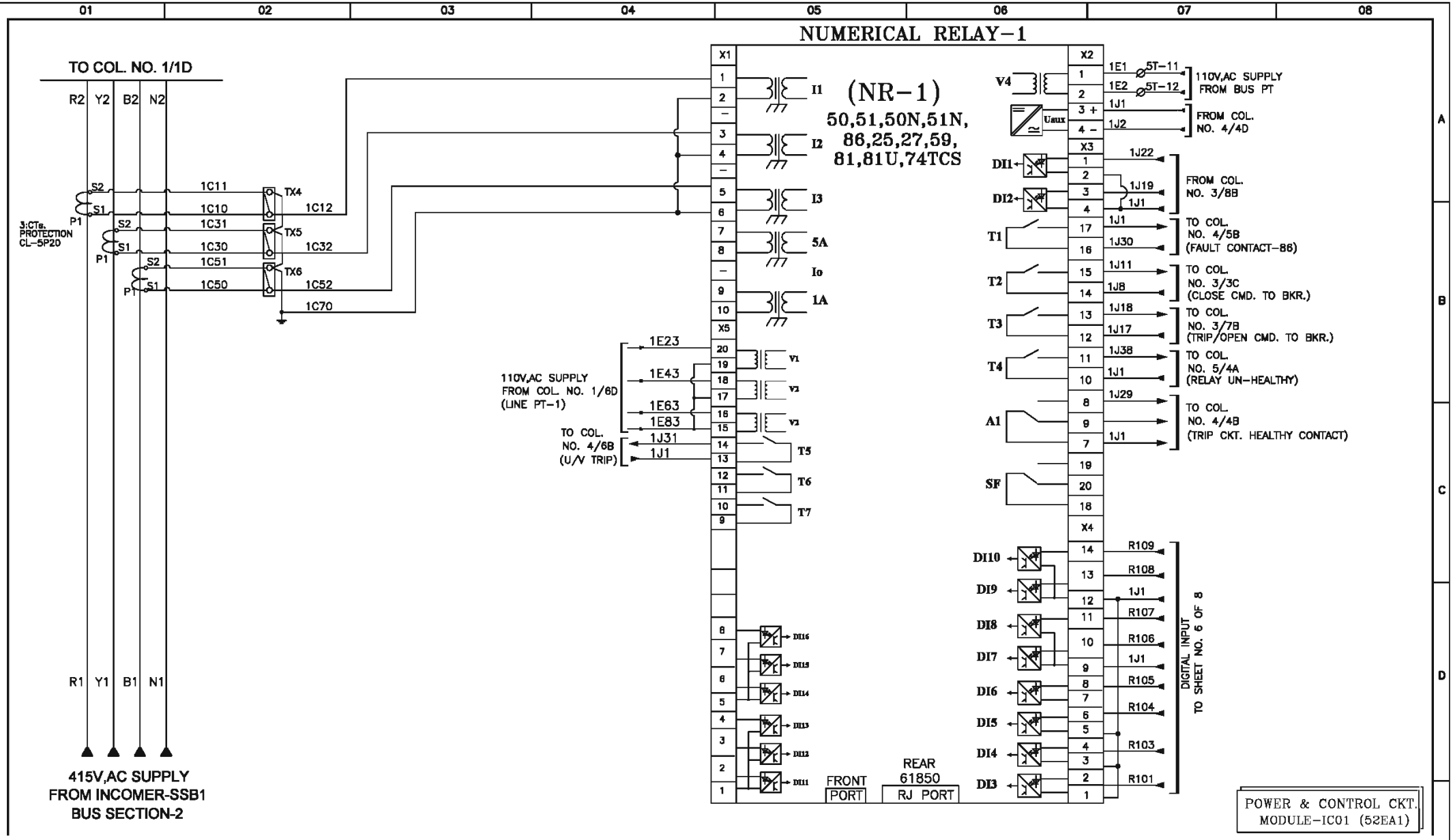
-- PLEASE SPECIFY THE CABLE SIZE

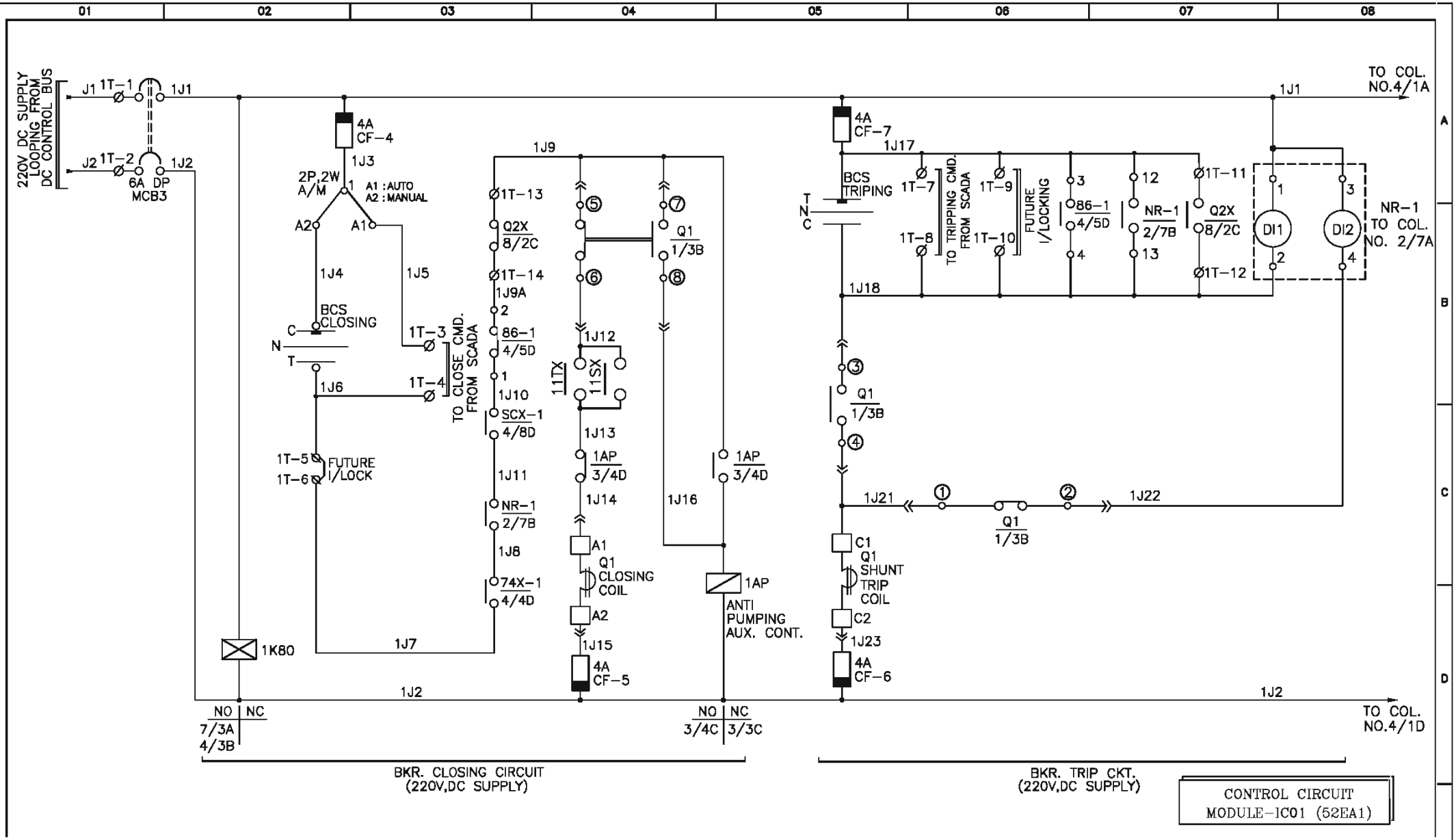


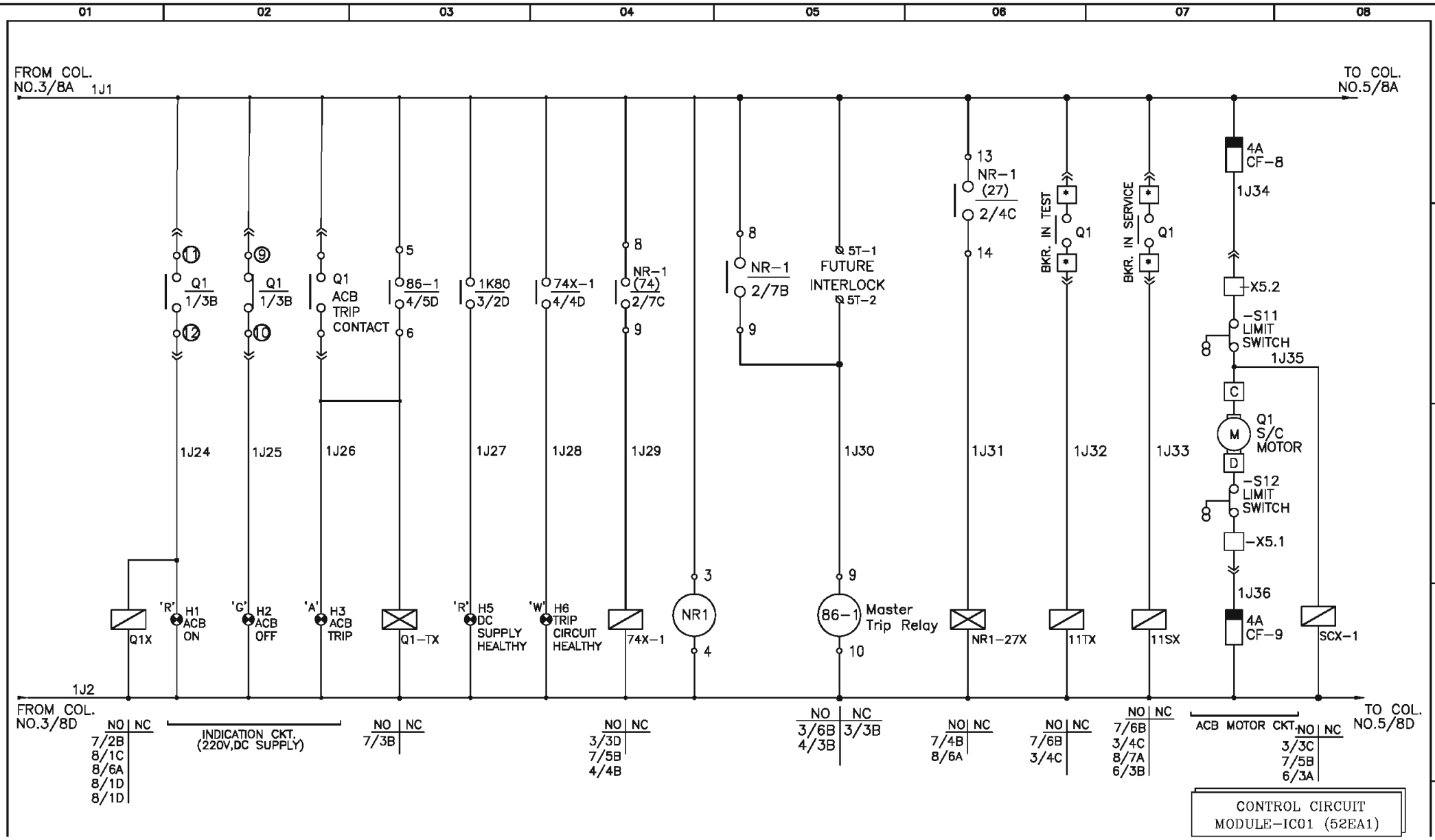
FEEDER No.	4R4	4R5	4R6	3R3	3R4	3R5	3R6	3R7
FEEDER RATING	63A	63A	200A	32A	63A	63A	63A	250A
TYPE OF FEEDER/STARTER	PSF	PSF	PSF	PSF	PSF	PSF	PSF	PSF
FEEDER DESCRIPTION	OIL WATER PUMP MOTOR–1	OIL WATER PUMP MOTOR–2	E/B LOAD	SPARE	SPARE	E/B LOAD	E/B LOAD	SPARE
SCHEME TYPE	E01	E01	E01	E01	E01	E01	E01	E01
CABEL SIZE	1R X PLT3.5C025ALXLPE	1R X PLT3.5C025ALXLPE	UJVNL Scope	––	––	UJVNL Scope	UJVNL Scope	––

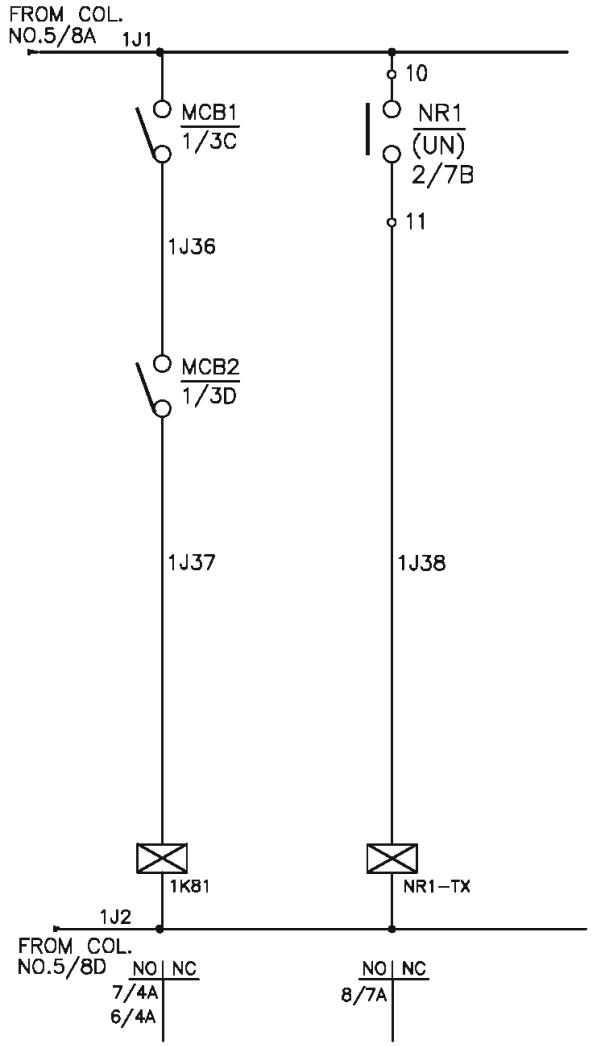
–– PLEASE SPECIFY THE CABLE SIZE


3ø 4W 415V±10% AC TPN BUS BAR
R
Y
B
N
Q1
TPN, EDO
ACB
3/6C 3/5C 3/4B 3/4B 4/2B 4/2B 8/1D 6/3B
FOR CLIENT USE
4T-1ø ø4T-2ø4T-3
A1+
A0-
COM.
SHIELD CABLE
A+ A-
RS485
DIGITAL MFM
3ø,4W SYSTEM
R Y B PHASE
AUX. SUPPLY
S1 S2 S1 S2 S1 S2 VR VY VB N VR N
ANALOG AMMETER
S1 S2
ANALOG VOLTMETER
V1 V2
A1 A2
ASS
3 POST. WITH OFF
R Y B
VSS
3 POST. WITH OFF
R Y B
S2
S1
P1
METERING.
3CTs.
CL-0.5
MCT1-3
1D11
1D10
1D12
TX1
1D31
1D30
1D32
TX2
1D51
1D50
1D52
TX3
1D70
1D13
1D33
1D53
CONTROL MCB ON
F/B TO SCADA
5/3A
1J1
1J36
EPT-1,CL-0.2/3P
415/√3 VOLT
110/√3/110/√3
50VA
6A,TP
MCB1
1E12
1E32
1E52
1E72
1E13
1E33
1E53
1E73
NL1
E10 6A 1E11
E30 6A 1E31
E50 6A 1E51
CT1-3
E71
6A,TP
MCB2
1E22
1E42
1E62
1E82
1E23
1E43
1E63
1E83
NL2
110V,AC SUPPLY
TO NR-1
2/4C
R1 Y1 B1 N1
FROM COL. NO. 2/1A
CONTROL MCB ON
F/B TO SCADA
5/3B
1J36
1J37
POWER & METERING CKT.
MODULE-IC01 (52EA1)

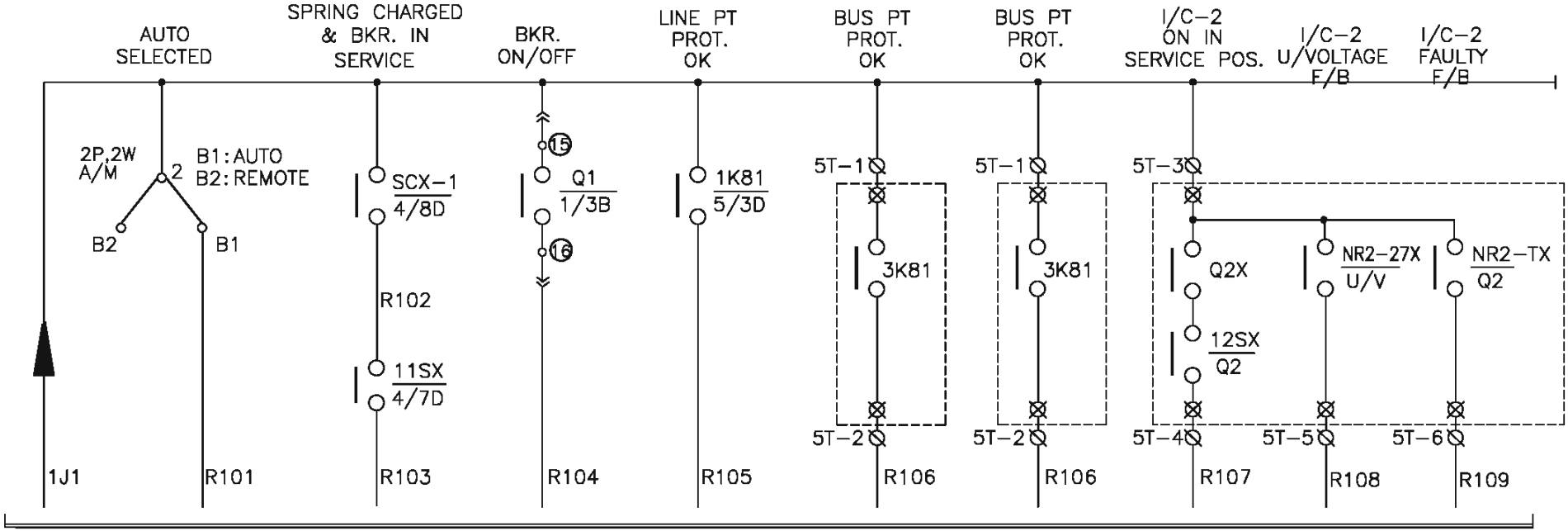

NUMERICAL RELAY-1
TO COL. NO. 1/1D
R2 Y2 B2 N2
R1 Y1 B1 N1
415V,AC SUPPLY
FROM INCOMER-SSB1
BUS SECTION-2
3;CTs.
PROTECTION
CL-5P20
S2
S1
P1
1C11
1C10
1C31
1C30
1C51
1C50
TX4
TX5
TX6
1C12
1C32
1C52
1C70
(NR-1)
50,51,50N,51N,
86,25,27,59,
81,81U,74TCS
I1
I2
I3
5A
Io
1A
V1
V2
V3
V4
Uaux
110V,AC SUPPLY
FROM COL. NO. 1/6D
(LINE PT-1)
1E23
1E43
1E63
1E83
TO COL.
NO. 4/6B
(U/V TRIP)
1J31
1J1
T5
T6
T7
1E1
1E2
5T-11
5T-12
110V,AC SUPPLY
FROM BUS PT
1J1
1J2
FROM COL.
NO. 4/4D
DI1
DI2
1J22
1J19
1J1
FROM COL.
NO. 3/8B
T1
1J1
1J30
TO COL.
NO. 4/5B
(FAULT CONTACT-86)
T2
1J11
1J8
TO COL.
NO. 3/3C
(CLOSE CMD. TO BKR.)
T3
1J18
1J17
TO COL.
NO. 3/7B
(TRIP/OPEN CMD. TO BKR.)
T4
1J38
1J1
TO COL.
NO. 5/4A
(RELAY UN-HEALTHY)
A1
1J29
1J1
TO COL.
NO. 4/4B
(TRIP CKT. HEALTHY CONTACT)
SF
DI10
DI9
DI8
DI7
DI6
DI5
DI4
DI3
R109
R108
R107
R106
R105
R104
R103
R101
1J1
DIGITAL INPUT
TO SHEET NO. 6 OF 8
FRONT
PORT
REAR
61850
RJ PORT
POWER & CONTROL CKT.
MODULE-IC01 (52EA1)


01
02
03
04
05
06
07
08
A
B
C
D
220V DC SUPPLY LOOPING FROM DC CONTROL BUS
J1 1T-1 1J1
J2 1T-2 1J2
6A DP MCB3
4A CF-4
1J3
2P,2W A/M
A1 : AUTO
A2 : MANUAL
A2
A1
1J4
1J5
BCS CLOSING
C
N
T
1T-3
1T-4
TO CLOSE CMD. FROM SCADA
1J6
1T-5
1T-6
FUTURE I/LOCK
1K80
1J7
1J9
1T-13
Q2X 8/2C
1T-14
1J9A
2
86-1 4/5D
1
1J10
SCX-1 4/8D
1J11
NR-1 2/7B
1J8
74X-1 4/4D
11TX
11SX
1J12
1J13
1AP 3/4D
1J14
A1
Q1 CLOSING COIL
A2
1J15
4A CF-5
1J16
1AP 3/4D
1AP
ANTI PUMPING AUX. CONT.
1J2
NO NC
7/3A
4/3B
NO NC
3/4C 3/3C
BKR. CLOSING CIRCUIT (220V,DC SUPPLY)
4A CF-7
1J17
BCS TRIPING
T
N
C
1T-7
1T-8
TO TRIPPING CMD. FROM SCADA
1T-9
1T-10
FUTURE I/LOCKING
3
86-1 4/5D
4
12
NR-1 2/7B
13
1T-11
Q2X 8/2C
1T-12
DI1
DI2
1
2
3
4
NR-1 TO COL. NO. 2/7A
1J18
1J1
TO COL. NO.4/1A
Q1 1/3B
1J21
1J22
C1
Q1 SHUNT TRIP COIL
C2
1J23
4A CF-6
1J2
TO COL. NO.4/1D
BKR. TRIP CKT. (220V,DC SUPPLY)
CONTROL CIRCUIT MODULE-1C01 (52EA1)


01
02
03
04
05
06
07
08
FROM COL. NO.3/8A
1J1
TO COL. NO.5/8A
Q1 1/3B
Q1 1/3B
Q1 ACB TRIP CONTACT
86-1 4/5D
1K80 3/2D
74X-1 4/4D
NR-1 (74) 2/7C
NR-1 2/7B
5T-1 FUTURE INTERLOCK 5T-2
NR-1 (27) 2/4C
BKR. IN TEST
Q1
BKR. IN SERVICE
Q1
4A CF-8
1J34
X5.2
-S11 LIMIT SWITCH
1J35
Q1 S/C MOTOR
-S12 LIMIT SWITCH
-X5.1
1J36
4A CF-9
1J24
1J25
1J26
1J27
1J28
1J29
1J30
1J31
1J32
1J33
Q1X
'R' H1 ACB ON
'G' H2 ACB OFF
'A' H3 ACB TRIP
Q1-TX
'R' H5 DC SUPPLY HEALTHY
'W' H6 TRIP CIRCUIT HEALTHY
74X-1
NR1
86-1 Master Trip Relay
NR1-27X
11TX
11SX
SCX-1
1J2
FROM COL. NO.3/8D
TO COL. NO.5/8D
NO NC
7/2B
8/1C
8/6A
8/1D
8/1D
INDICATION CKT. (220V,DC SUPPLY)
NO NC
7/3B
NO NC
3/3D
7/5B
4/4B
NO NC
3/6B 3/3B
4/3B
NO NC
7/4B
8/6A
NO NC
7/6B
3/4C
NO NC
7/6B
3/4C
8/7A
6/3B
ACB MOTOR CKT.
NO NC
3/3C
7/5B
6/3A
CONTROL CIRCUIT MODULE-IC01 (52EA1)

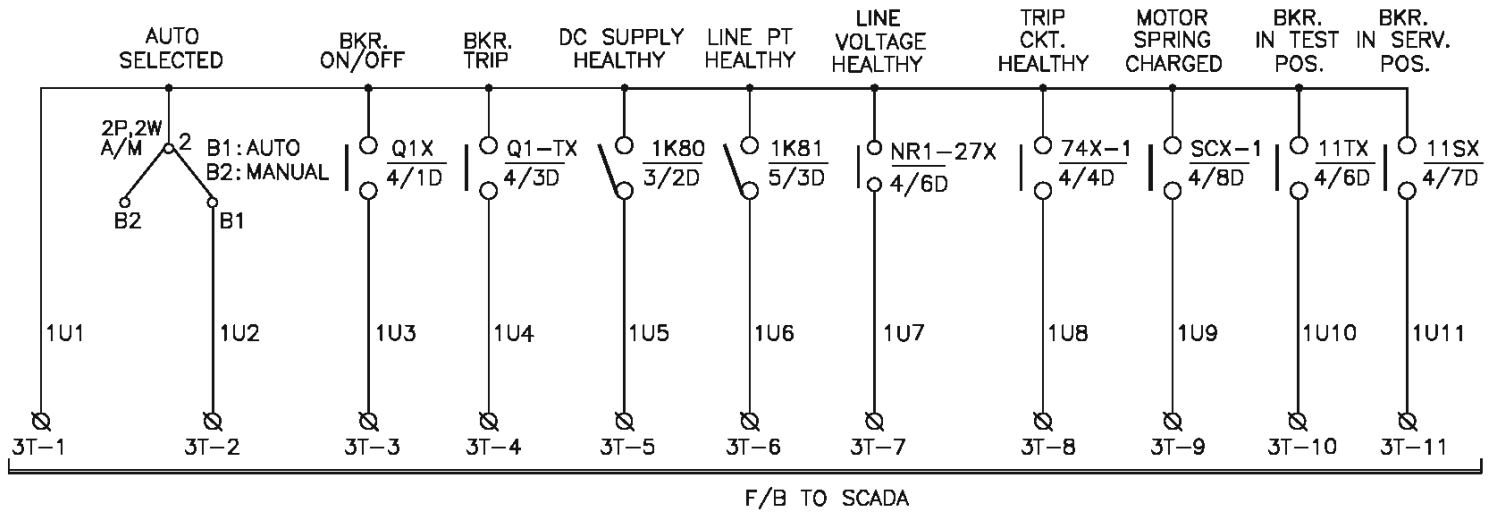


CONTROL CIRCUIT
MODULE-IC01 (52EA1)

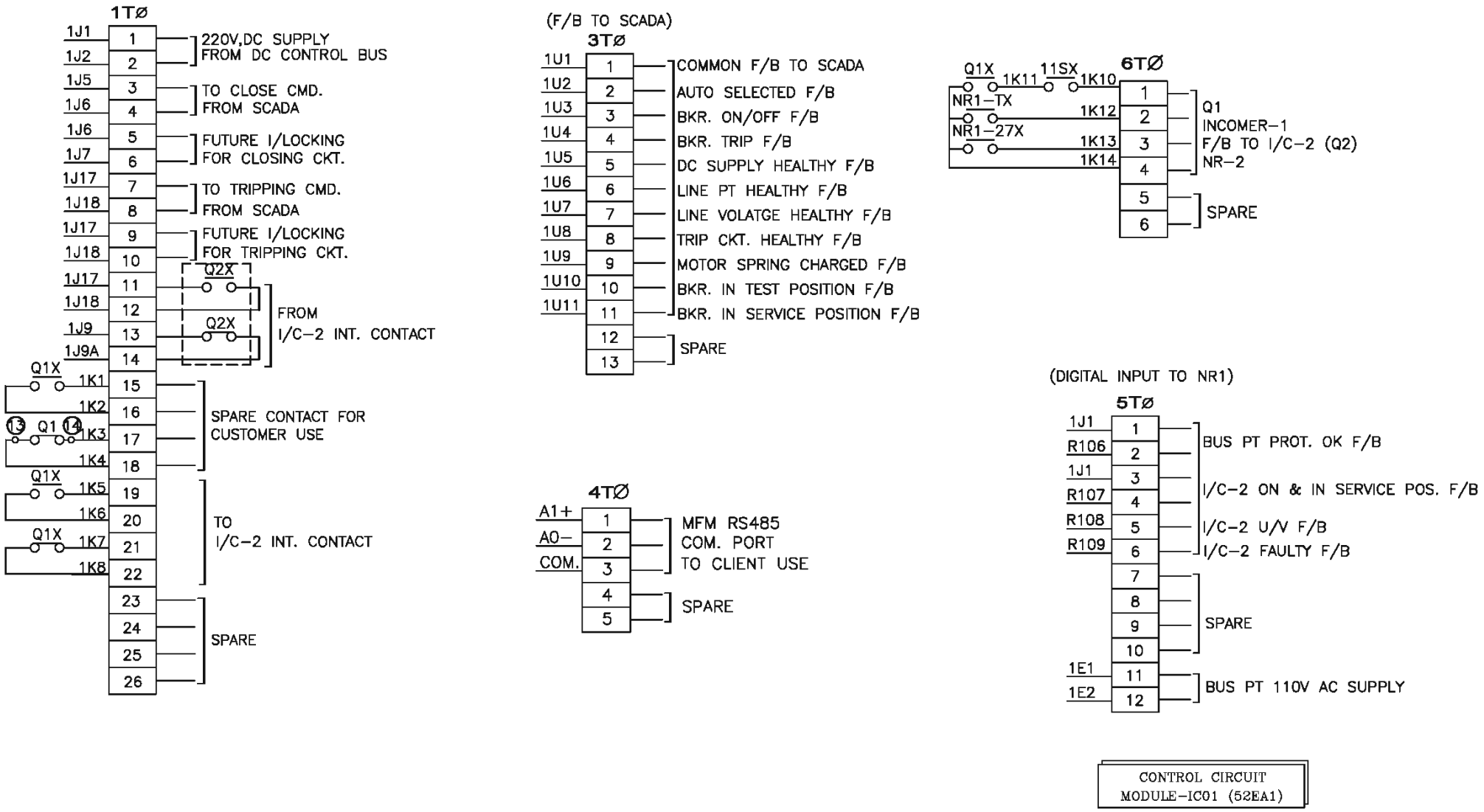


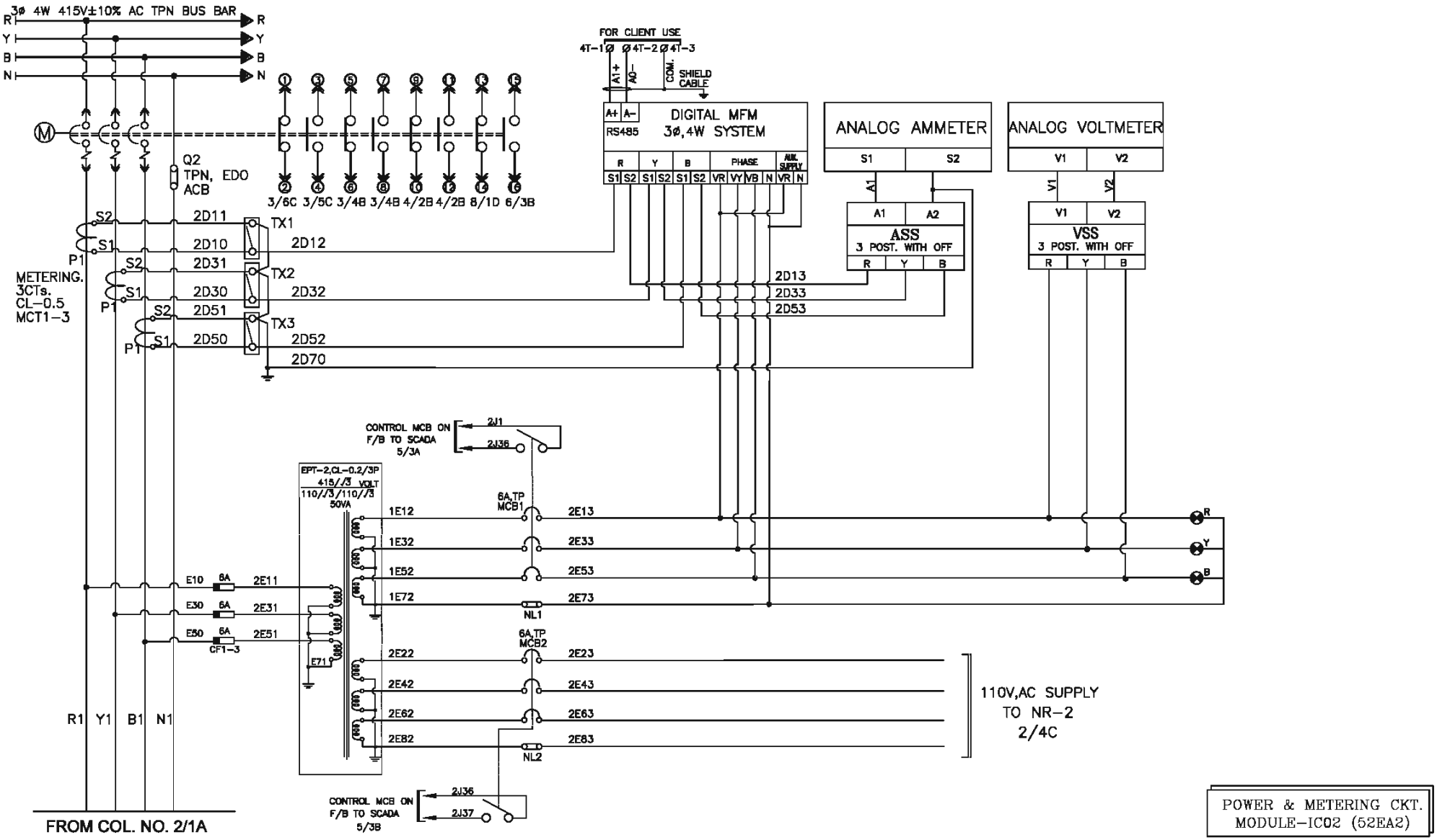
DIGITAL INPUT TO NUMERICAL RELAY-1 (NR-1)

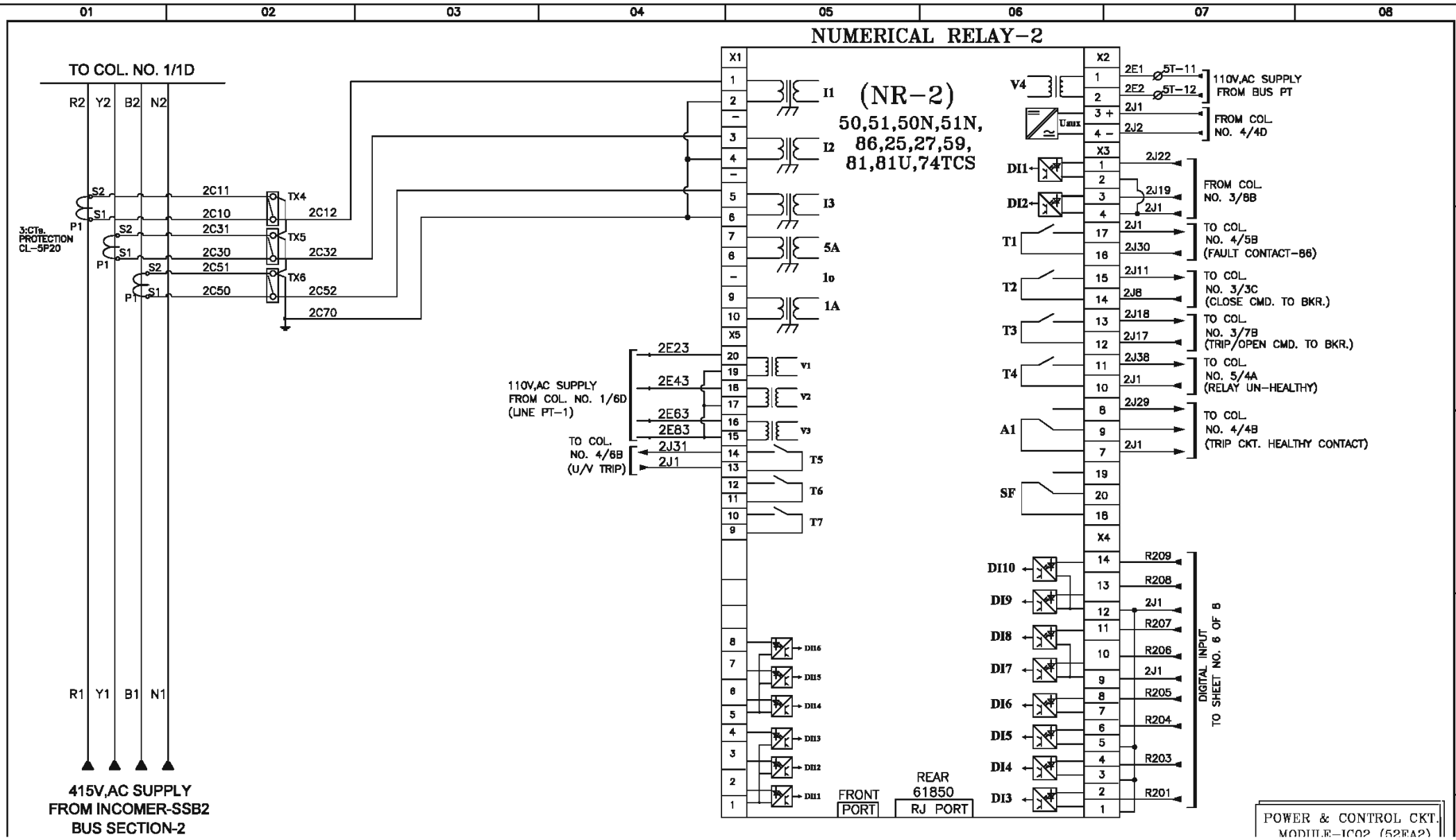
CONTROL CIRCUIT
MODULE-IC01 (52EA1)

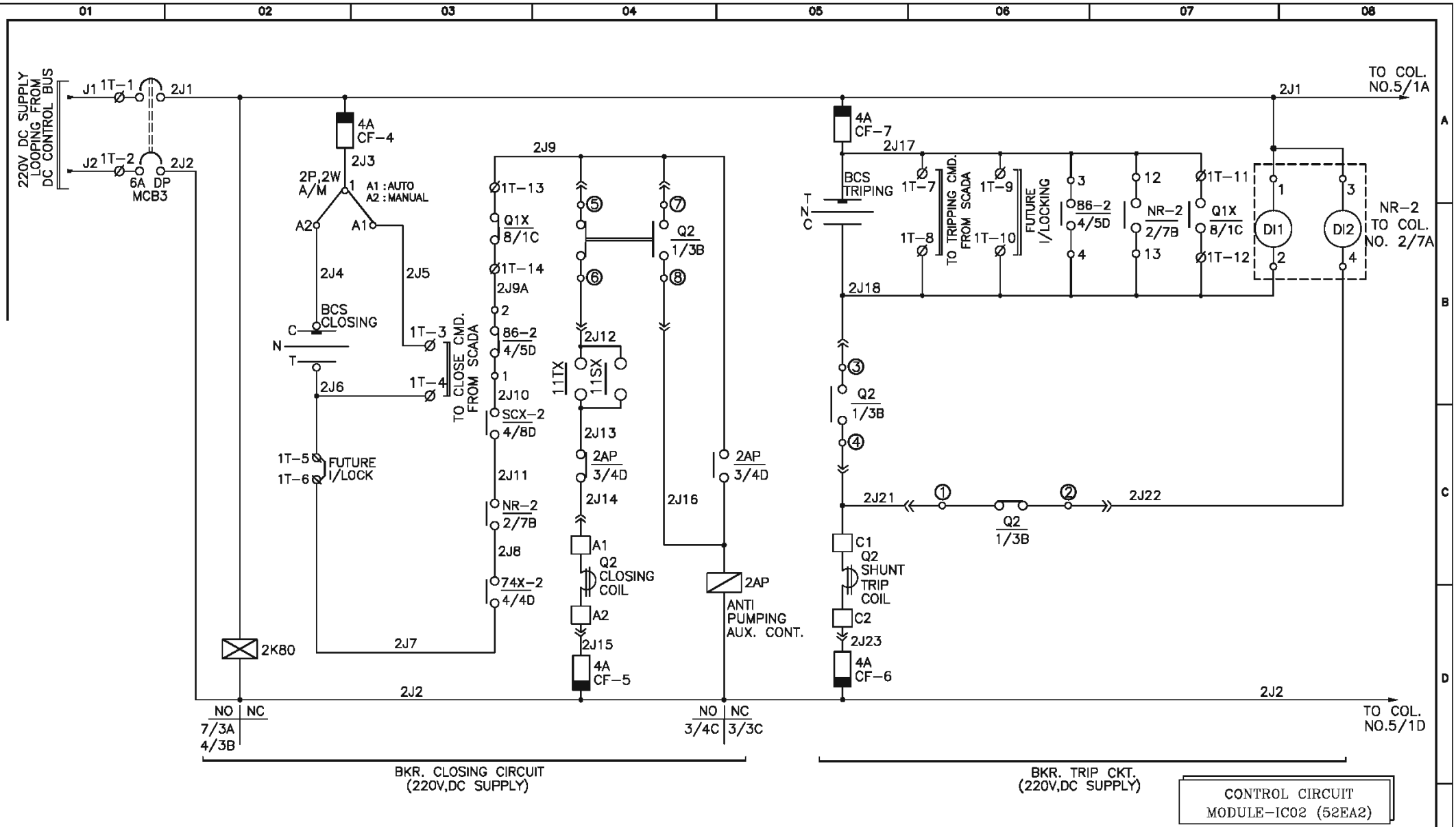


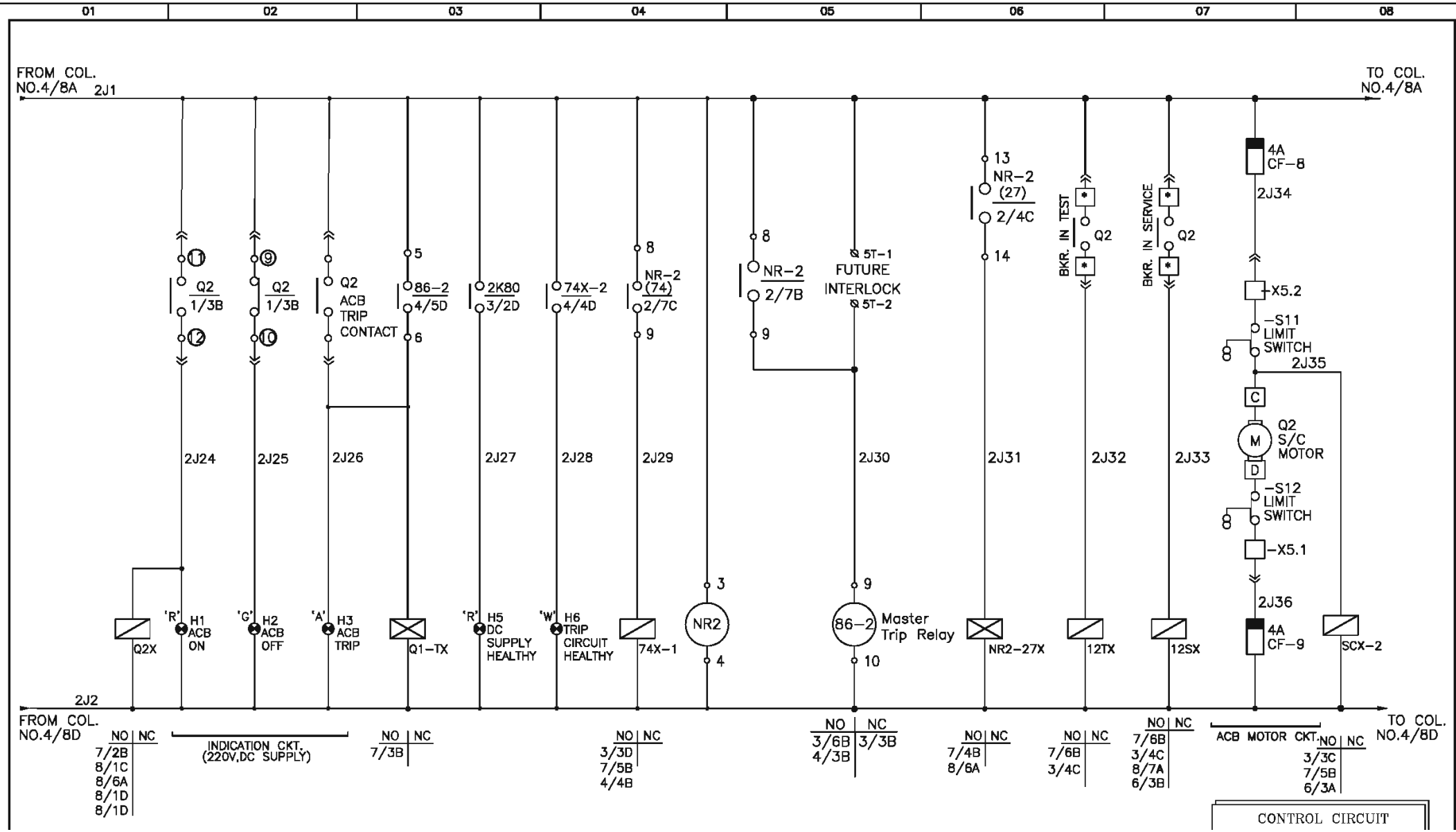
CONTROL CIRCUIT
MODULE-IC01 (52EA1)

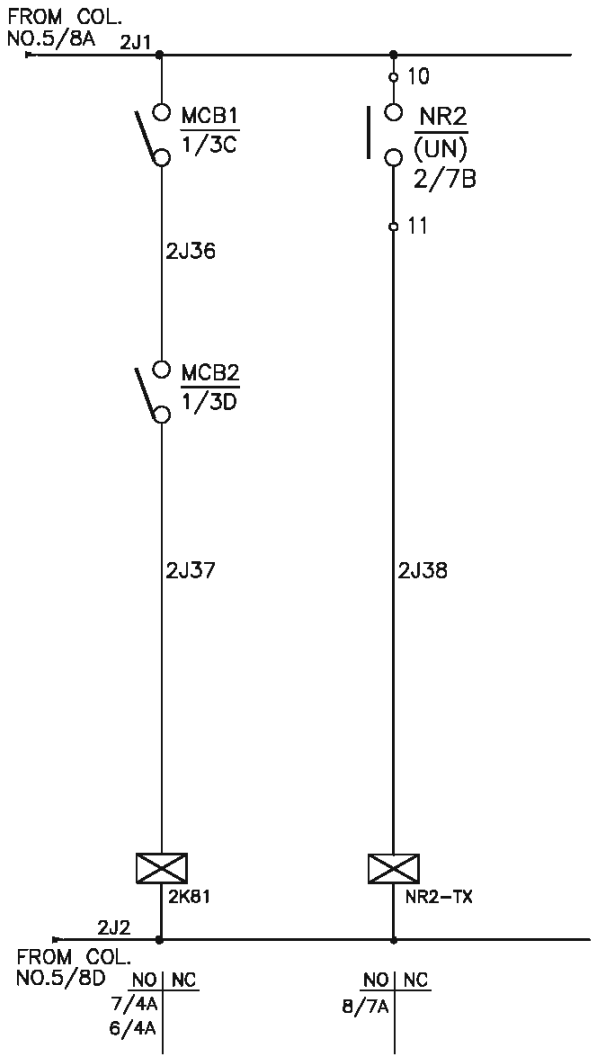

1TØ
1J1 1 220V,DC SUPPLY FROM DC CONTROL BUS
1J2 2
1J5 3 TO CLOSE CMD. FROM SCADA
1J6 4
1J6 5 FUTURE I/LOCKING FOR CLOSING CKT.
1J7 6
1J17 7 TO TRIPPING CMD. FROM SCADA
1J18 8
1J17 9 FUTURE I/LOCKING FOR TRIPPING CKT.
1J18 10
Q2X
1J17 11 FROM I/C-2 INT. CONTACT
1J18 12
Q2X
1J9 13
1J9A 14
Q1X 1K1 15 SPARE CONTACT FOR CUSTOMER USE
1K2 16
13 Q1 14 1K3 17
1K4 18
Q1X 1K5 19 TO I/C-2 INT. CONTACT
1K6 20
Q1X 1K7 21
1K8 22
23 SPARE
24
25
26
(F/B TO SCADA)
3TØ
1U1 1 COMMON F/B TO SCADA
1U2 2 AUTO SELECTED F/B
1U3 3 BKR. ON/OFF F/B
1U4 4 BKR. TRIP F/B
1U5 5 DC SUPPLY HEALTHY F/B
1U6 6 LINE PT HEALTHY F/B
1U7 7 LINE VOLATGE HEALTHY F/B
1U8 8 TRIP CKT. HEALTHY F/B
1U9 9 MOTOR SPRING CHARGED F/B
1U10 10 BKR. IN TEST POSITION F/B
1U11 11 BKR. IN SERVICE POSITION F/B
12 SPARE
13
4TØ
A1+ 1 MFM RS485 COM. PORT TO CLIENT USE
A0- 2
COM. 3
4 SPARE
5
Q1X 1K11 11SX 1K10
NR1-TX 1K12
NR1-27X 1K13
1K14
6TØ
1 Q1 INCOMER-1 F/B TO I/C-2 (Q2) NR-2
2
3
4
5 SPARE
6
(DIGITAL INPUT TO NR1)
5TØ
1J1 1 BUS PT PROT. OK F/B
R106 2
1J1 3 I/C-2 ON & IN SERVICE POS. F/B
R107 4
R108 5 I/C-2 U/V F/B
R109 6 I/C-2 FAULTY F/B
7
8 SPARE
9
10
1E1 11 BUS PT 110V AC SUPPLY
1E2 12
CONTROL CIRCUIT
MODULE-IC01 (52EA1)


3ø 4W 415V±10% AC TPN BUS BAR
R
Y
B
N
Q2
TPN, EDO
ACB
3/6C 3/5C 3/4B 3/4B 4/2B 4/2B 8/1D 6/3B
FOR CLIENT USE
4T-1ø ø4T-2ø4T-3
A1+
A0-
COM.
SHIELD CABLE
A+ A-
RS485
DIGITAL MFM
3ø,4W SYSTEM
R Y B PHASE AUX. SUPPLY
S1 S2 S1 S2 S1 S2 VR VY VB N VR N
ANALOG AMMETER
S1 S2
A1
A1 A2
ASS
3 POST. WITH OFF
R Y B
ANALOG VOLTMETER
V1 V2
V1
V2
VSS
3 POST. WITH OFF
R Y B
METERING.
3CTs.
CL-0.5
MCT1-3
TX1
TX2
TX3
2D11
2D10
2D12
2D31
2D30
2D32
2D51
2D50
2D52
2D70
2D13
2D33
2D53
CONTROL MCB ON F/B TO SCADA 5/3A
2J1
2J36
EPT-2,CL-0.2/3P
415/√3 VOLT
110/√3/110/√3
50VA
6A,TP MCB1
1E12
1E32
1E52
1E72
2E13
2E33
2E53
2E73
NL1
E10 6A 2E11
E30 6A 2E31
E50 6A 2E51
CF1-3
E71
6A,TP MCB2
2E22
2E42
2E62
2E82
2E23
2E43
2E63
2E83
NL2
110V,AC SUPPLY
TO NR-2
2/4C
R1 Y1 B1 N1
FROM COL. NO. 2/1A
CONTROL MCB ON F/B TO SCADA 5/3B
2J36
2J37
POWER & METERING CKT.
MODULE-IC02 (52EA2)

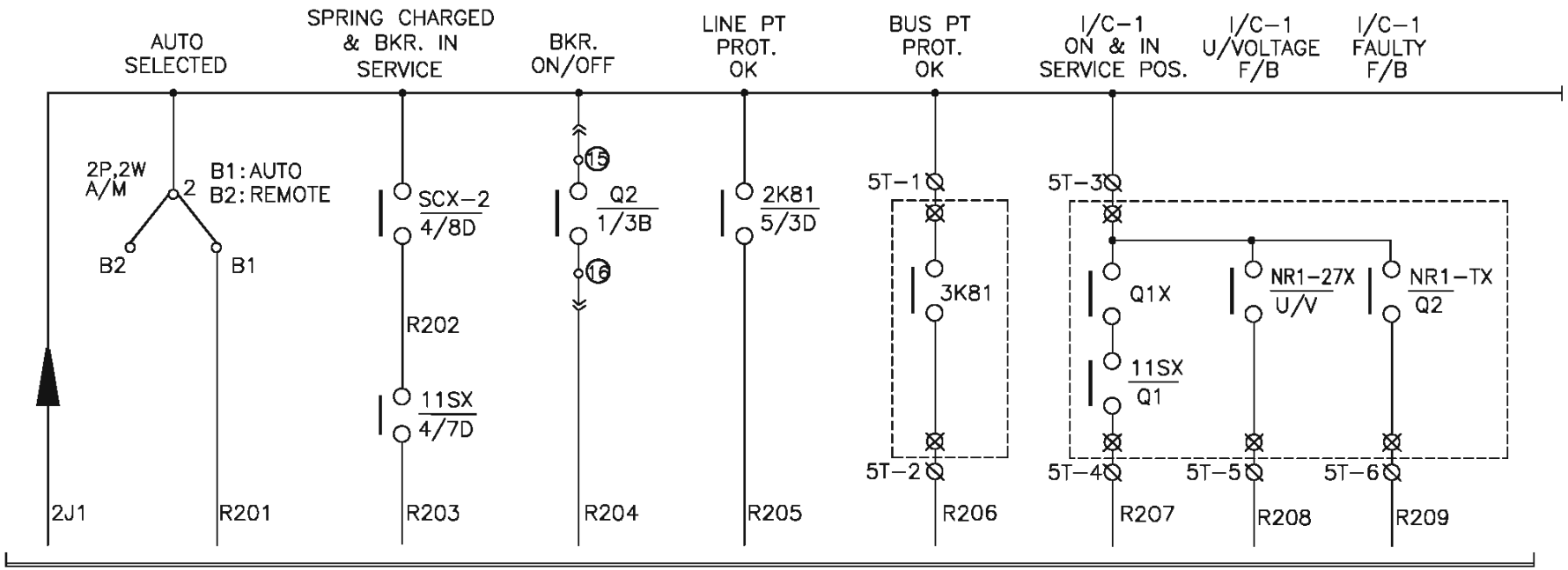

NUMERICAL RELAY-2
(NR-2)
50,51,50N,51N,
86,25,27,59,
81,81U,74TCS
TO COL. NO. 1/1D
R2 Y2 B2 N2
R1 Y1 B1 N1
415V,AC SUPPLY
FROM INCOMER-SSB2
BUS SECTION-2
3:CTs.
PROTECTION
CL-5P20
2C11
2C10
2C31
2C30
2C51
2C50
2C70
2C12
2C32
2C52
TX4
TX5
TX6
I1
I2
I3
5A
Io
1A
110V,AC SUPPLY
FROM COL. NO. 1/6D
(LINE PT-1)
2E23
2E43
2E63
2E83
V1
V2
V3
TO COL.
NO. 4/6B
(U/V TRIP)
2J31
2J1
T5
T6
T7
DI1
DI2
DI3
DI4
DI5
DI6
DI7
DI8
DI9
DI10
V4
Umx
2E1
2E2
5T-11
5T-12
110V,AC SUPPLY
FROM BUS PT
2J1
2J2
FROM COL.
NO. 4/4D
2J22
2J19
2J1
FROM COL.
NO. 3/8B
T1
2J1
2J30
TO COL.
NO. 4/5B
(FAULT CONTACT-86)
T2
2J11
2J8
TO COL.
NO. 3/3C
(CLOSE CMD. TO BKR.)
T3
2J18
2J17
TO COL.
NO. 3/7B
(TRIP/OPEN CMD. TO BKR.)
T4
2J38
2J1
TO COL.
NO. 5/4A
(RELAY UN-HEALTHY)
A1
2J29
2J1
TO COL.
NO. 4/4B
(TRIP CKT. HEALTHY CONTACT)
SF
R209
R208
R207
R206
R205
R204
R203
R201
DIGITAL INPUT
TO SHEET NO. 6 OF 8
FRONT
PORT
REAR
61850
RJ PORT
POWER & CONTROL CKT.
MODULE-IC02 (52EA2)


220V DC SUPPLY LOOPING FROM DC CONTROL BUS
J1 1T-1 2J1
J2 1T-2 2J2
6A DP MCB3
4A CF-4
2J3
2P,2W A/M
A1 : AUTO
A2 : MANUAL
A2
A1
2J4
2J5
BCS CLOSING
C
N
T
2J6
1T-3
1T-4
TO CLOSE CMD. FROM SCADA
1T-5 FUTURE I/LOCK
1T-6
2K80
2J7
2J9
1T-13
Q1X 8/1C
1T-14
2J9A
2
86-2 4/5D
1
2J10
SCX-2 4/8D
2J11
NR-2 2/7B
2J8
74X-2 4/4D
11TX
11SX
2J12
2J13
2AP 3/4D
2J14
A1
Q2 CLOSING COIL
A2
2J15
4A CF-5
2J16
2AP 3/4D
2AP ANTI PUMPING AUX. CONT.
2J2
NO NC
7/3A
4/3B
NO NC
3/4C 3/3C
BKR. CLOSING CIRCUIT (220V,DC SUPPLY)
4A CF-7
2J17
BCS TRIPING
T
N
C
1T-7
1T-8
TO TRIPPING CMD. FROM SCADA
1T-9
1T-10
FUTURE I/LOCKING
3
86-2 4/5D
4
12
NR-2 2/7B
13
1T-11
Q1X 8/1C
1T-12
DI1
DI2
NR-2 TO COL. NO. 2/7A
2J18
2J21
2J22
Q2 1/3B
C1
Q2 SHUNT TRIP COIL
C2
2J23
4A CF-6
2J1
TO COL. NO.5/1A
2J2
TO COL. NO.5/1D
BKR. TRIP CKT. (220V,DC SUPPLY)
CONTROL CIRCUIT MODULE-IC02 (52EA2)


01
02
03
04
05
06
07
08
A
B
C
D
FROM COL. NO.4/8A 2J1
TO COL. NO.4/8A
Q2 1/3B
Q2 1/3B
Q2 ACB TRIP CONTACT
86-2 4/5D
2K80 3/2D
74X-2 4/4D
NR-2 (74) 2/7C
NR-2 2/7B
5T-1 FUTURE INTERLOCK 5T-2
13 NR-2 (27) 2/4C
14
BKR. IN TEST
Q2
BKR. IN SERVICE
Q2
4A CF-8
2J34
X5.2
-S11 LIMIT SWITCH
2J35
C
M
Q2 S/C MOTOR
D
-S12 LIMIT SWITCH
-X5.1
2J36
4A CF-9
SCX-2
2J24
2J25
2J26
2J27
2J28
2J29
2J30
2J31
2J32
2J33
Q2X
'R' H1 ACB ON
'G' H2 ACB OFF
'A' H3 ACB TRIP
Q1-TX
'R' H5 DC SUPPLY HEALTHY
'W' H6 TRIP CIRCUIT HEALTHY
74X-1
NR2
86-2 Master Trip Relay
NR2-27X
12TX
12SX
2J2
FROM COL. NO.4/8D
TO COL. NO.4/8D
NO NC
7/2B
8/1C
8/6A
8/1D
8/1D
INDICATION CKT. (220V,DC SUPPLY)
NO NC
7/3B
NO NC
3/3D
7/5B
4/4B
NO NC
3/6B 3/3B
4/3B
NO NC
7/4B
8/6A
NO NC
7/6B
3/4C
NO NC
7/6B
3/4C
8/7A
6/3B
ACB MOTOR CKT.
NO NC
3/3C
7/5B
6/3A
CONTROL CIRCUIT

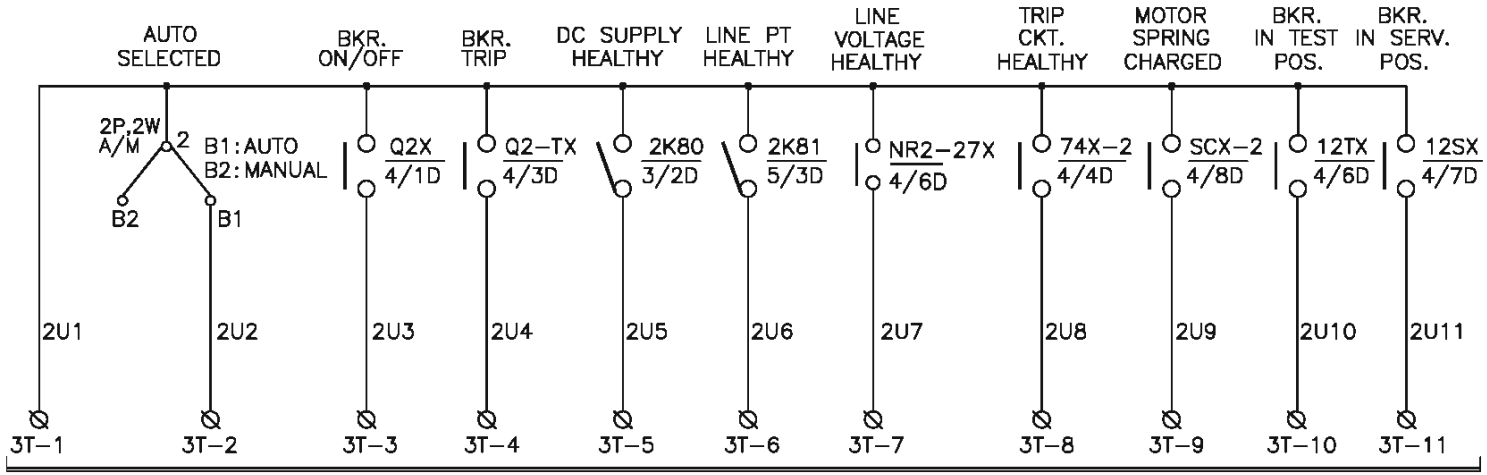


CONTROL CIRCUIT
MODULE-IC02 (52EA2)

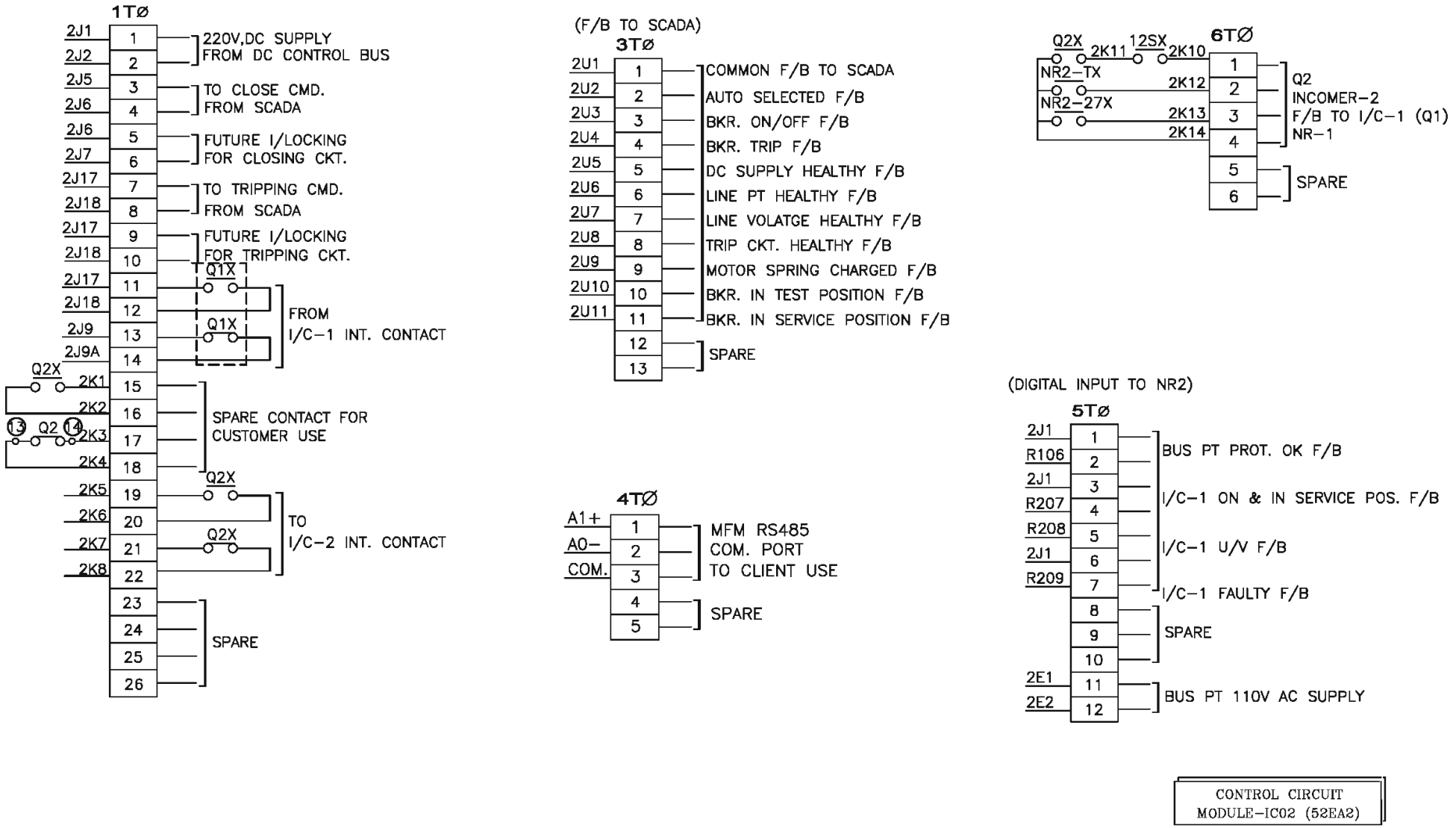


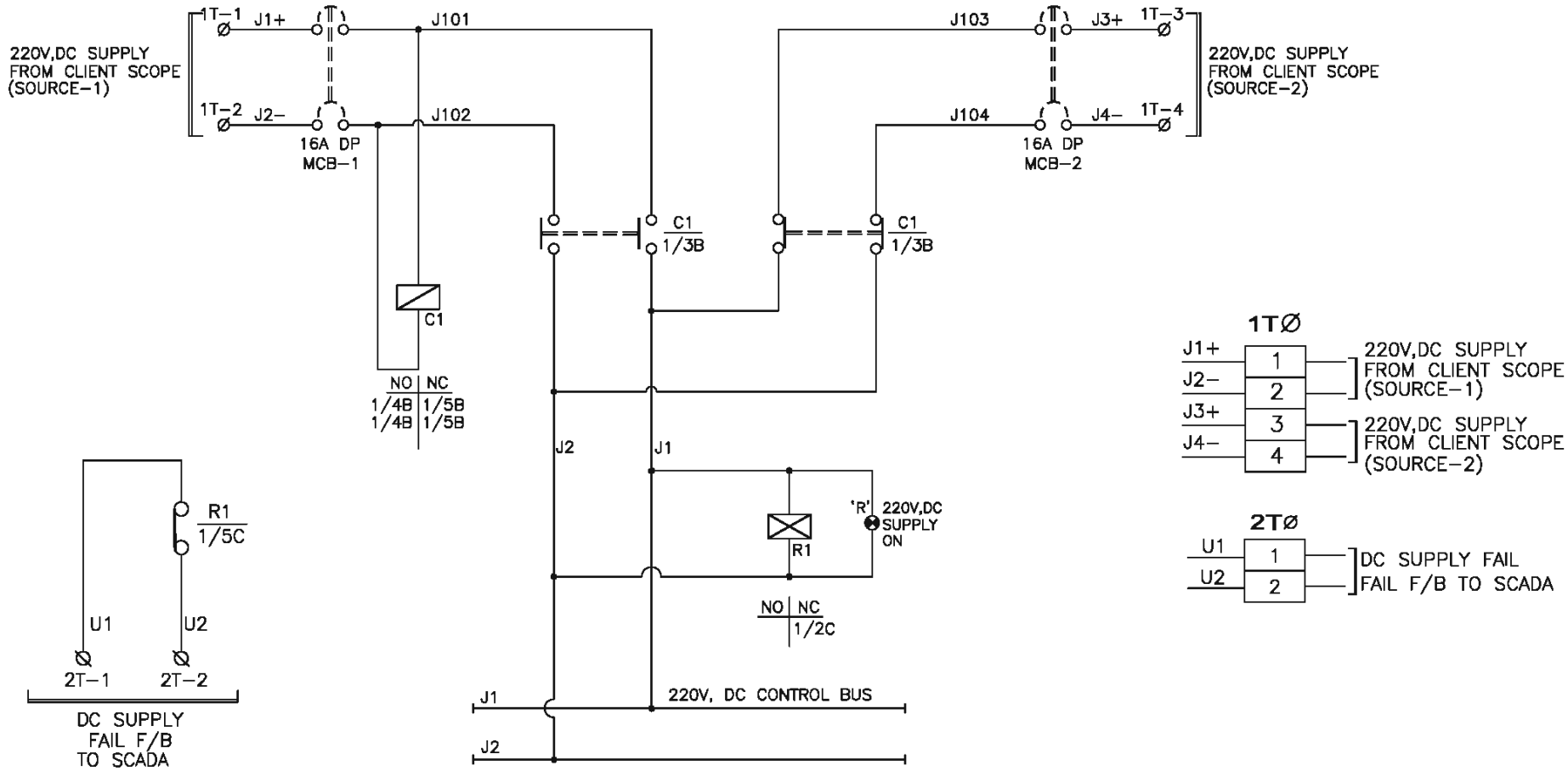
DIGITAL INPUT TO NUMERICAL RELAY-2 (NR-2)

CONTROL CIRCUIT
MODULE-IC02 (52EA2)

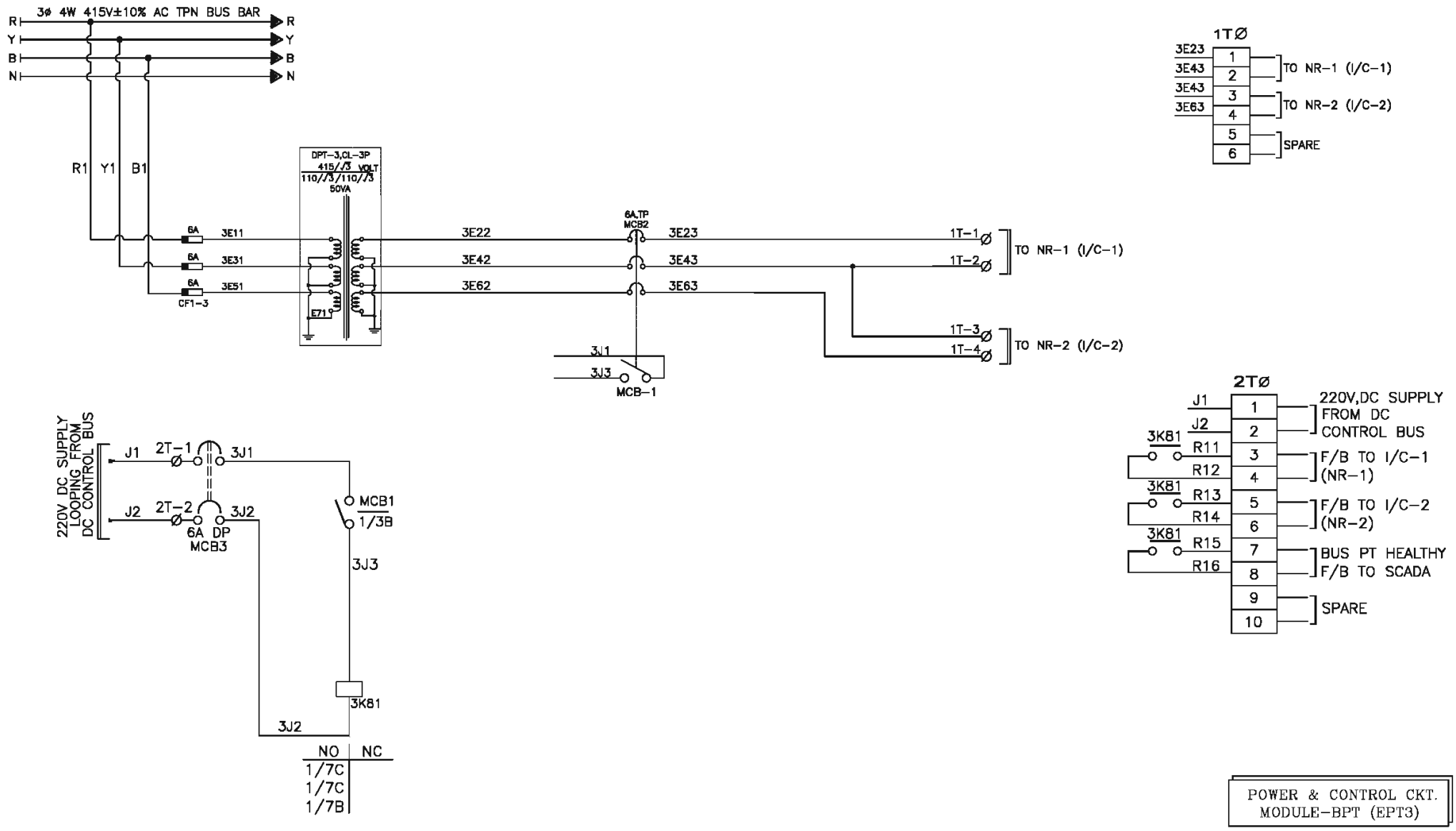


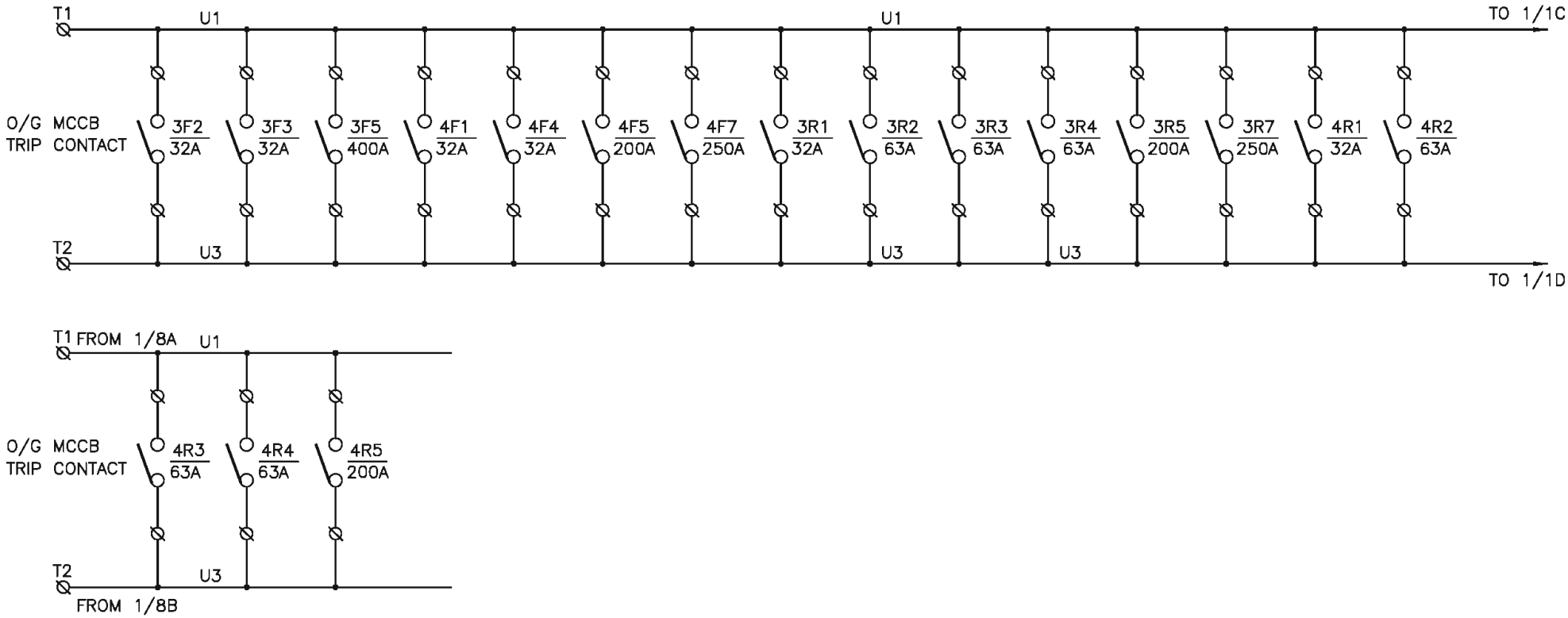
CONTROL CIRCUIT
MODULE-IC02 (52EA2)


1TØ
2J1 1
2J2 2
220V,DC SUPPLY FROM DC CONTROL BUS
2J5 3
2J6 4
TO CLOSE CMD. FROM SCADA
2J6 5
2J7 6
FUTURE I/LOCKING FOR CLOSING CKT.
2J17 7
2J18 8
TO TRIPPING CMD. FROM SCADA
2J17 9
2J18 10
FUTURE I/LOCKING FOR TRIPPING CKT.
Q1X
2J17 11
2J18 12
2J9 13
2J9A 14
FROM I/C-1 INT. CONTACT
Q2X
2K1 15
2K2 16
13 Q2 14
2K3 17
2K4 18
SPARE CONTACT FOR CUSTOMER USE
Q2X
2K5 19
2K6 20
2K7 21
2K8 22
TO I/C-2 INT. CONTACT
23
24
25
26
SPARE
(F/B TO SCADA)
3TØ
2U1 1
2U2 2
2U3 3
2U4 4
2U5 5
2U6 6
2U7 7
2U8 8
2U9 9
2U10 10
2U11 11
COMMON F/B TO SCADA
AUTO SELECTED F/B
BKR. ON/OFF F/B
BKR. TRIP F/B
DC SUPPLY HEALTHY F/B
LINE PT HEALTHY F/B
LINE VOLATGE HEALTHY F/B
TRIP CKT. HEALTHY F/B
MOTOR SPRING CHARGED F/B
BKR. IN TEST POSITION F/B
BKR. IN SERVICE POSITION F/B
12
13
SPARE
4TØ
A1+ 1
A0- 2
COM. 3
MFM RS485 COM. PORT TO CLIENT USE
4
5
SPARE
Q2X
2K11
12SX
2K10
6TØ
NR2-TX
2K12
1
2
Q2 INCOMER-2 F/B TO I/C-1 (Q1) NR-1
NR2-27X
2K13
3
2K14
4
5
6
SPARE
(DIGITAL INPUT TO NR2)
5TØ
2J1 1
R106 2
BUS PT PROT. OK F/B
2J1 3
R207 4
R208 5
2J1 6
I/C-1 ON & IN SERVICE POS. F/B
I/C-1 U/V F/B
R209 7
I/C-1 FAULTY F/B
8
9
10
SPARE
2E1 11
2E2 12
BUS PT 110V AC SUPPLY
CONTROL CIRCUIT
MODULE-IC02 (52EA2)

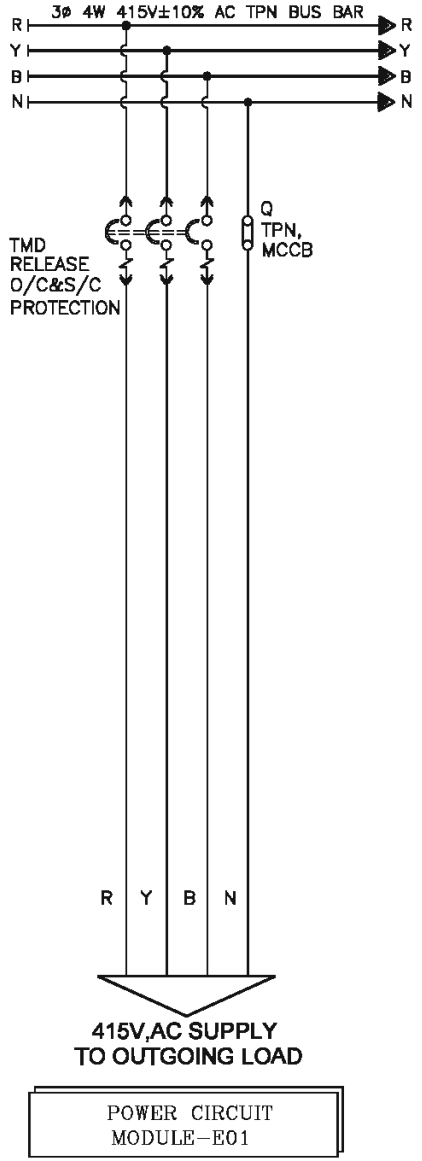


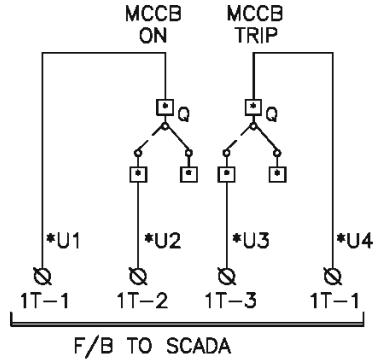
220V,DC CONTROL BUS
AUTO C/O CIRCUIT DIAGRAM

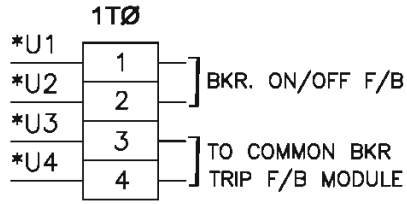

01
02
03
04
05
06
07
08
A
B
C
D
3ø 4W 415V±10% AC TPN BUS BAR
R
Y
B
N
R1
Y1
B1
DPT-3,CL-3P
415/√3 VOLT
110/√3/110/√3
50VA
6A
3E11
3E31
3E51
CF1-3
E71
3E22
3E42
3E62
6A,TP
MCB2
3E23
3E43
3E63
1T-1
1T-2
1T-3
1T-4
TO NR-1 (I/C-1)
TO NR-2 (I/C-2)
3J1
3J3
MCB-1
1TØ
3E23
3E43
3E43
3E63
1
2
3
4
5
6
TO NR-1 (I/C-1)
TO NR-2 (I/C-2)
SPARE
220V DC SUPPLY
LOOPING FROM
DC CONTROL BUS
J1
J2
2T-1
2T-2
3J1
3J2
6A DP
MCB3
MCB1
1/3B
3J3
3K81
3J2
NO
NC
1/7C
1/7C
1/7B
2TØ
J1
J2
3K81
R11
R12
3K81
R13
R14
3K81
R15
R16
1
2
3
4
5
6
7
8
9
10
220V,DC SUPPLY
FROM DC
CONTROL BUS
F/B TO I/C-1
(NR-1)
F/B TO I/C-2
(NR-2)
BUS PT HEALTHY
F/B TO SCADA
SPARE
POWER & CONTROL CKT.
MODULE-BPT (EPT3)

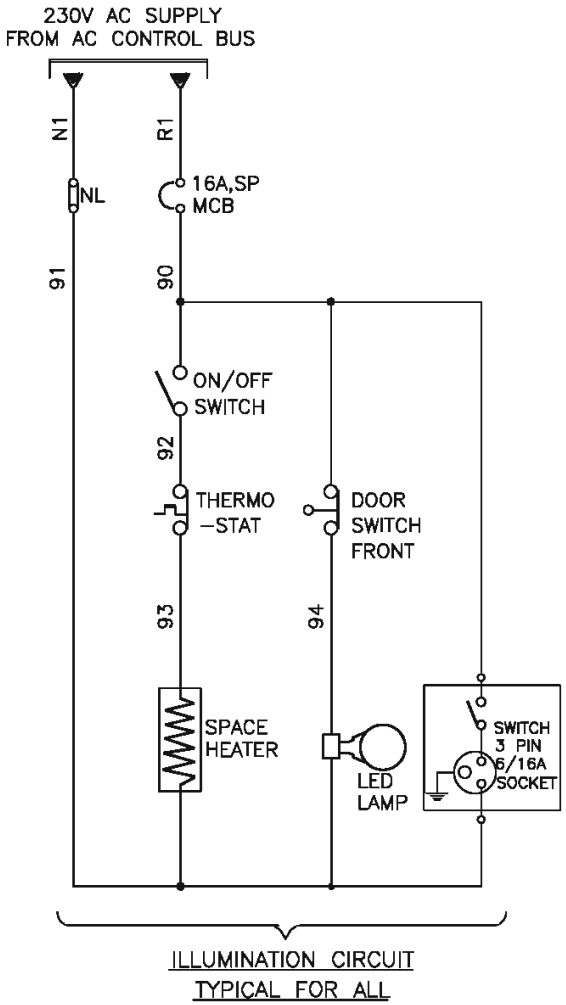


O/G MCCB'S COMMON TRIP
F/B TO SCADA
(3F3 MODULE)


3ø 4W 415V±10% AC TPN BUS BAR
R
Y
B
N
TMD
RELEASE
O/C&S/C
PROTECTION
Q
TPN,
MCCB
R Y B N
415V,AC SUPPLY
TO OUTGOING LOAD
POWER CIRCUIT
MODULE-E01


MCCB
ON
MCCB
TRIP
Q
Q
*U1
*U2
*U3
*U4
1T-1
1T-2
1T-3
1T-1
F/B TO SCADA


1TØ
*U1
*U2
*U3
*U4
1
2
3
4
BKR. ON/OFF F/B
TO COMMON BKR
TRIP F/B MODULE



ILLUMINATION CIRCUIT
TYPICAL FOR ALL

	▶	5	**Erection Bay Board (EBSB)**	
Legend	**Qty**	**Unit**	**ITEM DESCRIPTION**	**Makes**
	1	Set	▶ **Incomer 1 - 800A ACB (52EA - 1) - From SSB-1**	**Each with following**
ACB	1	No.	800A 50kA TP EDO ACB, with MP Based O/C, S/C & E/F Release with following accessories:- ▶ Closing Coil - 220V DC ▶ Tripping Coil - 220V DC ▶ Spring Charge Motor - 220V DC ▶ Door Interlock ▶ Test, Service & Spring Microswitch ▶ 4NO+4NC Aux contact	Schneider MVS / L&T Upower Omega
T-N-C	1	No.	25A Breaker Control Switch (Trip - Neutral - Close)	Salzer(L&T) / Kaycee
A/M	1	No.	6A Local - Remote / Auto - Manual Switch (2P-2W)	Salzer(L&T) / Kaycee
IL	1	Set.	R / Y / B Phase Indicating Lights (LED Type) 110 / √3 V AC	Esbee(L&T) / C&S / Werner
IL	5	Nos.	▸On(Red) / Off(Green) / Trip(Amber) / Trip Ckt Healthy(White) / DC Supply Healthy(Blue) Indication Lights (LED Type) 220V DC	Esbee(L&T) / C&S / Werner
A	1	No.	Analog Ammeter ▸0 - 800A, CL: 1.0, 96sqmm Flush Mounted	AE / RISHABH /Selec
Ass	1	No.	6A Ammeter Selector Switch (Ass)	Salzer(L&T) / Kaycee
V	1	No.	Analog Voltmeter ▸0 - 500V, CL: 1.0, 96sqmm Flush Mounted	AE / RISHABH /Selec
Vss	1	No.	6A Voltmeter Selector Switch (Vss)	Salzer(L&T) / Kaycee
MFM	1	No.	Digital Multifunction Meter (LED Display) with RS-485 Port, CL: 1 ▸V, A, PF, F, W, Wh, VA, VAh, Var, Varh	Secure / L&T / Trinity / Schneider
NR-1	1	No.	**Numerical Feeder Protection Relay** **▸(51, 50, 51N, 50N,27,59,64,74,95) with IEC 61850 Protocol, Aux 220V DC**	**Schneider - P3U30**
86-1	1	No.	Master Trip Relay (Lockout relay), 2NO + 2NC, 220V DC	GE Alstom VAJH13
MCT	3	Nos.	Metering CT ▶ 800 / 1A, CL: 0.5, 30VA Resin Cast	Indcoil / Procom / Kalpa / Perfect / Trinity
PCT	3	Nos.	Protection CT ▶ 800 / 1A, CL: 5P20, 15VA Resin Cast	Indcoil / Procom / Kalpa / Perfect / Trinity
LPT	3	Nos.	Potential Transformer (Line PT) ▶ 50VA, CL: 0.2/3P, PT Ratio: 415/√3 / 110/√3V AC, 1-Phase	Indcoil / Kalpa / Perfect / Reputed
1AP	1	No.	Auxiliary Contactor, 2NO+2NC, 220V DC	Schneider / L&T
Q1x, 74x-1, 11Tx, 11Sx, SCX-1	5	Nos.	Auxiliary Contactor, 4NO, 220V DC	Schneider / L&T

Q1x	1	No.	2NO Add On Block, 220V DC	Schneider / L&T
1K80, 1K81, Q1Tx, NR1-27X, NR1-Tx	5	Nos.	Auxilliary Interposing Relay 5A, 2 C/O, 220V DC	Salzer(L&T) / Schneider
Fuse	3	Nos.	6A HRC Control Fuse with base	L&T / C&S
Fuse	6	Nos.	4A HRC Control Fuse with base	L&T / C&S
CMCB	1	No.	6A 2P 10kA, C-Curve MCB	Schneider / L&T
CMCB	2	Nos	6A TP 10kA, C-Curve MCB with 1C/O Aux Contact	Schneider / L&T
NL	1	No.	Neutral Link	Rept.
Wir	1	No.	Control Wiring	Polycab / Havells / RR Cable / KEI / HPL
	1	**Set**	**►Incomer 2 - 800A ACB (52EA-2) - From SSB-2**	**Each with following**
ACB	1	No.	800A 50kA TP EDO ACB, with MP Based O/C, S/C & E/F Release with following accessories:- ►Closing Coil - 220V DC ►Tripping Coil - 220V DC ►Spring Charge Motor - 220V DC ►Door Interlock ►Test, Service & Spring Microswitch ►4NO+4NC Aux contact	Schneider MVS / L&T Upower Omega
T-N-C	1	No.	25A Breaker Control Switch (Trip - Neutral - Close)	Salzer(L&T) / Kaycee
A/M	1	No.	6A Local - Remote / Auto - Manual Switch (2P-2W)	Salzer(L&T) / Kaycee
IL	1	Set	R / Y / B Phase Indicating Lights (LED Type) 110 / √3 V AC	Esbee(L&T) / C&S / Werner
IL	5	Nos.	►On(Red) / Off(Green) / Trip(Amber) / Trip Ckt Healthy(White) / DC Supply Healthy(Blue) Indication Lights (LED Type) 220V DC	Esbee(L&T) / C&S / Werner
A	1	No	Analog Ammeter ►0 - 800A, CL: 1.0, 96sqmm Flush Mounted	AE / RISHABH /Selec
Ass	1	No.	6A Ammeter Selector Switch (Ass)	Salzer(L&T) / Kaycee
V	1	No.	Analog Voltmeter ►0 - 500V, CL: 1.0, 96sqmm Flush Mounted	AE / RISHABH /Selec
Vss	1	No.	6A Voltmeter Selector Switch (Vss)	Salzer(L&T) / Kaycee
MFM	1	No.	Digital Multifunction Meter (LED Display) with RS-485 Port, CL: 1 ►V, A, PF, F, W, Wh, VA, VAh, Var, Varh	Secure / L&T / Trinity / Schneider
NR-2	1	No.	**Numerical Feeder Protection Relay** **►(51, 50, 51N, 50N,27,59,64,74,95) with IEC 61850 Protocol, Aux 220V DC**	**Schneider - P3U30**
86-2	1	No.	Master Trip Relay (Lockout relay), 2NO + 2NC, 220V DC	GE Alstom VAJH13
MCT	3	Nos.	Metering CT ►800 / 1A, CL: 0.5, 30VA Resin Cast	Indcoil / Procom / Kalpa / Perfect / Trinity
PCT	3	Nos	Protection CT ►800 / 1A, CL: 5P20, 15VA Resin Cast	Indcoil / Procom / Kalpa / Perfect / Trinity
LPT	3	Nos.	Potential Transformer (Line PT) ►50VA, **CL: 0.2/3P**, PT Ratio: 415/√3 / 110/√3V AC, 1-Phase	Indcoil / Kalpa / Perfect / Reputed
1AP	1	No.	Auxiliary Contactor, 2NO+2NC, 220V DC	Schneider / L&T

Q2x, 74x-2, 12Tx, 12Sx, SCX-2	5	Nos.	Auxiliary Contactor, 4NO, 220V DC	Schneider / L&T
Q2x	1	No.	2NO Add On Block, 220V DC	Schneider / L&T
2K80, 2K81, Q2Tx, NR2-27X, NR2-Tx,	5	Nos.	Auxilliary Interposing Relay 5A, 2 C/O, 220V DC	Salzer(L&T) / Schneider
Fuse	3	Nos.	6A HRC Control Fuse with base	L&T / C&S
Fuse	6	Nos.	4A HRC Control Fuse with base	L&T / C&S
CMCB	1	No.	6A 2P 10kA, C-Curve MCB	Schneider / L&T
CMCB	2	Nos.	6A TP 10kA, C-Curve MCB with 1C/O Aux Contact	Schneider / L&T
NL	1	No.	Neutral Link	Rept.
Wir.	1	No.	Control Wiring	Polycab / Havells / RR Cable / KEI / HPL
	1	**Set**	**Bus PT - 1 50VA**	**Each with following**
Fuse	3	Nos.	6A HRC Control Fuse with base	L&T / C&S
BPT	3	Nos.	Potential Transformer (Line PT) ▶ 50VA, CL: 3P, PT Ratio: 415/√3 / 110/√3V AC, 1-Phase	Indcoil / Kalpa / Perfect / Reputed
CMCB	1	No.	6A TP 10kA, C-Curve MCB with 1C/O Aux Contact	Schneider / L&T
Wir.	1	No.	Wiring	Polycab / Havells / RR Cable / KEI / HPL
	1	**Set**	**220V DC Control Supply Module**	**Each with following**
CMCB	2	Nos.	6A 2P 10kA, C-Curve MCB	Schneider / L&T
AuxC	1	No.	Auxiliary Contactor, 2NO+2NC, 220V DC	Schneider / L&T
AuxR	1	No.	Auxilliary Interposing Relay 5A, 2 C/O, 220V DC	Salzer(L&T) / Schneider
IL	1	No.	▸DC Supply ON (Red) Indication Lights (LED Type) 220V DC	Esbee(L&T) / C&S / Werner
Wir.	1	No.	Wiring	Polycab / Havells / RR Cable / KEI / HPL
	1	**Set**	**▶ Outgoing - MCCB - 400A**	**Each with following**
MCCB	1	No.	400A 25kA TP MCCB Thermal - Magnetic Release for O/L, S/C Protection ▸Rotary Operated Handle (Extended) ▸Aux + Trip Contact ▸Spreader Links	Schneider / L&T
Wir.	1	No.	Wiring	Polycab / Havells / RR Cable / KEI / HPL
Cu Link	1	No.	TP+NL Copper Busbar Links	Rept
D/O Module	1	No.	**Draw out module with male female contacts, cranking assembly, telescopic rails etc**	**Kandi Electrical**
	2	**Set**	**▶ Outgoing - MCCB - 250A**	**Each with following**
MCCB	1	No.	250A 25kA TP MCCB Thermal - Magnetic Release for O/L, S/C Protection ▸Rotary Operated Handle (Extended) ▸Aux + Trip Contact ▸Spreader Links	Schneider / L&T
Wir.	1	No.	Wiring	Polycab / Havells / RR Cable / KEI / HPL
Cu Link	1	No.	TP+NL Copper Busbar Links	Rept.
D/O Module	1	No.	**Draw out module with male female contacts, cranking assembly, telescopic rails etc**	**Kandi Electrical**

	3	**Set**	**►Outgoing - MCCB - 200A**	**Each with following**
MCCB	1	No.	200A 25kA TP MCCB Thermal - Magnetic Release for O/L, S/C Protection ►Rotary Operated Handle (Extended) ►Aux + Trip Contact ►Spreader Links	Schneider / L&T
Wir.	1	No.	Wiring	Polycab / Havells / RR Cable / KEI / HPL
Cu Link	1	No.	TP+NL Copper Busbar Links	Rept.
D/O Module	1	No.	**Draw out module with male female contacts, cranking assembly, telescopic rails etc**	**Kandi Electrical**
	6	**Set**	**►Outgoing - MCCB - 63A**	**Each with following**
MCCB	1	No.	63A 25kA TP MCCB Thermal - Magnetic Release for O/L, S/C Protection ►Rotary Operated Handle (Extended) ►Aux + Trip Contact	Schneider / L&T
Wir.	1	No.	Wiring	Polycab / Havells / RR Cable / KEI / HPL
D/O Module	1	No.	**Draw out module with male female contacts, cranking assembly, telescopic rails etc**	**Kandi Electrical**
	6	**Set**	**►Outgoing - MCCB - 32A**	**Each with following**
MCCB	1	No.	32A 25KA TP MCCB Thermal - Magnetic Release for O/L, S/C Protection ►Rotary Operated Handle (Extended) ►Aux + Trip Contact	Schneider / L&T
Wir.	1	No.	Wiring	Polycab / Havells / RR Cable / KEI / HPL
D/O Module	1	No.	**Draw out module with male female contacts, cranking assembly, telescopic rails etc**	**Kandi Electrical**
	6	**Set**	**Acessories (Space Heater & panel light)**	**Each with following**
PS	1	No.	6/16A, Power Switch Socket Combine	Anchor / Havells / Reputed
Ther.	1	No.	Space Heater with Thermostat	Rept.
DS	1	No.	Door Limit Switch	Suraj / reputed
PL	1	No.	Panel illumination LED Batten 5W	Orpat / Eveready / Reputed
CMCB	1	No.	16A SP 10kA, C-Curve MCB	Schneider / L&T
Wir.	1	No.	Wiring	Polycab / Havells / RR Cable / KEI / HPL

CHAPTER-13: CABLING SYSTEM

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13.1. SCOPE OF CHAPTER

13.1.1. Scope of work under this chapter covers the provision of all labour, supervision, tools, material, material handling equipments like hydraulic cranes, truck cranes, loaders etc., for dismantling /removal of all existing cables of all sizes and voltage grades from different equipment installed in indoor / outdoor areas of Chilla HEP after disconnection from respective equipment along with cable racks & trays, transportation of old items/scraps to store and tagging, stacking & storage at Employer's store or disposal as per applicable standards and regulations as per Employer's choice.

13.1.2. Scope of work under this chapter covers the provision of labour, tools, plants, material and performance of work necessary for design and engineering, manufacture, quality assurance, quality control, shop assembly, shop testing, transportation, delivery at site, site storage and preservation, erection, testing and commissioning, performance testing, field acceptance testing, training of the Employers personnel, handing over to the Employer and guarantee for Twenty Four (24) months of "Cabling System" primarily comprising of new power cables (AC & DC), control cables, coaxial cables, communication cables and instrumentation cables, cable racks & trays, support structures, complete with cable terminals and all accessories for making the systems complete and for warranting a trouble free and safe operation.

13.1.3. Dismantling of existing power, control, coaxial, communication and instrumentation cables, and associated equipment and auxiliaries shall be done in such a way that dismantling allows operation of remaining units without any trouble while one of them is under comprehensive RMU.

13.1.4. The Powerhouse complex included powerhouse & switchyard complex along with fore-bay intake, clean water filtration plant etc. and all associated adjoining areas.

13.1.5. The specification shall be read and construed in conjunction with other chapters of Volume-III of bidding document. In the event of any discrepancy with listed documents, the stipulation of this specification shall govern.

13.2. SCOPE OF SUPPLY

The scope of work including supply, erection, testing & commissioning shall be a comprehensive functional cabling system complete in every respect including but not be limited to following:

13.2.1. One (1) lot of High Voltage (HV) power cables for voltage grade 1.1kV & above, with FRLS - XLPE insulation, Aluminium Conductor (for AC)/ Copper Conductor (for DC), screened, armoured.

13.2.2. One (1) lot of Low Voltage (LV)/ power cables for voltage grade 1.1kV & below, with FRLS - XLPE insulation, Aluminium Conductor (for AC)/ Copper Conductor (for DC), screened, armoured.

13.2.3. One (1) lot of Control cables, instrumentation cables, coaxial cables and communication cables etc. with FRLS - XLPE insulation, Copper Conductor, screened and armoured.

13.2.4. One (1) lot of Cable racks & trays, supporting steel structures, cable terminals, sleeves, heat shrinkable cable termination kit (Preferably of 3M make), cable lugs, cable glands, GI & industrial grade FRLS PVC conduits, button tape (strap & stud), cable junction boxes, hydraulic operated crimping tools and control cable crimping tools and all other accessories.

13.2.5. Civil work required for new cable trenches, dismantling old cable, refurbishment of support structures etc.

13.2.6. All special devices, tools, maintenance equipment etc required for installation, testing, commissioning and maintenance of power and control cable.

13.2.7. Set of spares

The intent of scope is to provide all cabling, cable routing & termination in power house and all adjoining functional areas.

13.3. EXISTING HV, LV AND CONTROL CABLES OF CHILLA HEP

The HV and LV/ LT cables are installed in the Chilla HEP for providing interconnectivity between various auxiliary loads and supply boards. The station/ unit auxiliary power supply system primarily comprises Two (2) Nos. 1000 kVA 11/0.415 kV Station Auxiliary Transformers (SAT) charging respective Station Auxiliary Boards (SABs) & being fed through 11kV feeders from 33/11 kV

substation at Chilla colony. Apart from that Four (4) Nos. 500 kVA, 11/0.415 kV Unit Auxiliary Transformers (UAT) being fed from 11 kV unit bus ducts charges respective Unit Auxiliary Boards (UABs). Together these boards supply to various receptacles and auxiliary boards.

The control cables are installed for interconnections in between various equipment, protection & control panels located in the power house complex for ensuring necessary control, alarm & anunciation and protection monitoring at local site as well as remote centralized location i.e. the Powerhouse Control Room thus achieving interlocking, wherever required.

Most of the existing cables are laid in air, in cable trenches in the power house, fore-bay intake and switchyard. The outdoor switchyard and power house is interconnected through a cable duct/ tunnel. Inside the cable duct, cables have been laid on steel racks. The new cables shall be laid on the new cable racks & trays and cable ways after cleaning, strengthening and painting the cable tray support structures.

Only requirement and technical specification of cables is defined under this chapter. For quantity of cables, the bidders shall assess the actual site requirement of different grades and sizes of cables before submission of the bid considering provision for the new system at the Chilla HEP post RM&U.

13.4. SPECIAL DESIGN, LAYOUT CONDITIONS & REQUIREMENT OF CABLES

13.4.1. Power Cables

I. 11kV Cable:

The 11 kV, 3-core, with FRLS - XLPE insulation, Aluminium Conductor, screened, graded and armoured shall be required to the following interconnections:

a) 11kV cable (Incomer-1) from 33/11kV substation at Chilla colony to 11kV indoor panel bus at switchyard. The cable shall be designed for catering full load of 5 MVA.
b) 11kV cables (Feeder-1 & 2) for connecting the SAT-1 & SAT-2 with the 11kV indoor panel bus at switchyard. The cable for each feeder shall be designed for catering full load of 1.1 MVA.

c) 11kV cable (Incomer–2) for connecting 11kV side of 132/11kV Station Transformer with 11kV indoor panel bus at switchyard. The cable shall be designed for catering full load of 5 MVA.

The cables shall be supplied in lengths suitable to be laid without mid joints. All the cables shall be designed for catering full loads individually. The cables shall be laid in air in covered cable trenches. In case of road crossing, proper strengthening of the trench covered shall be ensured by the contractor.

II. LT Power Cables:

FRLS-XLPE insulation, Aluminium Conductor, screened, graded, armoured cables for 3-Ø, 415V AC & 1-Ø, 240V AC connections while FRLS-XLPE insulation, Copper Conductor, screened, graded, armoured cables shall be used for 220V/48V/24V DC applications for interconnecting different auxiliary service boards and various equipment to respective distribution boards as per the requirement. Primarily the LT cable connections shall include the following: -

a) 1.1 kV cables for connecting SAB-1&2 to SAT1&2 respectively.
b) 1.1 kV cables for connecting each UAB to each UAT.
c) 1.1 kV cables for interconnecting the SAB and UABs.
d) 1.1 kV cables for connecting different auxiliaries & auxiliary supply boards from SABs & UABs.
e) Power connection to Battery Charger, three phase motors, heaters, compressors etc;
f) Supply to power house illumination system, HVAC system, fire fighting system, cooling water system etc..
g) 220V/ 48V/ 24V DC power cables for DC Distribution system

The cables shall be supplied in lengths suitable to be laid without mid joints. All the cables shall be designed for catering full loads individually. The cables shall be laid in air in covered cable trenches. In case of road crossing, proper strengthening of the trench covered shall be ensured by the contractor.

13.4.2. 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 complex, switchyard area and other areas in vicinity of power house. It shall also include the central control and monitoring system with their local control panels, operator station, metering, protection and automatic control cubicles. The network shall also include cabling for Unit Control Boards incorporating the digital turbine governors, the digital voltage regulators, the local control panels and the logic control functions. The cabling shall also cover the equipment for fire-fighting system as fire pump, fire tank etc, HVAC system, cooling water system, PLCC system, communication system etc. and all automatic and manual control of unit and station services such as cooling water, drainage system etc.

The scope of remote instrumentation, protection, control and alarm systems is specified in the relevant chapters. Apart from that following shall be ensured by the contractor: -

a) External CT & PT cabling shall not be less than 6 mm^2 Copper Cable. 4x4 Copper conductor cables shall be used for a group of 3 phase wiring of CT & PT.

b) All Control cabling for operation & interlocking of circuit breakers, Isolators & operation of unit etc. shall be not less than 2.5 mm^2 Copper conductor cable.

c) Alarm /annunciation / signalling cables shall be of minimum 1.5 mm^2 size copper Conductor cable.

13.4.3. Cable trenches, Racks & Trays, Supporting Structures, Cables Terminals

All the existing cable tranches & covers shall be refurbished and additional cables tranches & covers shall be constructed as per requirement which shall be finalized during detailed engineering. The new cable racks & trays for all cables along with supporting structures, cable terminating lugs and other accessories shall be supplied, erected, tested and commissioned to interconnect various service boards and equipment in order to complete the system.

13.5. CODES AND STANDARDS

The cables shall be manufactured, tested strictly as per recommendations of the following standards:

Item	Code/Standard	Title of Codes/Standards
1	IEC60038:1983	IEC standard voltages
2	IEC60183:1984	Guide to the selection of high-voltage cables
3	IS: 8130-1984	Conductors for insulated electric cables and flexible cords.
4	IEC 60288	Nominal cross sectional area and composition of conductor of insulated cables.
6	IS:3975 – 1999	Mild steel wires formed wires and tapes for armouring of cables
7	IS: 10810-1984	Method of Test of cables
8	IEC60230:1966	Impulse tests on cables and their accessories
9	IEC60332:1993	Tests on electric cables under fire conditions. Part 1: Test on a single vertical insulated wire or cable
10	ASTM E1354	Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter
11	ASTM D2863 – 09	Standard test method for measuring the minimum oxygen concentration to support candle-like combustion of plastics (oxygen index)
12	IEC 60332-3-24:2000	Tests on electric cables under fire conditions. Part 3-24: Test for vertical flame spread of vertically-mounted bunched wires or cables. Category C
13	ISO 5660-1:2002	Reaction-to-fire tests -- Heat release, smoke production and mass loss rate -- Part 1: Heat release rate (cone calorimeter method)
14	IEC 60540	The methods for insulations and sheath of electric cables and cords (elastomeric and thermoplastic compounds)
15	IEC 60230	Impulse tests on cables and their accessories.
16	IEC 60060	High voltage test techniques.
17	IEC 60287	Calculation of the continuous current rating of the cables (100% load factor).

Item	Code/Standard	Title of Codes/Standards
18	IEC 60502	Extruded solid dielectric insulated power cables for rated voltages from 1kV up to 30kV.
19	ASTM-D-2843	Standard test method for density of smoke from burning or decomposition of plastics.
20	IEC 332-1	Test on electric cables under fire conditions.
21	ASTM-D-2863	ASTM D2863 - 09 Standard Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-Like Combustion of Plastics (Oxygen Index)
22	IEC 754-I	Test method for acid gas generation...
23	IEC 331	Fire resisting characteristics of electric cables
24	IER 1956	Indian Electricity Rule 1956
25	IEC 60332-1-2	Tests on electric and optical fibre cables under fire conditions Part 1-2: Test for vertical flame propagation for a single insulated wire or cable Procedure for 1 kW pre-mixed flame
26	IEC 60754	Test on Gases Evolved During Combustion of Materials from Cables - Part 1: Determination of the Amount of Halogen Acid Gas
27	ASTM G53	Standard Practice for Operating Light- and Water-Exposure Apparatus (Fluorescent UV-Condensation Type) for Exposure of Non-metallic Materials
28	IS: 10418-1982	Specification for drums for Cables
29	IS: 1225-1983	Guide for practice for Installation and Maintenance of Power Cables up to and including 33 kV rating
30	IS 7098 (Part-1,II)	Cross linked Polyethylene Insulated PVC sheathed cables

Cables conforming to any other standard, which ensures equal or better quality, may be accepted subject to approval of the Employer. In such case, copies of the English version of the standards adopted shall have to be submitted along with the Tender. The electrical installation shall meet the requirements of Indian Electricity Rules as amended up to date and relevant IS Codes of Practice. In addition, other rules and regulations applicable to the work shall be followed.

13.6. PERFORMANCE CRITERIA AND GUARANTEE

The power, control, coaxial communication and instrumentation and other cables systems shall be capable of performing all intended duties and it is the responsibility of the contractor to supply the equipment as per guaranteed technical particulars.

13.7. BASIC CRITERIA , DIMENSIONS AND RATINGS

13.7.1. General for all kind of Cables

I. All cables shall be designed to cope with

a) The short–circuit conditions.

b) The applied protective system in respect to cross-section and number of cores.

II. All the cables shall be capable of satisfactory operation under a power supply system voltage variation of ± 10% and frequency variation of + 5% and a combined frequency voltage variation of 10% (absolute sum). The cables shall have heat and moisture resistant properties. These shall be of type and design, with proven record of power station installation.

III. The insulation and sheath materials of all the cables shall be resistant to oil, acid & alkali and shall be armoured & strong enough to withstand mechanical stresses during handling.

IV. The outer sheath of all the cables shall have flame retardant low smoke (FRLS) characteristics and shall meet the requirements of additional tests specified for this purpose in IS and IEC thus achieving following properties

S.No.	Property	Value
1	Oxygen index	Min. 29(Test as per ASTM D2863 performed on 27 ± 2^0c)
2	Smoke density	Min. 40% light transmittance (Test as per ASTM D2863)
3	Acid gas	Max. 20% by weight(as per IEC 60754-1)
4	Flame propagation	As per IEC 60332-1, IEEE 383

V. All the cables shall be chosen taking into account the following factors:

a) System fault level.
b) Maximum time for fault clearance (i.e., operating time of the back up protection relays plus the time of operation of the circuit breakers).
c) Full load current of the circuit.
d) Short circuit current and duration (for breaker protected cables)
e) Installation conditions.
f) Voltage drop under normal running and starting condition.
g) Voltage drop at motor terminals shall be within permissible limit during starting and normal running.
h) Consideration shall also be given to limit the cable to the nearest standard sizes instead of using too many sizes.
i) The insulation level of the cable shall be as per the type of earthing (effectively/non-effectively earthed) of the system and the ground fault clearing time.

VI. **All LT AC power Cables up to 10 mm^2 shall be of copper conductor and those equal and above 10mm^2 shall be of Aluminium conductor. However all DC, communication, instrumentation and control cables shall be having Copper conductor.**

13.7.2. Power Cables - 11 kV System - Single & Multi Core Cables

13.7.2.1. 11kV power cables shall be heavy duty, stranded circular aluminium conductor, cross linked polyethylene (XLPE) insulated provided with conductor screening and insulation screening, laid up, extruded PVC inner-sheathed, armoured FRLS type conforming to IS 7098 (Part-II) / Relevant IEC and as specified in this specification. The conductor screening shall be by strippable extruded semi-conducting thermo setting material with a minimum thickness of 0.3 mm. as per IS. The insulation and screening shall be extruded, semi-conducting and with copper tape screening (with at least 0.075 mm thickness) about it.

13.7.2.2. Technical Specification of HV Power cables:

The rating and requirement of the cables are indicated in the following:-

Item	Particulars	Specified
1	Type of cable	Single /Three (3) cores 6.35(P-N)/11(P-P) kV, aluminium conductor, screened, XLPE insulated, FRLS type, armoured cables.
2	Voltage grade	As mentioned in 1 above
3	Frequency	50 Hz
4	Highest system voltage	12 kV
5	Impulse withstand voltage	75 kV
6	Method of system earthing	Generator neutral is unearthed; 33/11 kV and 11/0.4 kV transformers neutrals are solidly earthed.
7	Installation	Partly indoor and partly outdoor
8	Laying method	In air on horizontal / vertical cable trays/ladders in groups.
9	Short circuit Current and duration	To calculate by the formula 0.094 A/√t where A= cross sectional area of aluminium conductor of XLPE cables and t= duration of short circuit =1 s.
10	Normal ambient temperature	50 ^{0}C
11	Maximum Conductor Temperature	
11.1	Continuous	90 ^{0}C
11.2	Short time	250^{0}C
12	Conductor Material	Stranded, compacted and circular, aluminium conductor of class 2 as per IS: 8130-1984
13	Whether conductor is screened	Yes
14	Insulation	XLPE
15	Conductor Insulation Screen material	Shall be provided as per IS:7098 part -2 1985
16	Core Identification	Shall be provided
17	Inner Sheath	Shall be provided
18	Armouring	Shall be provided
19	Over All sheath	Extruded FRLS PVC compound with rodent and termite retardant

Item	Particulars	Specified
		compound.
20	Bending radius	20D for single core and 15D for three core cables (D= cable overall diameter)
21	Embossing of cable particulars	To be provided
22	Tests	As per IS/IEC
23	Code/standards	IS:7098 part-2 1985 and IEC 60502 part-2
24	Method of construction	
24.1	Conductor screening, insulation and insulation screening	By triple extrusion method
24.2	Inner sheath	By extrusion or wrapping
24.3	Outer sheath	By extrusion
25	Tests	As per clauses of IS:7098 part-2 1985 and latest revision

13.7.3. LV/ LT Power Cables - 1100 Volt Grade

All LT power cables shall be of stranded Aluminium conductor except DC power cables, which shall be of stranded copper conductor. The connections to the batteries shall be carried out with highly flexible cables only.

I. Single Core Cables

These cables shall be at least 1100 volt grade, heavy duty, single core, stranded Aluminium conductor, cross linked polyethylene (XLPE) insulated FRLS type and sheathed, armoured and shall conform to the same design and properties as cables conforming to IS 7098 Part I / IEC.

II. Multi core Cables:

The cable shall be at least 1100 volt grade, heavy duty, FRLS type multi core, stranded Aluminium conductor, cross linked polyethylene (XLPE) insulated, colour coded, laid up, armoured, inner sheathed with extruded FRLS PVC, 2/3.5 cores, conforming to IS 7098 Part I / relevant IEC. The outer sheath is of specially formulated PVC compound.

III. Technical Specification of LV Cables

The rating and requirement of the cables are indicated in the following:-

Item	Particulars	Specified
1	Type of cable	Three cores and three and half cores 1100V grade XLPE insulated, armoured, aluminium conductor of FRLS type.
2	Voltage grade	As mentioned in 1 above
3	Frequency	50 Hz
4	Highest voltage	3 kV
5	Impulse withstand voltage	7.2 kV for five minutes between conductors and between conductor and ECC.
6	Method of system earthing	LV side of transformers are solidly earthed.
7	Installation	Partly indoor and partly out door
8	Laying method	In air on horizontal / vertical cable trays/ladders in groups.
9	Short circuit current and duration	0.094 A/√t where A= cross sectional area of aluminium conductor of XLPE cables and t= duration of short circuit =1 s
10	Normal ambient temperature	50^0C
11	Maximum Conductor Temperature	
11.1	Continuous	90^0C
11.2	Short time	250^0C
12	Conductor Material	Stranded, compacted and circular, aluminium conductor of grade H2 as per IS: 8130 1984
13	Whether conductor is screened	No
14	Insulation	XLPE
15	Core	Shall be provided

Item	Particulars	Specified
	Identification	
16	Inner Sheath	Shall be provided in case of three core cables
17	Armouring	Shall be provided
18	Over all sheath material	Extruded FRLS PVC compound with rodent and termite retardant compound.
19	Bending radius	20D for single core; 15D for three core cables (D= cable overall diameter)
20	Embossing of cable particulars	To be provided
21	Tests	As per IS/IEC
22	Code/standards	IS:7098 part-1 1988 & IEC 60502 part-2
23	Tests	As per clauses of IS: 7098 part-1 1988 and latest revision

IV. DC cables

DC power cables shall be single core and shall be of stranded copper conductor. The DC cable shall be FRLS, XLPE insulated, screened and armoured. However, the connections to the batteries shall be carried out with highly flexible cables only.

13.7.4. Control & Instrumentation Cables

13.7.4.1. The control & instrumentation cables shall be 1,000V grade, multi-core, colour coded, armoured, annealed stranded high conductivity Copper ,Single conductor , insulated with XLPE Insulation , FRLS type with anti oxidant stabilizers, rodent and termite retardant, manufactured strictly as per recommendations of national and international standards.

13.7.4.2. Technical Specification of Control & Instrumentation Cables

The rating and requirement of the cables are indicated in the following:-

Item	Particulars	Specified
1	Type of cable	1000V grade, colour

Item	Particulars	Specified
		coded, armoured/unarmoured, annealed stranded high conductivity Copper, Single conductor, insulated with XLPE Insulation, FRLS type multi core cables.
2	Voltage grade	As mentioned in 1 above
3	Frequency	50 Hz
4	AC highest voltage withstand capacity	3 kV for 5 min
5	DC high voltage withstand capacity	7.2 kV for 5 min
6	Installation	Partly indoor and partly out door
7	Laying method	In air on horizontal / vertical cable trays/ladders in groups.
8	Normal ambient temperature	50^0C
8.1	Continuous	90^0C
8.2	Short time	250^0C
9	Conductor Material	High conductivity copper conforming to IS: 613 1964 (latest amendments)
10	Type of conductor	Plain copper, circular shape, compacted, stranded conforming to IS: 8130 1984
11	Whether conductor is screened	No
12	Insulation	XLPE
13	Core Identification	By numbers as per relevant IS recommendation
14	Inner Sheath	Shall be provided in case of multi- core cables
15	Armouring	Shall be provided
16	Over all sheath	Extruded PVC compound, FRLS with rodent and termite retardant compound.
17	Embossing of cable particulars	To be provided

Item	Particulars	Specified
18	Tests	As per IS/IEC
19	Code/standards	IS:7098 Part-1 1988 & IEC 60502
20	Tests	As per clauses of IS: 7098 Part -1 1988, latest revision

13.7.5. Coaxial Cable

Coaxial cable shall be offered to connect coupling unit installed in the switchyard to the PLCC terminals, installed in carrier room of powerhouse. The cable offered by the contractor shall be steel armoured. The cable shall have braided tinned Copper conductor. The capacitance of the cable shall be low so as to minimize attenuation in the carrier frequency range. The impedance of the cable shall be so as to match with the output impedance of the PLC terminals and secondary impedance of the coupling units. The cable shall be insulated to withstand a test voltage of 4kV .The contractor shall supply H.F. cable with following properties:

a) Co-axial H.F. cable with 75 ohms characteristic impedance (unbalanced or unbalanced as per the design requirement)
b) Capacitance per meter – 53-pf approx.
c) Test voltage in kV – 4 kV RMS for 1 minute
d) Size of conductor – 7 strands/0.4mm

The maximum attenuation at various frequencies shall be as follows

S.No.	Frequency in kHz	Attenuation in db/km
1	60	1.4
2	300	3.3
3	500	4.7

13.8. SPECIFIC TECHNICAL REQUIREMENTS

13.8.1. Types of cables

All type of cables shall be as per clause- 13.7

13.8.2. Conductors

The conductor of cables shall be as per clause- 13.7. All LT AC power Cables up to 10 mm2 shall be of copper conductor and those equal and above 10mm2 shall be of Aluminium conductor. However all DC, communication, instrumentation and control cables shall be having Copper conductor.

13.8.3. Conductor Shield

The conductor having a semi-conducting screen shall ensure perfectly smooth profile and avoid stress concentration. The conductor screen shall be extruded in the same operation as the insulation. The semi-conducting polymer shall be cross linked (for XLPE cables). All cables shall be armoured.

13.8.4. Insulation

The insulation of the cables shall be extruded type and shall be designed and manufactured for the specified system voltage. The manufacturing process shall ensure that insulation is free from voids. The insulation shall withstand mechanical and thermal stresses under steady state and transient operating conditions. The extrusion method should give very smooth interface between semi-conducting screen and insulation. The insulation of the cable shall be of high standard quality. This should be in accordance with relevant IS and IEC standards.

13.8.5. Insulation Shield

In XLPE cables, to confine electrical field to the insulation a non-magnetic semi-conducting shield shall be put over the insulation. The insulation shield shall be extruded in the same operation as the conductor shield and the insulation by Triple extrusion process. The XLPE cable insulation shall be strippable. Metallic screening as given in this specification for the various control and power cables and special cables shall be provided

13.8.6. Sheath

The sheath shall be suitable to withstand the site conditions and specified temperature conditions. It shall be of adequate thickness and applied by a continuous process to produce a sheath of

consistent quality, free from any defects. The sheath shall be extruded. This should be in accordance with relevant IS and IEC standards.

13.8.7. Armour

Hard drawn Aluminium wire armouring /single galvanized steel tape/wire armouring shall be used for single core and multi core cables respectively. The diameter of the Aluminium wire shall be as per the table for the dimensions of the galvanized steel wire armour given in the relevant standard. This should be in accordance with relevant IS and IEC standards.

13.8.8. Service and Outer Sheath

Extruded PVC serving as specified shall be applied over armouring with suitable additives to prevent attack by rodents and termites. All servings must be given anti-termite treatment. The cable shall have suitable fillers laid up with the conductors, before the sheath is applied and the fillers shall be of substantially circular cross section. Fillers shall be suitable for operating temperature of the insulation and compatible with the insulation.

13.8.9. Size & Length of Cables

The number of cores and sizes of the cables required for various circuits shall be worked out during detailed engineering.
The cables covered by this specification shall be supplied in one length or in standard length as approved by the Employer.

13.8.10. Colour Scheme and Identification

To facilitate easy identification of phases a colour scheme of Red, yellow and Blue for phases and black for neutral shall be adopted for power cables. Multi-core control cables shall be colour coded for identification of cores or numbered at equal interval as per relevant IS/IEC standards.

All the cables shall carry manufacturer data and UJVNL embossing in a permanent, legible manner at an interval of at least 3 meter run. The manufacturer's data shall include the name, cable size, and voltage rating together with any other information.

13.8.11. Termination Kit

The termination kits required for 11 kV XLPE cables terminations shall be heat shrinkable type of “3M” make as per relevant IS / IEC.

The contractor shall supply all hardware consumables such as plumbing metal, sealing compound, tapes and other materials required for the making of these terminal connections of various sizes of cables and should leave at least 5% of these items for future use by the Employer.

13.8.12. Cable Lugs

The contractor shall ensure that no bimetallic action takes place, between the conductor of the cable and the cable-connecting lug by filling the lugs with suitable compound. The lugs shall be of standard quality IEC / IS make only.

13.8.13. Cable Accessories

The contractor shall supply all the required accessories that may be found necessary during actual execution of the job, within the quoted prices. No intermediate joint will be allowed in the run of any cable.

13.8.14. Cable Glands

The cable glands shall be made of brass duly electro tinned in order to avoid corrosion and oxidation of the surface. The nipple threads shall be in accordance with IS 1653 / IEC. Glands shall provide neat, tight, dust and vermin proof termination. Gland shall be provided with rubber ring to hold the cables firmly when check-nut is slightly tightened. Gland shall be complete with suitable washers etc

13.8.15. Compression Type Terminals for Control Wiring

These terminals are required for Copper conductor of control wiring. They shall be crimped to the conductor while other end will provide flat surface for better connections. The connectors shall be made of Copper electro tinned.

13.8.16. Button Tape (Strap & Stud)

This consists of perforated cable strapping with holes conveniently spaced for assembly and moulded studs. The strapping shall be made of NYLON Grade 220 or other elastic material to give proper performance. The studs shall be made of 'NYLON'.

13.8.17. Self Adhesive Marker

Self-adhesive marker in the form of strips of any one character, which can be easily peeled from the backing cards and can be applied on the cable, shall be supplied. The strips shall be water-proof duly marked with special formulated ink with specific thermo-setting adhesive to withstand high temperature.

Suitable plastic ring type ferrules marked with engraved indelible ink for control cables and sticker type ferrules for power cables shall be supplied. These shall be marked as per cable schedule such that each core of each cable can be identified easily.

13.8.18. Aluminium Strip

Aluminium strip of adequate size for making tags for labels shall be supplied.

PVC tapes, cotton tapes and any other accessory required for laying, termination, testing & commissioning shall be supplied of good quality as per relevant Indian Standards.

13.8.19. Cable Trays & Support Structure

Existing support structure shall be utilized and if required additional support shall be provided.

Perforated cable trays made out of hot dipper Galvanized steel sheet shall be fabricated. The trays shall be provided with long shape slots of 20mm x 8mm size. The trays shall be of perforated plates for proper ventilation of the cables.

The cable trays shall be fully galvanized as per the relevant IS / IEC and the Employer reserves the right to test galvanizing as specified in the relevant IS / IEC in presence of its representative. The tack-welded portion of trays and the contact surfaces shall be given a

layer of epoxy paint or shall be treated with galvanized compound. The cable support shall be painted.

Detailed design of the cable trays & additional supports shall be approved by the Employer before commencement of fabrication/assembly. The fixing of supports to the walls/ceiling/tunnel/column/ trench etc. is also covered in the scope of supply. The fixing arrangement shall be approved by the engineer. Embedment for the fixing of the supports shall be provided and installed by the contractor.

In addition to this, ladder type tray with double bends should be used wherever required. Also, various cable tray accessories such as vertical elbow, horizontal elbow, reducer, horizontal tee, and horizontal cross should be used.

13.8.20. Fire Proofing

Cables passing through different fire zones shall be provided with fireproof barriers and “Stanvac” make fire proof brushable coating with the same fire rating as the penetrated walls or partitions.

13.8.21. Cable Junction Boxes

Junction box shall be constructed of galvanised sheet steel of thickness not less than 2mm. The door shall be adequately strengthened to ensure rigidity and strength. Sheet steel and sections used in enclosures shall be cut neatly and finished free from burrs. Ample wiring space shall be provided at the sides, and back of the enclosure for incoming and outgoing circuits.

Removable plates with gaskets shall be fitted at the top and bottom of the box to provide the entry for conduit or cable. The door shall be provided with suitable gasket and fitted with a lock type handle. The door shall be hung on hinges having brass bodies and stainless steel pins.

Each cable junction box shall be provided with terminals of adequate rating on the terminal strip of suitable thickness. Disconnecting (sliding) type terminal blocks shall be provided, to facilitate testing & maintenance without disconnecting the cables.

Multi block terminal board of 15 A, 500 V rating shall be provided to form in assembly of number of terminal block. Assembly may be

secured with only two screws on the surface. There shall be provision on the strips to add more terminal in case of further requirement.
Except where specifically specified in the tender, all the junctions boxes, distribution boards for the wires and cables shall be of polycarbonate material with terminals, cable glands etc. of “Hensel” or “Schneider” or “Siemens” make and shall be designed for IP 54/ IP 67 ingress protection for indoor/ outdoor application.

13.8.22. Packing

All the cable shall be supplied on non-returnable wooden drums with adequate barrel diameter so as to avoid any damage to the cables and to withstand rough handling during transportation and storage.

A layer of waterproof paper shall be applied to the surface of the drums and over the outer cable layer. A circular space of at least 40mm shall be left between the cable and the lagging. Each drum shall carry the name of the manufacturer, the name of the Employer, his address, order number, item number, type, size length of cable, net and gross weight duly stencilled thereon.

13.9. QUALITY CONTROL AND ASSURANCE

The contractor shall follow the quality assurance and testing requirements specified separately in Volume-III-D: Quality Assurance Plan.

13.10. DRAWINGS, DOCUMENTS AND DESIGN CALCULATIONS

The Contractor is required to submit the design calculation for following to the Engineer for approval during detail engineering.

a) Calculations of the fault level.
b) Design criterion for selection of the individual cable capacity
c) Detailed cable schedule. In case of changes during execution, as executed cable schedule shall also be submitted by the contractor.

13.11. TESTS

13.11.1. Shop Tests

The cables shall be routine tested as per relevant IEC/IS at the works of Contractor in presence of Engineer. The Contractor is required to submit type test certificate and routine test reports of equipments.

Requirement of tests for power and control cables (IS 1554 & IS 7098 / IEC)

13.11.2. Type Tests:

Tests on conductor:
a) Annealing test (for Cu.)
b) Tensile test (for Al.)
c) Wrapping test (for Al.)
d) Conductor resistance test.

Test for armouring wires/strips: -
a) Nominal thickness (for steel strip)
b) Nominal diameter (for round wire)
c) Test for thickness of insulation and sheath.
d) Physical test for insulation and outer sheath.
e) Tensile strength and elongation at break of insulation and sheath.
f) Ageing in air oven.
g) Shrinkage test
h) Hot deformation
i) Loss of mass in air oven.
j) Heat shock test.
k) Thermal stability.
l) Insulation resistance test.
m) High voltage test (water immersion test)
n) High voltage test at room temperature.
o) Test for bleeding and blooming of pigments.
p) Fire Resistance Test

13.11.3. Acceptance Tests:

a) Annealing test (for Cu.)
b) Tensile test (for Al.)
c) Wrapping test (for Al.)
d) Conductor resistance test.
e) Test for thickness of insulation and sheath.

f) Tensile strength and elongation at break of insulation and sheath.
g) Insulation resistance test.
h) High voltage test at room temperature

13.11.4. Routine Tests:

a) Conductor resistance test.
b) High voltage test at room temperature

13.11.5. Optional Tests:

a) Cold bend test
b) Cold impact test
c) Armour resistance test (for other than mining cables)
d) The following FRLS tests are to be conducted as per the referred standard

13.11.6. FRLS Tests:

a) HCL gas evolution test (IEC - 754.1)
b) Oxygen Index (ASTM-D-2863)
c) Temperature Index (ASTM-D-2863)
d) Smoke density test (ASTM-D-2863)
e) Flammability test (IEC-332.1)
f) Swedish Chimney test (SS-424 14 75)
g) Ladder Test (IEEE-383)
h) XLPE cables shall be tested as per IS 7098 / IEC.
i) The instrumentation cables shall be routine tested as per relevant IEC/IS

13.12. INSTALLATION AND COMMISSIONING

All installation and laying of cables and cable trays shall be done by skilled workers in a workman like manner. Sufficient cores in control cables shall be kept as spare cores in cable scheduling for future use. Before charging of cables all wiring/cable shall be checked as per cable schedule program.

13.12.1. Cable Routing

For the main cableways, a system of cable racks and trays as well as cable ducts and trenches shall be provided.

The cables for emergency lighting, fire alarm systems, etc., shall be run on separate trays.

The 11kV XLPE cables and power and control cables shall be run separately on racks/trays, in cable trenches/cable tunnels and on columns, walls, ceiling and pulled through pipes. The contractor shall be responsible for carrying out proper dressing of the cables and supply non-magnetic/moulded fiber-glass cable fixing cleats, fasteners and clamps wherever necessary to hold the cables firmly to the trays.

Contractor shall take proper care in the handling of cables against external damage of any kind. Necessary rollers etc. shall be used while pulling and laying of the cables. Engineer- in- charge of the work shall have the right to stop the work in case of improper handling of the cables.

Cables shall be properly clamped at regular intervals with the help of non-magnetic/moulded fiberglass strip clamps/PVC sleeved clamps, of suitable size. Contractor shall submit typical drawings along with tender giving proposed clamping arrangement and give distance of clamping at bends and in regular run of cables.

13.12.2. Cable Markers and Cable Binding

Suitable cable markers of Aluminium with punch marks shall be provided and suitably tagged to the cable permanently so that cable could be easily identified.

Wire identification ferrules shall be provided in each core of the cables. Spare cores shall also be numbered indicating cable number & spare core number.

13.12.3. Cable Binding/Strapping

All control cables after glanding shall be neatly routed and bonded with the help of cable straps and studs inside the panel. Complete routing in panel shall be such that it gives a neat appearance good workmanship.

For L.T. Power cables, suitable holding clamps will be provided in the panel if required.

The contractor shall do the cable glanding suitable for each cable size at both ends of termination of each cable.

13.13. FIELD TESTS

Before commissioning of complete system, all cabling system shall be checked as per cable schedule and complete report shall be prepared by contractor and shall be submitted.

Field test shall include:

a) Cabling checking
b) Continuity checking
c) Megger testing in accordance with the applicable codes and standards.
d) Resistance checking

Contractor shall be responsible for conducting tests as per IS / IEC before termination of the cables i.e. measuring insulation resistance of each core to earth and core to core, identification of cores, all tests before and after termination etc.

13.14. SPARE PARTS

The following specified spare parts shall comprise the total requirement for Power &Control Cables Including Cable Trays under this Contract, shall be supplied.

S.No.	Description	Unit & Quantity
1	Cable 11kV	10% of Installed quantity
2	LV power cable each type	10% of Installed quantity
3	Control cable each type	10% of Installed quantity
4	Communication cable each type	10% of Installed quantity
5	Terminals-11 kV Outdoor type Indoor type	10% of Installed quantity
6	Lugs of each size	10% of Installed quantity
7	Coaxial cables	10% of Installed quantity
8	Cable glands of each size	20% of Installed quantity
9	Junction boxes of each size	20% of Installed quantity

10	Cable tray of each size	10% of Installed quantity
11	Cable supports, hardware etc	20% of Installed quantity

13.15. SPECIAL TOOLS

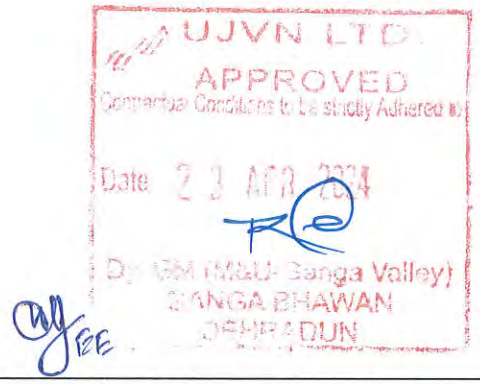
The Contractor shall provide one set of all necessary special tools and maintenance equipment for repairs and maintenance of the systems under this chapter as recommended by the manufacturer. It shall primarily include the following:

a) Electrical motorized cable cutter– 1 set (for cables of various sizes).
b) Hydraulic cable lug crimping tool - 1 set (for cables of various sizes).
c) Cable stripper - 1 set (for cables of various sizes).
d) Hot air blower for heat shrinkable termination kit – 2 sets

Apart from above, a list of such tools shall be approved during detail engineering.

REV.	DATE	ALTERED	REV.	DATE	ALTERED	REV.	DATE	ALTERED
		CHECKED			CHECKED			CHECKED
		APPROVED			APPROVED			APPROVED

DESIGN MEMORANDUM OF CABLING SYSTEM FOR POWER HOUSE (EXCLUDING SWITCHYARD)



CUSTOMER	M/s. UJVNL, UTTARAKHAND

CHILLA R&M
(4X39 MW)

		NAME	SIG.	DATE	
BHARAT HEAVY ELECTRICALS LTD. BHOPAL (INDIA) (A GOVERNMENT OF INDIA UNDERTAKING)	PREP.	S.SARKAR		20.04.2024	HPE 415
	CKD.	S.JUNEJA		20.04.2024	
	APPD.	S.SHARMA		20.04.2024	

SIGN. & DATE

INVENTORY NO.

TITLE:-

DESIGN MEMORANDUM OF CABLING SYSTEM FOR POWER HOUSE (EXCLUDING SWITCHYARD)

BHEL DOC. NO. HPE/CHIL/DP/CABLING — REV. **01**

UJVNL DOC. NO.

SIZE A4

1.0 Purpose:

The purpose of this document is to elaborate the approach being adopted to meet the cabling requirement and to underline the design features of Cabling System for CHILLA R&M (4X39MW).

2.0 SCOPE

Interconnecting cabling between two equipments (both supplied by BHEL under present contract) shall be covered in this scope of supply comprising following

1. HT Power Cables
2. LT Power Cables
3. Control Cables
4. Instrumentation cables
5. Cable trays and supports
6. HT Cable Termination Kit
7. Cable accessories.

Cables between BHEL supplied equipments/ instruments not specifically mentioned in this document shall also be supplied.

3.0 Type of Cables to be Used:

The hardwired connections between various field devices, Power and Control Boards/ Panels/ Cubicles etc. for CHILLA R&M will be done by various types of cables as per system application requirements & out of the following-

A. HT Power Cables: 11 kV (UE) cables (as per IS-7098 Part-II):

3 core, 300 sq.mm & 3 core,70 sq.mm, 11 kV (UE) heavy duty power cable, with compact circular stranded H2 grade Aluminium conductor with extruded conductor shielding of semiconducting compound (min thickness 0.3mm), XLPE insulated, with insulation shielding over core consisting of extruded semi- conducting compound (min thickness 0.3mm), followed by lapped semi conducting material and copper tape (min thickness 0.075mm), cores stranded together with a holding tape provided with a common covering of extruded inner FRLS sheath (for multi core only) of type ST2 compound, single galvanized steel formed wire (strip) / wire armoured for multi core cables and FRLS PVC (with rodent and termite retardant compound) outer sheath (Black Colour) of type ST2 compound as per IS : 7098 (Pt-II)-1973 as amended up to date.

The 11/11KV(UE) 3 Core, 300 Sq.mm, stranded AL conductor, XLPE insulated, FRLS , Armoured cable

connections has being considered only from 11 KV Switchgear (location: Switchyard) to following Transformers/ Switchgear:
1) From 5MVA Station Transformer(at Switchyard) to 11kV Switchgear (at Switchyard)
2) From 33/11KV, Substation Transformer (Existing) to 11kV Switchgear (at Switchyard)

The 11/11KV(UE) 3 Core, 70 Sq.mm, stranded AL conductor, XLPE insulated, FRLS , Armoured cable

connections has being considered only from 11 KV Switchgear (location: Switchyard) to following Transformers/ Switchgear:
1) From 11kV Switchgear (at Switchyard) to 11/0.415KV, 1000KVA SAT-1 (PH Transformer deck)
2) From 11kV Switchgear (at Switchyard) to 11/0.415KV, 1000KVA SAT-2 (PH Transformer deck)

APPROVED
Contractual Conditions to be strictly Adhered to
Date 23 APR 2024
Dy. GM (MSU-Ganga Valley)

No other 11KV Cable Connection is considered in BHEL scope.

Cable shall be buried underground where there is no existing trench or available space in trench is not sufficient.

LT Power Cables :

B1: LT Power Cables, **Aluminium conductor** (as per IS-7098 Part-I):

1.1 KV, heavy duty power cable multicore with standard sector shaped or with compact circular stranded or circular stranded, H2 grade **Aluminium conductors** as applicable, XLPE insulated suitable for 90 deg. C. operation as per IS: 7098, (Part-1), as amended up to date, core stranded together provided with a common covering of FRLS PVC inner sheath (for multi core only) of type ST2 PVC compound, armoured and FRLS PVC (with rodent and termite retardant compound) outer sheathed (Black colour) of type ST2 PVC compound.

Cables will be provided out of the below mentioned cables size as applicable and may be deleted/ added suiting to final equipment rating, during detailed design. Other cable sizes/type may be added or changed to meet the specific requirement/application.

1. 4 Core, 10 sq. mm, multi strand Aluminium Conductor, XLPE Insulation, FRLS PVC inner sheath(ST2), armoured, PVC outer sheath (ST2) with FRLS properties, 1.1kV grade LT Power Cable.
2. 4 Core, 16 sq. mm, multi strand Aluminium Conductor, XLPE Insulation, FRLS PVC inner sheath (ST2), armoured, PVC outer sheath (ST2) with FRLS properties, 1.1kV grade LT Power Cable.
3. 3.5 Core, 25 sq. mm, multi strand Aluminium Conductor, XLPE Insulation, FRLS PVC inner sheath (ST2), armoured, PVC outer sheath (ST2) with FRLS properties, 1.1kV grade LT Power Cable.
4. 3.5 Core, 35 sq. mm, multi strand Aluminium Conductor, XLPE Insulation, FRLS PVC inner sheath (ST2), armoured, PVC outer sheath (ST2) with FRLS properties, 1.1kV grade LT Power Cable.
5. 3.5 Core, 50 sq. mm, multi strand Aluminium Conductor, XLPE Insulation, FRLS PVC inner sheath (ST2), armoured, PVC outer sheath (ST2) with FRLS properties, 1.1kV grade LT Power Cable.
6. 3.5 Core, 70 sq. mm, multi strand Aluminium Conductor, XLPE Insulation, FRLS PVC inner sheath (ST2), armoured, PVC outer sheath (ST2) with FRLS properties, 1.1kV grade LT Power Cable.
7. 3.5 Core, 95 sq. mm, multi strand Aluminium Conductor, XLPE Insulation, FRLS PVC inner sheath (ST2), armoured, PVC outer sheath (ST2) with FRLS properties, 1.1kV grade LT Power Cable.
8. 3.5 Core, 150 sq. mm, multi strand Aluminium Conductor, XLPE Insulation, FRLS PVC inner sheath (ST2), armoured, PVC outer sheath (ST2) with FRLS properties, 1.1kV grade LT Power Cable.
9. 1 Core, 300/400/500 sq. mm, multi strand Aluminium Conductor, XLPE Insulation, armoured, PVC outer sheath (ST2) with FRLS properties, 1.1kV grade LT Power Cable. (for connection between Excitation transformer LV side to Excitation/Thyristor panel)

B2: LT Power Cables, **Copper conductor** (as per IS-7098 Part-I)

1.1 KV, heavy duty power cable multicore with standard sector shaped or with compact circular stranded or circular stranded Class 2 Electrolytic grade **Copper conductors** as applicable, XLPE insulated suitable for 90 deg. C. operation as per IS: 7098, (Part-1), as amended up to date, core stranded together provided with a common covering of FRLS PVC inner sheath (for multi core only) of type ST2 PVC compound, armoured and FRLS PVC (with rodent and termite retardant compound)outer sheathed (Black colour) of type ST2 PVC compound.

Cables will be provided out of the below mentioned cables size as applicable and may be deleted/ added suiting to final equipment rating, during detailed design. Other cable sizes/type may be added or changed to meet the specific requirement/application.

1. 4 Core, 2.5 sq. mm, multi strand annealed Copper Conductor, XLPE Insulation, FRLS PVC inner sheath(ST2), armoured, PVC outer sheath (ST2) with FRLS properties, 1.1kV grade LT Power Cable.
2. 4 Core, 4 sq. mm, multi strand annealed Copper Conductor, XLPE Insulation, FRLS PVC inner sheath(ST2), armoured, PVC outer sheath (ST2) with FRLS properties, 1.1kV grade LT Power Cable.
3. 1 Core, 300 sq. mm, multi strand annealed Copper Conductor, XLPE Insulation, armoured, PVC outer sheath (ST2) with FRLS properties, 1.1kV grade LT Power Cable. (for DC side connection between Field breaker to Sliprings)

B. Control cables (as per IS-7098 Part-I**):**

650/1100V circular stranded annealed copper conductor, XLPE insulated suitable for 90^0C operation, as per IS:7098 (Part-1), as amended up to date, cores stranded together provided with a common covering of PVC inner sheath of type ST2 PVC compound, Armoured, overall FRLS PVC (with rodent and termite retardant compound) sheathed (Grey colour) of type ST2 PVC compound.

1. 2C x 2.5 sq. mm, Multi strands, annealed copper conductor, XLPE insulated, PVC(ST-2) inner sheathed, Armoured, PVC (ST-2) outer sheath with FRLS properties, 650/1100 V grade control cable.
2. 4C x 2.5 sq. mm, Multi strands, annealed copper conductor, XLPE insulated, PVC(ST-2) inner sheathed, Armoured, PVC (ST-2) outer sheath with FRLS properties, 650/1100 V grade control cable.
3. 7C x 2.5 sq. mm, Multi strands, annealed copper conductor, XLPE insulated, PVC(ST-2) inner sheathed, Armoured, PVC (ST-2) outer sheath with FRLS properties, 650/1100 V grade control cable.
4. 12C x 2.5 sq. mm, Multi strands, annealed copper conductor, XLPE insulated, PVC(ST-2) inner sheathed, Armoured, PVC (ST-2) outer sheath with FRLS properties, 650/1100 V grade control cable.

C. Instrumentation cables(as per IS-7098 Part-I):

650/1100V, 1.5 sq. mm cross section, electrolytic grade, multi stranded (7 strand wire) tinned Copper conductor, XLPE insulated suitable for 90^{0}C operation, as per IS:7098 (Part-1), as amended up to date, PVC (ST-2) inner sheath, Armoured, twisted pairs/ multi-triad cable with ATC drain wire, overall FRLS PVC (with rodent and termite retardant compound) sheathed (Grey colour) of type ST2 PVC compound.

1. Two pairs, 1.5 sq. mm, multi strands, tinned copper conductor, XLPE insulated, Individual Pair Screened and Overall Screened, PVC inner sheathed (ST-2), FRLS PVC (ST-2) outer sheath, armoured, 650/1100V grade Instrumentation Cable.
2. Four pairs, 1.5 sq. mm, multi strands, tinned copper conductor, XLPE insulated, Individual Pair Screened and Overall Screened, PVC inner sheathed (ST-2), FRLS PVC (ST-2) outer sheath, armoured, 650/1100V grade Instrumentation Cable.
3. Eight pairs, 1.5 sq. mm, multi strands, tinned copper conductor, XLPE insulated, Individual Pair Screened and Overall Screened, PVC inner sheathed (ST-2), FRLS PVC (ST-2) outer sheath, armoured, 650/1100V grade Instrumentation Cable.
4. Twelve pairs, 1.5 sq. mm, multi strands, tinned copper conductor, XLPE insulated, Individual Pair Screened and Overall Screened, PVC inner sheathed (ST-2), FRLS PVC (ST-2) outer sheath, armoured, 650/1100V grade Instrumentation Cable.
5. Six cores (2 Triad), 1.5 sq. mm, multi strands tinned copper conductor, XLPE insulated, Individual triad Screened and Overall Screened, PVC(ST-2) inner sheathed, FRLS PVC(ST-2) outer sheath, armoured, 650/1100V Grade Instrumentation Cable.
6. Twelve cores (4 Triad), 1.5 sq. mm, multi strands tinned copper conductor, XLPE insulated, Individual triad Screened and Overall Screened, PVC(ST-2) inner sheathed, FRLS PVC(ST-2) outer sheath, armoured, 650/1100V Grade Instrumentation Cable.

NOTE:

1. Conductor shield, Insulation Shield and Metallic screening shall be applicable for 11kV Power Cables as per IS-7098-II.
2. Screening of Aluminium Mylar Tape shall be applicable for Instrumentation Cable.
3. Screening shall not be applicable for any other cable.
4. All the cables shall carry manufacturer data and Customer's name (i.e. ULVNL) by embossing/ printing as per OEM's standard/ availability of marking machine with OEM.
5. Cable packing shall be supplied in non-returnable wooden drums only.
6. The armouring for multi core cables shall be of galvanized steel formed wire (strip) / wire as per relevant IS. The armouring for Single core cables shall be of Aluminium round wire.

4.0 Cable Type Selection based on the application and use:

The HT Power Cables, LT Power Cables, Control Cables & Instrumentation Cables have been selected as per the following for different application-

(i) 11kV HT power cable has been considered for the following connections only –
11 KV Switchgear to :

- 5 MVA (132/11KV) Station Transformer at Switchyard
- 33/11KV Substation Panel (Colony substation)
- 1.0 MVA SAT-1 (PH Transformer deck)
- 1.0 MVA SAT-2 (PH Transformer deck)

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(ii) 1.1 KV grade LT power cables has been considered for interconnection only between BHEL supplied equipment in the following applications –

- Unit Aux. Transformer(UAT) to Unit Aux. Board (UAB)
- 1000KVA SAT-1 & 2 to Station Service Boards (SSBs)
- SABs to UABs
- Station Service Boards (SSBs) to various service boards (i.e. EBSB,DDSB, WSB, FISB, MSBs)
- 415V AC Supplies from UAB & SAB to respective panels/cubicles/Station Auxiliaries
- 415V AC Supplies from Starter panels to Pump/Valve Motors
- Single phase supplies from LT Distribution Boards to respective panels
- 220V DC supply from 220V DCDB to various DC loads.
- 220V DC Battery Chargers to Batteries & 220V DCDBs
- Field connection from Excitation transformer LV side to Excitation/Thyristor panel & from Field breaker to Sliprings.
- Wiring for single phase connection of CTs & PTs i.e. between individual CTs/PTs & terminal blocks in JB/Marshaling box shall be with 6 mm^2 Copper Cable whereas after formation of group of 3 phase (star formation) it shall be 4CX4 mm^2 Copper Cable (as per Clause. No 13.4.2 of PTS).
- All internal panel wiring shall be governed by Clause. No 1.28.3 of PTS.

(iii) 1.1 KV grade Control Cables has been considered for interconnection only between BHEL supplied equipment in the following applications -

- ON/OFF Command from Unit/Common UCB/LCB/SCADA to respective drives
- Carrying field device auxiliary contacts to Contact multiplier ckt in different panels/cubicles using 220V DC and 230V AC supplies.

(iv) 650/1100V grade Instrumentation Cables have been considered for interconnection between BHEL supplied equipment only in the following applications

- Feedback signal contacts from different field devices, cubicles/panels to UCB/LCB/SCADA panels etc.
- Carrying analog signals from UCB/LCB/SCADA to meters mounted at other related panels etc.
- Carrying RTD signals from Generator Marshalling Box, Transformers (ETs, UAT, SRT), Generator and Turbine Bearings etc. to UCB/LCB/SCADA.
- Alarm signals

5.0 Cable Identification Numbering System:

The following numbering system shall be adopted for clear understanding the use and applications.

The cable numbering/Tag system shall consist of 6/5 Digits alpha numeric for power/control & instrumentation cables respectively.

First 2 digits alpha code shall be used for Circuit Function as per the following

HX - HT 11KV Cables

PX - LT AC Power Cables, CT & PT Cables

PY – DC Power Cables (220V DC Supplies)

M – 230V AC Control Cables

K – 220V DC and Control Cables

X – Feedback Signal Cables

S – Analog Signals (RTD signals, current 4-20 mA signals, 0-10V Signals etc.)

Third digit numeric code shall be used System Identification as per for the following

1- For Unit Cables
2- For Common system Power House Cables

Last three digits numeric code shall be used for cable Sr Nos., System wise as per the following i.e. 001-999

6.0 Cable Sizing:-

Cable sizing shall be based on De-rating Factor Consideration & Voltage Drop Criteria.

4.1 De-rating Factor Consideration:-

(i) Considering Cable rating factor-1 = 1.0 x 1.0 = 1.0 (for Ambient temp 40oC)

(ii) Considering Cable rating factor-2 = 0.68 (cables touching & are laid in cable trays are exposed to air in upto 3 tiers spaced by 30cm & clearance between wall & cable is 25cm.).

Group Derating Factor (GDF) = Cable rating factor-1 x Cable rating factor-2
= 1.0 x 0.68
= 0.68

4.2 Voltage Drop Criteria :-

(i) 415V, AC, THREE PHASE SYSTEM:-

(a) The voltage drop at steady state conditions :-

$$\text{Voltage drop in Volt. (Vdp)} = \frac{\sqrt{3} * I * L \sqrt{(R * R + X * X)}}{1000}$$

$$\text{Voltage drop in \%} = \frac{Vdp * 100}{V}$$

Where

V = System voltage (415V)

I = Full load current in Amperes

L = feeder length in meters

R = AC resistance of cable in Ohm/Km at 90 ^{O}C temp

X = Reactance of cable in Ohm/Km at 50 Hz. at 90 ^{O}C temp

Note: For calculation of voltage drop, PF of 0.85 is considered for steady state condition.

(ii) 240V, AC, SINGLE PHASE SYSTEM:-

(a) The voltage drop at steady state conditions :-

Voltage drop in Volt. (Vdp)= $\frac{2*I*L\sqrt{(R*R+X*X)}}{1000}$

Voltage drop in % = $\frac{Vdp*100}{V}$

Where

V = System voltage (240V)

I = Full load current in Amperes

L = feeder length in meters

R = AC resistance of cable in Ohm/Km at 90 ^{O}C temp

X = Reactance of cable in Ohm/Km at 50 Hz. at 90 ^{O}C temp

Note: For calculation of voltage drop, PF of 0.85 is considered for steady state condition.

(ii) 220V, DC SYSTEM :-

Voltage drop in Volt. (Vdp)= $\frac{2*I*L*R}{1000}$

Voltage drop in % = $\frac{Vdp*100}{V}$

Where

V = System voltage (220V)

I = Full load current in Amperes

L = feeder length in meters

R = DC resistance of cable in Ohm/Km at 20 ^{O}C temp.

7.0 Cable trays and accessories:

i. Existing cable Trays of Main route shall be utilized.

ii. In case of replacement of some portion of existing damaged cable tray (made by MS angle), the particular portion shall be replaced by newly supplied galvanized MS angle (50mm X 50mm X 6 mm) , if deemed necessary. Ladder type tray arrangement shall be fabricated at site with galvanized MS angles. Rung spacing shall be maintained as that of existing arrangement.

iii. However, additional quantity of short length branch cable trays with standard width of 150mm/300mm and standard length of 2.5 meter, associated supporting structure material shall be provided to meet the site requirement, if deemed necessary.

iv. The straight sections cable trays with standard width of 450mm/600mm and standard length of 2.5 meter shall be supplied (only, if required). The side rails shall have holes at each end of straight sections, elbows, tees, crosses etc. for fixing side couplers.

v. Associated structure Support material for above mentioned fixed type cable trays shall consist of Galvanized Angle (50x50x6mm), Anchor fasteners, hardware (nut, bolts) etc. shall be supplied in standard length. Fabrication of support structure shall be done at

site to suit the site requirement.

vi. Cables pertaining to BHEL Scope of Supply shall be of ladder/perforated type & shall be fabricated with high standard design & as per IS.

vii. Thickness of mild steel (HRCA) sheets used for fabrication of cable trays shall be 2 mm & shall be hot dip galvanized as per IS. Average Zinc coating on Cable Trays shall be 460gm/m^2 as per IS 4759:1996. Galvanization thickness for the same shall be 65 micron (Avg).

viii. Thickness of mild steel angles used for support structure shall be 6 mm & shall be hot dip galvanized as per IS. Average Zinc coating on support structure shall be 610gm/m^2 as per IS 4759:1996. Galvanization thickness for the same shall be 86 micron (Avg).

ix. A minimum clearance of 300mm shall be kept between instrument and power/signal cables. Separator shall be used if cables are to be laid side by side on same tray.

x. Cables which are not laid in the cable trays & which are to be laid on floor (within power house only) shall be laid through galvanized MS pipe (Medium class, 3mm thickness, 50NB/100NB/150NB). The standard length of pipe shall 6 meter.

xi. All burrs and sharp edges of cable trays & accessories shall be properly removed to have a smooth working surface for easy cable pulling / laying.

xii. Required bends, Tees, cross connectors, reducers, hardware shall be supplied to meet the cable tray requirement at Powerhouse.

ENCLOSURE:

Please refer **ANNEX-1** for **CABLE TRAY SUPPORTING ARRANGEMENT DRAWING**

8.0 HT Termination kits :

Required quantity of heat shrinkable type termination kits including accessories for 11kV(UE) XLPE cables terminations shall be provided.

8.0 Cable Accessories:

9.1 Cable Lugs:

Cables lugs shall be supplied for LT Power Cables, Control Cables & Instrument Cables pertaining to BHEL scope of supply only. Bimetalic Lugs of copper alloys shall be supplied for LT power cables where bimetallic contact (Al-Cu) is available. Compression type terminals made of electro-copper shall be supplied for Control & Instrument Cables.

9.2 Cable Glands:

Cables glands shall be supplied for cables pertaining to BHEL scope of supply only. Cable glands shall conform to BS: 6121 and shall be of robust construction capable of clamping cable firmly without injury to insulation. The cable glands shall be made of electro tinned brass material. Cable glands shall be double compression heavy duty type for armoured cables & single

compression heavy duty type for unarmoured cables. Rubber components shall be of neoprene and of tested quality.

9.3 Compression type terminals for control wiring:

Compression type Terminals made of electro-tinned copper for copper conductor of control wiring will be used. These are crimped to the conductor while other end will be a flat surface for better connection.

9.4 **Button tape:** Perforated cable strapping Button Tapes (Strap and Stud) having Nylon Grade 220 material Strapes and studs will be made of "NYLON".

9.5 **Self adhesive marker:** Self Adhesive Marker in form of strips of any one character, which can be easily peeled from the backing card will be used. The strips will be water proof duly marked with special formulated ink with thermosetting adhesive to withstand high temperature.

9.6 **Ferrules:** Plastic ring type ferrules (control & Instrumentation cable) with engraved indelible ink & and sticker type ferrules (for larger dia. Power cable) shall be provided. Each core of cable shall be marked for identification. Some quantity of blank ferrules shall also be supplied to cater to some urgent requirement at site using permanent marker.

9.7 **Aluminium strips:** Cable tags made of aluminium with the number punched on it will be used. Cable tags shall be of rectangular shape for all cables.

9.8 PVC tapes & cotton tapes shall also be provided.

NOTES:

1. Cable Accessories & Earthing material (Earthing strips/GI wire etc & related items) shall be procured from BHEL, Bhopal approved sources/ through GeM portal (as per contractual condition).

10.0 METHODOLOGY FOR INSTALLATION

Following installation methodology will be adopted for the cabling system:

1. Hung supports shall be fixed to the roof of cable spreader room/other areas using Anchor fastener bolts.

2. Where cable trenches cannot be provided cables shall run through the MS embedded inside the floor.

3. Fixed type (welded joint) supports shall be selected.

4. Power and control cables in the cable trench shall be laid in separate tiers. AC and DC Cables shall be laid in separate trays or having partition between them. The order of laying of various cables shall be as follows, for cables other than directly buried.

   i. Power cables on top tiers.
   ii. Control/ Instrumentation and other service cables in lower tiers.
   iii. All power cables shall be laid touching with the cables of same or other phases.

5. In case power and control cables being run on same tray, separator angle shall be used separately place the power and control cables.

6. Power and control cables shall be securely fixed to the tray/supports with self-locking type nylon ties at every 3 meter interval for horizontal run. Vertical and inclined cable run shall be secured at every 1m.

7. Cables shall not be bent below the minimum permissible limit. The permissible limits are as follows:

Voltage Rating	PVC Cables	
KV	Single Core	MultiCore
Upto 1.1	20D	15 D

Where D is outer diameter of cable

8. Some extra length of the cable shall be kept just below the Gland plates on both ends of the cable for all control and power cables.

9. Selection of cable drums for each run shall be so planned as to avoid using straight through joints. Cable splices will not be permitted except where called for by the drawings, unavoidable or where permitted by the Owner.

10. Control cable terminations inside equipment enclosures shall have sufficient lengths so that changing of termination in terminal blocks can be done without requiring any splicing.

11. Metal screen of the cables shall be bonded to the earthing system of the station.

12. All due care shall be taken during unreeling, laying and termination of cable to avoid damage due to twist, kinks, sharp bends, etc.

13. All cable terminations shall be appropriately tightened to ensure secure and reliable connections.

14. The termination and connection of cables shall be done in accordance with cable and termination kit manufacturer's instruction, drawing.

15. Cable packing shall be supplied in non-returnable wooden drums only. Both the ends of the cables shall be properly sealed with PVC/ rubber caps tightly secured so as to eliminate ingress of moisture/dust during transportation, storage and erection.

16. Each drum shall carry manufacturer's name, item number and type, size and length of cable and net gross weight stencilled on both the sides of the drum. An arrow accompanying suitable wording shall be marked on one end of cable drum indicating the direction in which it should be rolled.

17. Screen of instrumentation cables twisted at one point shall be connected to earth at one of the ends.

ENCLOSURE:

ANNEX-1 : CABLE TRAY SUPPORTING ARRANGEMENT DRAWING

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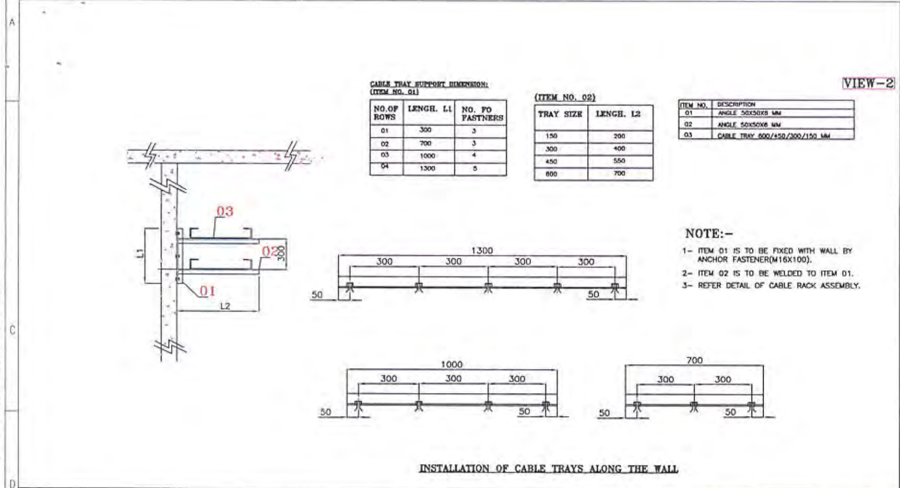
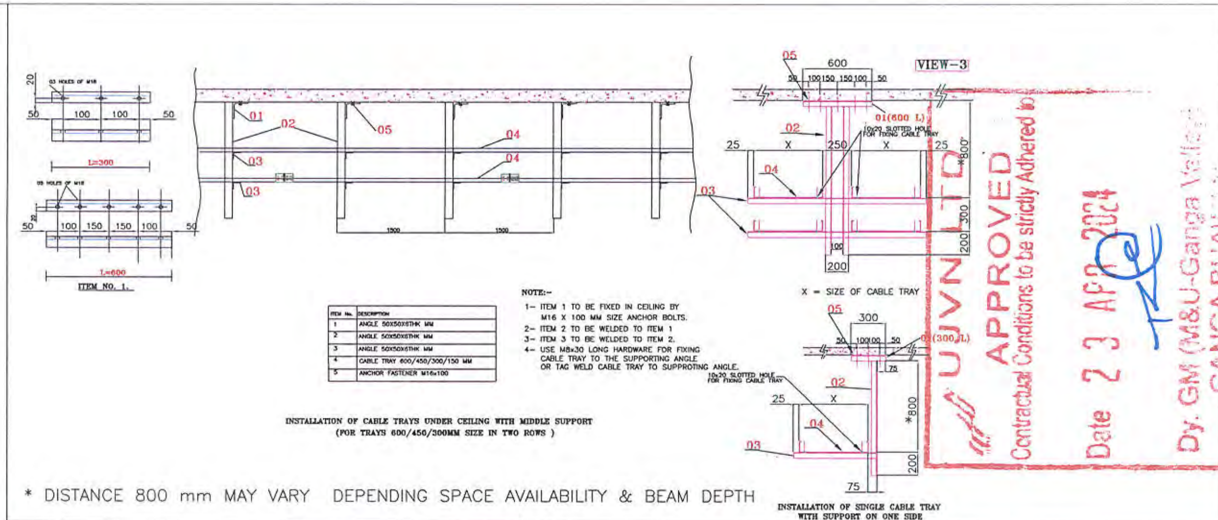
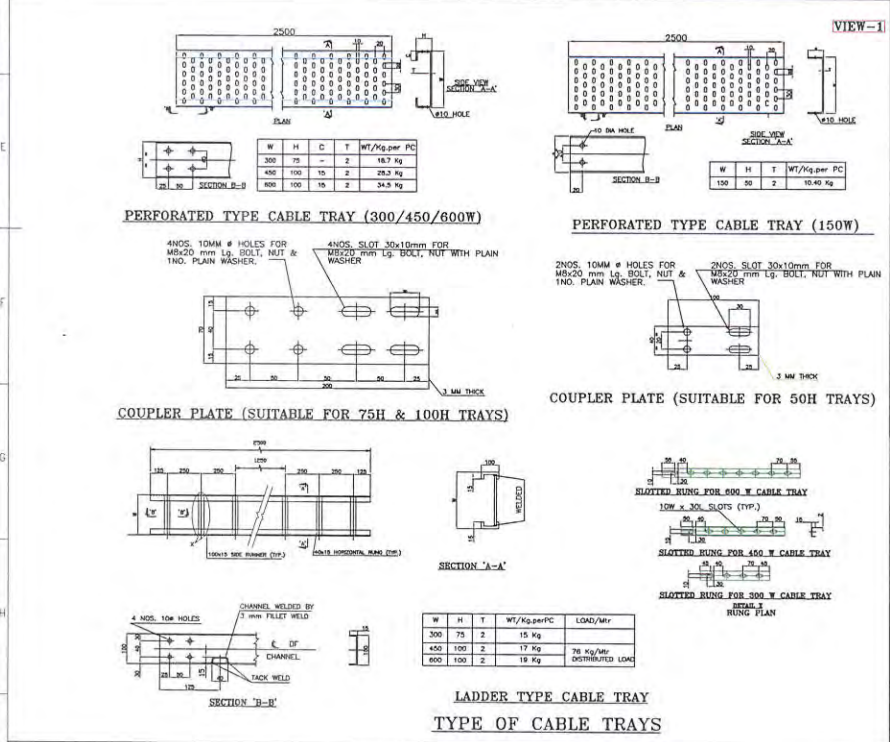
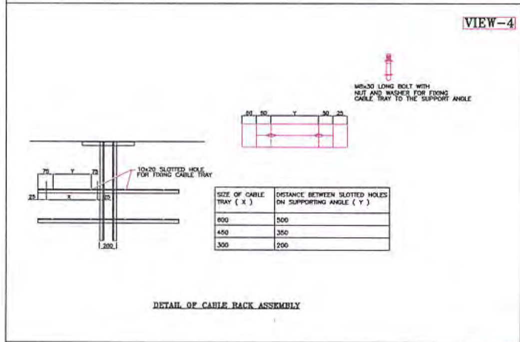
Date 23 APR 2024

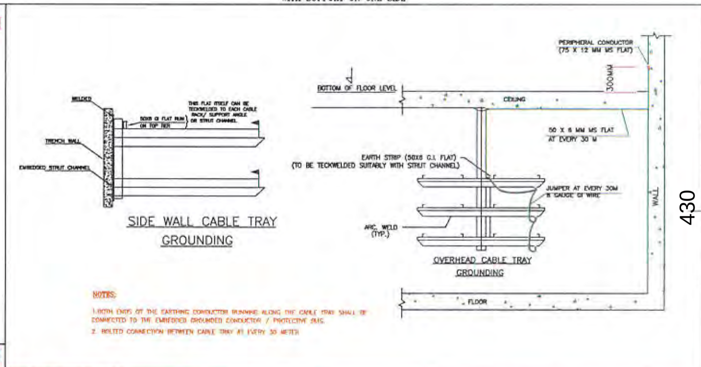
(ALL DIMENSIONS ARE IN mm)

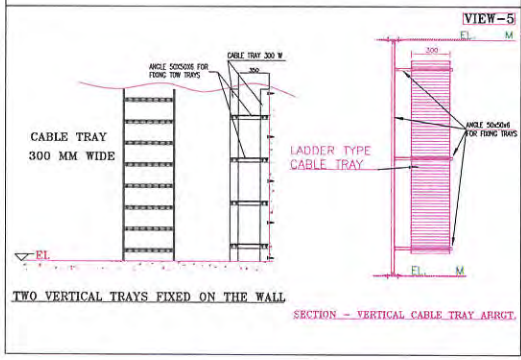












GENERAL NOTES:-

1. AS PER SITE SUITABILITY 150 MM WIDE CABLE TRAY SHALL BE USED FOR TERMINATING EQUIPMENT ENDS, ALSO 150 MM TRAY SHALL BE USED WHEREVER CABLE TRAYS ARE NOT SHOWN IN DRAWING FOR DRAWING CLARITY.
2. CABLE TRAY LEVEL SHALL BE LOWERED SUITABLY WHILE CROSSING THE BEAM.
3. BENDS, REDUCERS, TEE, CROSS, & ELBOW SECTIONS SHALL BE USED WHEREVER REQUIRED AS PER LAYOUT.WHEREVER THE STANDARD SIZE OF SECTIONS DO NOT FIT, SUITABLE SUPPORTS/BEND SHALL BE FABRICATED FROM STANDARD SECTIONS OF TRAYS AND ANGLES.
4. CABLE RACK ASSEMBLY (FOR SUPPORTING TRAYS) ARE TO FIXED USING ANCHOR FASTENERS.
5. FOR VERTICAL RUNS LADDER TYPE CABLE TRAYS SHALL BE USED.
6. SEPARATION PLATES/PARTITION PLATES SHALL BE USED IN CABLE TRAYS WHERE CONTROL/INSTRUMENTATION CABLES AND AC AUX. POWER SUPPLY CABLES RUN IN SINGLE TRAY.
7. LADDER TYPE CABLE TRAY SHALL BE USED FOR UPPER LAYERS WHERE POWER CABLES ARE TO BE LAID TO ENSURE GOOD HEAT DISSIPATION. CONTROL CABLES SHALL BE LAID IN LOWER TIERS ON PERFORATED CABLE TRAYS.
8. SUPPORT MEMBERS OF CABLE TRAYS SHALL BE FIXED AT AN INTERVAL OF 1.5 M, UNLESS SPECIFIED OTHERWISE.
9. EXTENSION OF CABLE TRAY AFTER FIXED SUPPORT SHALL BE TAKEN AS PER SITE SUITABILITY.
10. SUPPORT MEMBERS FOR INSTALLATION OF TRAYS ARE TO BE CUT TO SIZE AND DRILLED AT SITE FROM STANDARD LENGTH WHEREVER APPLICABLE.
11. SUPPORT MEMBERS OF TRAYS ARE TO BE FIXED USING ANCHOR FASTENERS.
12. ALL DIMENSIONS ARE IN MM.

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GANGA BHAWAN
DEHRADUN

PROJECT	CHILLA R&M (4X39 MW)
CUSTOMER	M/s. UJVNL, UTTARAKHAND
CONTRACTOR	भारत हेवी इलेक्ट्रिकल्स लिमिटेड, भोपाल Bharat Heavy Electricals Limited, Bhopal
TITLE	CABLE TRAY & SUPPORTING ARRANGEMENT

	NAME	SIGN	DATE	NO. OF VAR.
DRWN	S.SARKAR		19.01.24	
CHKD	S.JUNEJA		19.01.24	
APPD	S.SHARMA		19.01.24	

SUB-SUPPLIER / VENDOR

DEPT HPE | CODE 415 | UNTOL. DIMS. GR. | ANGLE | SCALE 1:200 | WEIGHT(kg) | REF.TO ASSY.DRG. | ITEM NO. | NO. OF ITEMS

DRAWING NO. 42920093001 (ANNEXURE-1) REV. 00

SHEET NO. 01 NO. OF SHEETS. 03

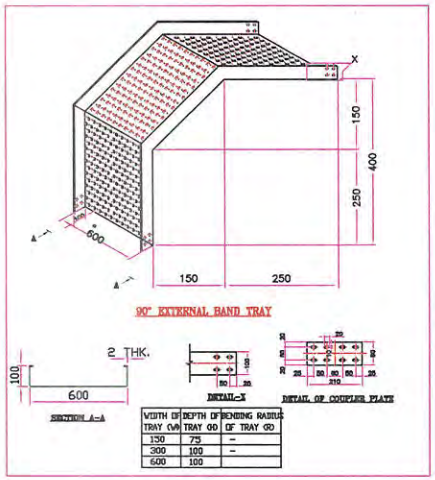
A1 SIZE

INVENTORY NO. | SIGN. & DATE | REF. DRG. NO.

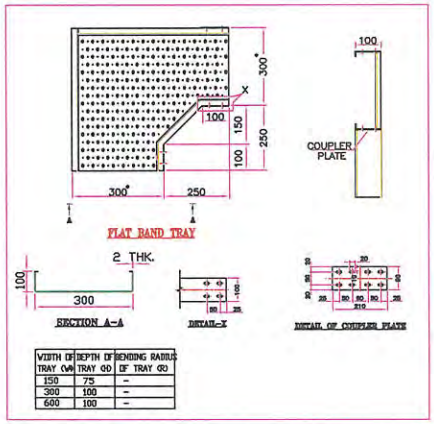
REV. | DATE | ALTERED CHECKED APPROVED | ZONE

FIRST ANGLE PROJECTION

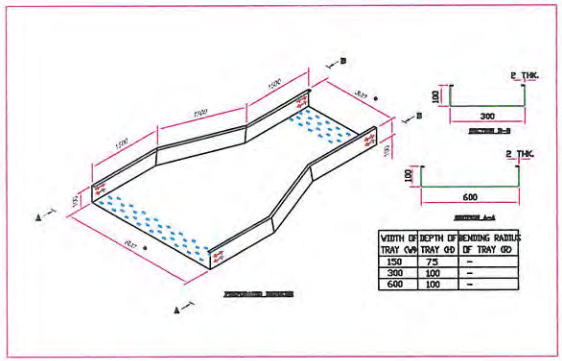
(ALL DIMENSIONS ARE IN "mm")



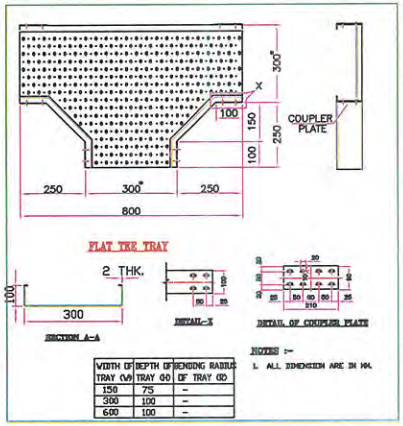
WIDTH OF TRAY (W)	DEPTH OF TRAY GD	BENDING RADIUS OF TRAY GD
150	75	–
300	100	–
600	100	–



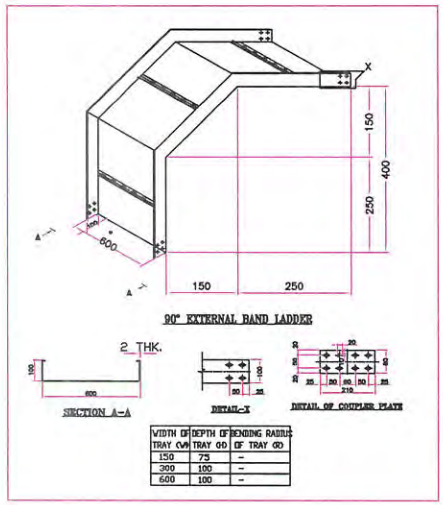
WIDTH OF TRAY (W)	DEPTH OF TRAY GD	BENDING RADIUS OF TRAY GD
150	75	–
300	100	–
600	100	–



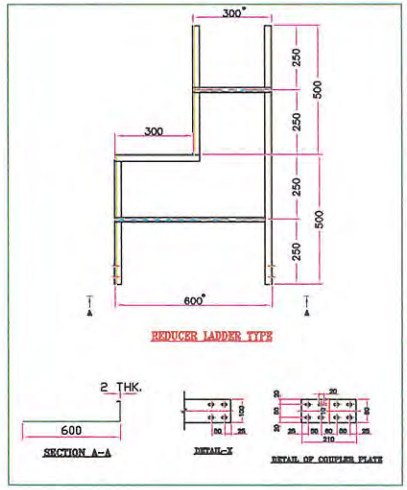
WIDTH OF TRAY (W)	DEPTH OF TRAY GD	BENDING RADIUS OF TRAY GD
150	75	–
300	100	–
600	100	–

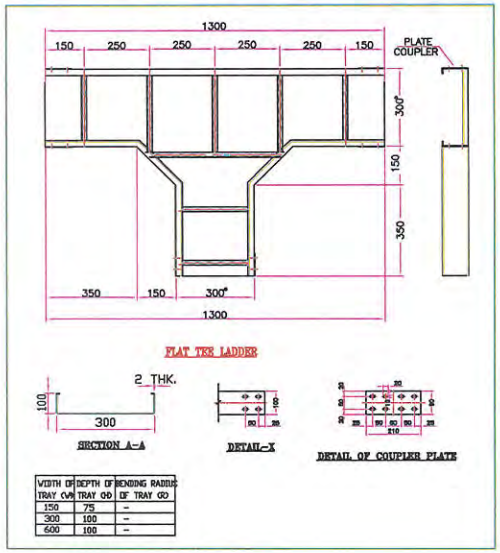


WIDTH OF TRAY (W)	DEPTH OF TRAY GD	BENDING RADIUS OF TRAY GD
150	75	–
300	100	–
600	100	–

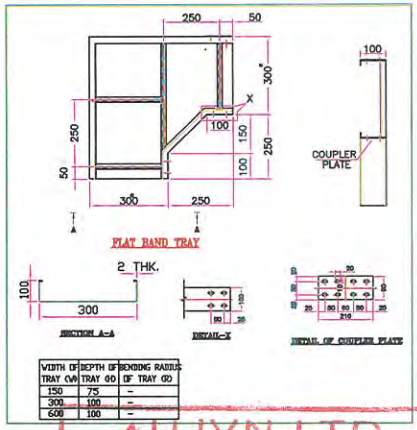


WIDTH OF TRAY (W)	DEPTH OF TRAY GD	BENDING RADIUS OF TRAY GD
150	75	–
300	100	–
600	100	–





WIDTH OF TRAY (W)	DEPTH OF TRAY GD	BENDING RADIUS OF TRAY GD
150	75	–
300	100	–
600	100	–



WIDTH OF TRAY (W)	DEPTH OF TRAY GD	BENDING RADIUS OF TRAY GD
150	75	–
300	100	–
600	100	–

UJVN LTD.
APPROVED
Contractual Conditions to be strictly Adhered to
Date 23 APR 2024
Dy. GM (M&C Cell)
GANGA BHAWAN
DEHRADUN

	NAME	SIGN	DATE	NO. OF VAR.
DRWN	S.SARKAR		19.01.24	
CHKD	S.JUNEJA		19.01.24	
APPD	S.SHARMA		19.01.24	

SUB-SUPPLIER / VENDOR

PROJECT: CHILLA R&M (4X39 MW)

CUSTOMER: M/s. UJVNL UTTARAKHAND

CONTRACTOR: भारत हेवी इलेक्ट्रिकल्स लिमिटेड, भोपाल
Bharat Heavy Electricals Limited, Bhopal

DEPT	HPE	UNTOL. DIMS. GR.	ANGLE	SCALE	WEIGHT(kg)	REF.TO ASSY.DRG.	ITEM NO.	NO.OF ITEMS
CODE	415			1:200				

TITLE: CABLE TRAY & SUPPORTING ARRANGEMENT

DRAWING NO. 42920093001 (ANNEXURE-1) REV. 00

SHEET NO. 02 NO. OF SHEETS. 03

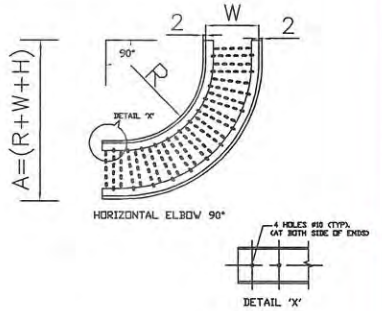
REV.	DATE	ALTERED / CHECKED / APPROVED	ZONE

A1 SIZE

FIRST ANGLE PROJECTION

(ALL DIMENSIONS ARE IN "mm")

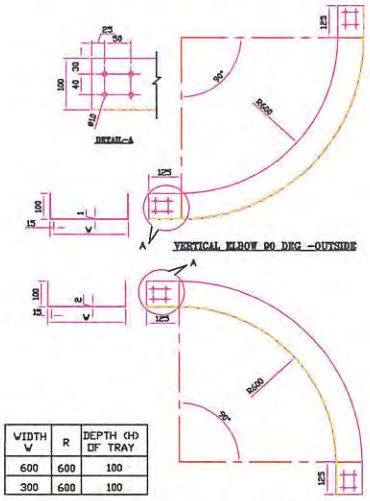
PERFORATED TRAY HORZONTAL BEND



1. MATERIAL : 2.0 MM THICK HOT ROLLED MS SHEET AS PER IS 1079/ IS 10748
2. COATING : HOT DIP GALVANIZED AS PER IS 2629/IS 4759

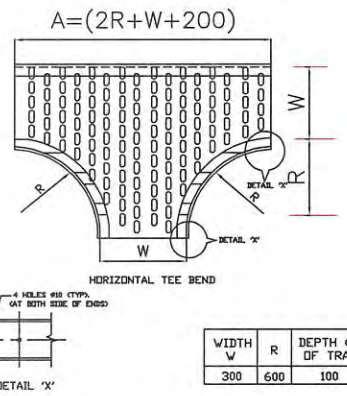
WIDTH W	R	DEPTH (H) OF TRAY
600	600	100
300	600	100

PERFORATED TRAY VERTICAL BEND



WIDTH W	R	DEPTH (H) OF TRAY
600	600	100
300	600	100

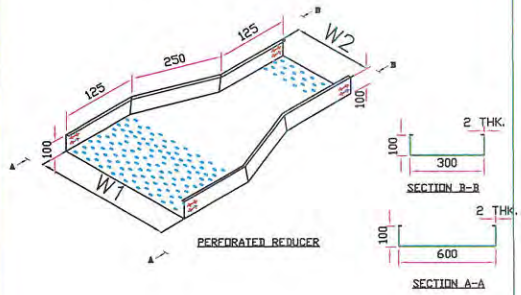
PERFORATED TYPE TEE BEND



WIDTH W	R	DEPTH (H) OF TRAY
300	600	100

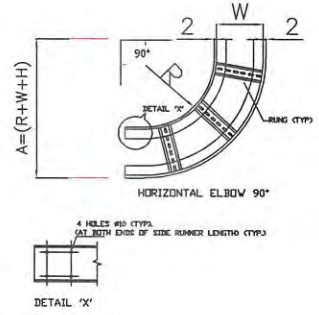
NOTE:
1. MATERIAL : 2.0 MM THICK GALVANIZED FLAT MS SHEET AS PER IS 1079/IS 10748
2. COATING : HOT DIP GALVANIZED AS PER IS 2629/IS 4759

REDUCER PERFORATED TYPE



WIDTH W1	WIDTH W2	DEPTH (H) OF TRAY
600	300	100

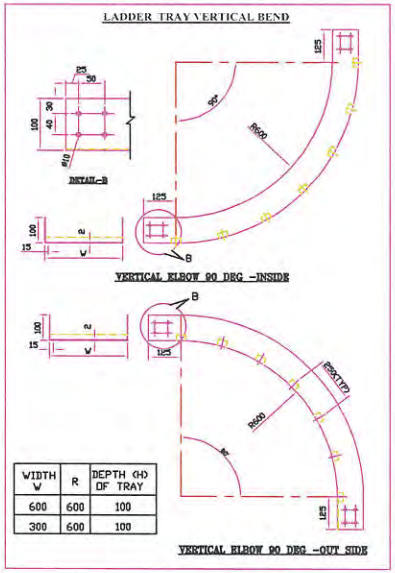
LADDER TRAY HORZONTAL BEND



NOTE:
1. MATERIAL : 2.0 MM THICK HOT ROLLED FLAT MS SHEET AS PER IS 1079/IS 10748
2. COATING : HOT DIP GALVANIZED AS PER IS 2629/IS 4759

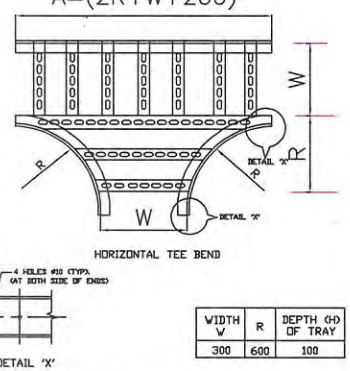
WIDTH W	R	DEPTH (H) OF TRAY
600	600	100
300	600	100

LADDER TRAY VERTICAL BEND



WIDTH W	R	DEPTH (H) OF TRAY
600	600	100
300	600	100

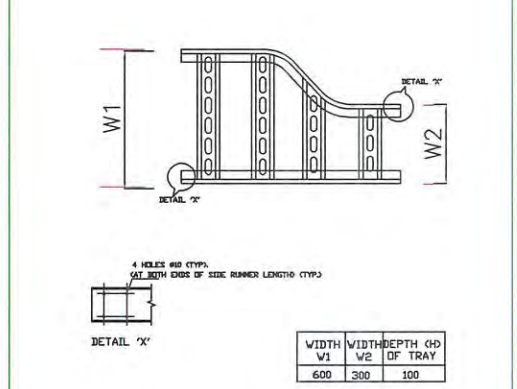
LADDER TYPE TEE BEND



WIDTH W	R	DEPTH (H) OF TRAY
300	600	100

NOTE:
1. MATERIAL : 2.0 MM THICK GALVANIZED FLAT MS SHEET AS PER IS 1079/IS 10748
2. COATING : HOT DIP GALVANIZED AS PER IS 2629/IS 4759

REDUCER LADDER TYPE



WIDTH W1	WIDTH W2	DEPTH (H) OF TRAY
600	300	100

UJVN LTD.
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	NAME	SIGN	DATE	NO. OF VAR.
DRWN	S.SARKAR		19.01.24	
CHKD	S.JUNEJA		19.01.24	
APPD	S.SHARMA		19.01.24	

SUB-SUPPLIER / VENDOR

PROJECT	CHILLA R&M (4X39 MW)
CONSULTANT	M/s. UJVNL, UTTARAKHAND
CONTRACTOR	भारत हेवी इलेक्ट्रिकल्स लिमिटेड, भोपाल Bharat Heavy Electricals Limited, Bhopal

DEPT HPE | CODE 415 | UNTOL. DIMS. GR. | ANGLE | SCALE 1:200 | WEIGHT(kg) | REF.TO ASSY.DRG. | ITEM NO. | NO.OF ITEMS

TITLE: CABLE TRAY & SUPPORTING ARRANGEMENT

DRAWING NO. 32920093001 (ANNEXURE-1) | REV. 00

SHEET NO. 03 | NO. OF SHEETS. 03

REV.	DATE	ALTERED / CHECKED / APPROVED	ZONE

INVENTORY NO. | SIGN. & DATE | REF. DRG. NO

A1 SIZE

BHEL Reply on Customer comments on DESIGN MEMORANDUM OF CABLING SYSTEM FOR POWER HOUSE (Drg. No. HPE/CHIL/DP/CABLING , REV 00) dated 29.02.24		
	UJVNL Comments	**BHEL REPLY**
	SINGL LINE DIAGRAM OF 220V DC SYSTEM (Rev 00)	
1.	Page 6 of11: Please provide 6 Sq.mm Copper cable as per the agreement relevant chapter.	Incorporated in revised design memorandum (Rev 01) in line with Clause 13.4.2 & Clause 1.28.3 of PTS.
2.	Page 10 of11: Comments on Ferrules, PVC tape & cotton Tape.	Incorporated in revised design memorandum (Rev 01).
	Additional Changes: Page 02 of11:	Size of the 11KV HT cable was mentioned in previous revision as 3CX240Sq.mm. The design calculation of HT Cable has been revised (based on 50 ^{0}C ambient temperature) and the cable size has been revised (upgraded) to 3CX300 Sq.mm. Revised HT POWER CABLE SIZING CALCULATION (Drg. No. HPE/CHIL/DP/ 11KV_HTCABLE , REV 01) shall be submitted separately.
	Additional Changes: Page 02 of11 & Page 05 of11 (note No.6)	Page 02 of 11: Galvanized steel formed wire(strip)/ wire armouring has been mentioned. Page 05 of 11: Note No.6 has been added.
		No other change has been done in revised document (rev01) w.r.t previously submitted revision (rev00). Please approve.

---X---

UJVN LTD.
APPROVED
Contractual Conditions to be strictly Adhered to
Date 23 APR 2024
Dy. GM (M&U-Ganga Valley)
GANGA BHAWAN
DEHRADUN

6.4 ELECTRIC MOTORS

6.4.1 General

All motors shall be of approved manufacture and shall comply with the requirements of this Chapter. Motors of the same type and size shall be fully interchangeable and shall comply - as far as applicable - to IEC standard motor dimensions.

The general construction shall be stiff and rigid; no light metal alloy casings will be accepted. All precautions shall be taken to avoid any type of corrosion.

All motors shall be fitted with approved types of lifting hooks or eyebolts as suitable.

AC motors shall have squirrel cage type rotors.

Motor Voltages and Power Ratings

The service voltages and corresponding power ratings for electric motors to be used in the Project shall be as follows:

- Motors up to 100 kW
- Service voltage : 3-phase a.c. 415/240 V,50 HZ
- Mode of starting : direct-on-line up to 50 kW

Above 50 kW with suitable starters

- Motors up to 0.75 kW
- Service voltage : single-phase a.c. 240 V, 50 HZ
- Mode of starting : condenser
- Motors intended to work on the d.c. System
- Service voltage : 220 V D.C.
- Mode of starting : resistor

6.4.2 Rating

The rating of the motors shall be adequate to meet the requirements of its associated equipment. The service factor, being the ratio of the installed motor output to the required power at the shaft of the driven machine at its expected maximum power demand, shall be applied as follows:

Power Demand of Driven Machine	Service Factor
Up to 5 kW	1.2
More than 5 kW	1.1

A.C. motors shall be capable of operating continuously under rated output conditions at any frequency between 95% and 105% of the rated frequency and/or with any voltage variation between 90% and 110% of the nominal voltage. A transient over voltage of 130% of the nominal voltage shall as well be sustained.

Further, the motors shall be capable of maintaining stable operation when running at 70% nominal voltage for a period of 10 seconds. The pullout torque for continuously loaded motors shall be at least 160% of the rated torque and for intermittently loaded motors 200% of the rated torque.

D.C. motors shall be capable of operating continuously under rated output conditions at any voltage between 90% and 110% of the nominal voltage with a fixed brush setting for all loads. Unless otherwise approved, the speed drop between no-load and full-load shall not exceed 10% of no-load speed.

6.4.3 Starting

A.C. motors shall be designed for direct on-line starting. They shall be capable of being switched on without damage to an infinite bus bar at 110% of the nominal voltage with an inherent residual voltage of 100% even in phase opposition. For starting the motors from the individual main and auxiliary bus bars, a momentary voltage drop of 20% referred to nominal voltage should be taken into consideration. With 85% of the nominal voltage applied to the motor terminals, each motor shall be capable of accelerating its associated load to full speed with a minimum accelerating torque of 5% of full load torque.

The maximum starting currents (without any tolerance) shall not exceed the following values: -

- 5 times of rated current for low voltage motors rated 100 kW or above
- 2 times of rated current for D.C. motors (by means of starting resistors)

Generally, all motors shall be able to withstand three cold starts per hour, equally spaced. In addition, each medium voltage motor shall be capable of enduring two successive starts with the motor initially at operating temperature. Each low voltage motor shall be capable of withstanding three successive starts under the same conditions or once every twenty minutes without detrimental heating.

Motors for frequent automatic starting shall have an adequate rating. In the motor list the Contractor shall state the frequency of starts permitted in compliance with the motor design.

6.4.4 Windings and Insulation Class

The insulation of all motors shall be of class F but will not exceed the temperature limits of class B materials in operation. It shall be suitable for operation in damp locations, for occasional contact with corrosive gases and vapours and for considerable fluctuations in temperature.

The stator winding shall be suitably braced to withstand the forces due to direct-on-line starting and transfer conditions as mentioned before. The winding envelopment and tails shall be non-hygroscopic. The stator winding shall withstand the maximum fault current for the period determined by the associated protective devices.

The rotor winding (if applicable) shall be designed to give trouble-free continuous service including repeated direct-on-line starting. The rotor shall be subjected to a 120% over speed test for 2 minutes without showing any winding dislocation.

6.4.5 Ventilation and Type of Enclosure

All motors shall be of the totally enclosed fan-cooled type, protection class IP 54 according to IEC Recommendation 144. Cable termination points shall be of class IP55.

They shall have a closed internal cooling air circuit re-cooled by an external cooling air circuit drawn from the opposite side of the driving end.

Where motors are installed outdoors, a weatherproof design shall be chosen. L.V. motors of IEC size 132 and above shall be equipped with automatically controlled heating elements for protection against internal condensation of moisture during standstill periods. Such A.C. heater shall be suitably fixed inside the motor casing; the leads shall be led to a separate L.V. terminal box.

Motors installed outdoors and directly subjected to solar radiation shall be rated such as not to exceed a maximum metal temperature of 85°C. Where necessary, such motors shall be provided with sun shields.

Vertical motors shall be provided with a top cover to prevent the ingress of dirt, etc.

6.4.6 Bearings

As far as possible, the motors shall have sealed ball or roller bearings. All motors with ratings of about 1 kW and above shall be equipped with lubricators permitting greasing while the motor is running and for preventing over-lubrication. Additionally, the bearings shall be fitted with grease nipples permitting the use of a universal grease gun.

Vertical motors shall have approved thrust bearings.

Where sleeve bearings are being used, they shall be of the self or forced lubricating type. If forced lubrication is required, it shall be arranged common to both the motor and the driven machine and provisions shall be made to ensure lubrication during start-up and

shutdown operations without the necessity to start an auxiliary lube oil pump. Self-lubricated bearings shall be equipped with an easily accessible oil reservoir with overflow pipe and oil collecting vessel.

All bearings shall be easily controllable during operation or standstill without dismantling the bearings. The bearings shall further be protected and sealed against dust penetration and oil leakage.

In case of independent bearings, motor and bearing pedestals shall be fitted on a common base plate.

For the transport of motors equipped with ball or roller bearings, special bearing inserts shall be provided to prevent transport damage.

6.4.7 Shafts and Couplings

The motors shall be provided with a free shaft extension of cylindrical shape with key and keyway according to IEC Recommendation 72-1 and with the motor side coupling, which shall be pressed on the motor shaft and be balanced together with it. A coupling guard shall be provided.

6.4.8 Brush gear and Commutators

Brush gear for D.C. motors shall be designed to ensure constant brush pressure. Carbon brushes shall be provided which stand at least 6 months of operation without replacement. Each brush shall be independently adjustable but should not require adjustment throughout its life. A design of brush gear which permits the brush holder to touch the commutator as the brushes wear or which passes current through the pressure fingers will not be accepted.

A sufficient number of brushes, not less than two per pole, shall be fitted to ensure that vibrations do not affect the commutation.

The minimum safe wearing margin of commutators shall not be less than 20 (twenty) per cent of the total thickness of the commutator bars and the minimum safe diameter shall be clearly marked on it.

6.4.9 Terminal Boxes and Earthing

The terminal leads, terminals, terminal boxes and associated equipment shall be suitable for terminating the respective type of cables as specified in these General Technical Specifications and in the Particular Technical Specifications.

The terminal boxes shall be of ample size to enable connections to be made in a satisfactory manner. Supports shall be provided at terminal boxes as required for proper guidance and fixing of the incoming cable.

The terminal boxes with the cables installed shall be suitable for connection to supply systems with the short-circuit current and the fault clearance time determined by the motor protective devices.

A permanently attached connection diagram shall be mounted inside the terminal box cover. If motors are provided for only one direction of rotation, this shall be clearly indicated.

Terminal boxes shall be totally enclosed and designed to prevent the ingress of moisture and dust. All joints shall be flanged with gaskets of neoprene or similar material. For motors above 1 kW, the terminal box shall be sealed from the internal air circuit of the motor.

Depending on the size, the terminal box of L.V. motors shall be fitted either with an approved cable sealing-end or with a gland plate drilled as required and provided with suitable fittings for cable fixing and sealing. Such openings shall be temporarily plugged or sealed during transportation.

For earthing purposes, each motor shall have adequately sized bolts with washers at the lower part of the frame. In addition, each terminal box shall contain one earthing screw. Each equipment/panel shall be earthed by at least two separate earthing strips.

The cable termination philosophy to be adopted shall be such that extensive grouping of signals by a large scale use of field-mounted group. Junction boxes at strategic locations (where large concentration of signals are available, e.g. switchgear) is done. Termination / Junction boxes shall have either maxi- terminal or cage clamp type terminals

6.4.10 Noise-Level and Vibrations

Under all operating conditions, the noise level of motors shall not exceed 85 dB (A).

In order to prevent undue and harmful vibrations, all motors shall be statically and dynamically balanced.

Vibration displacements or velocity shall be measured in accordance with DIN 45 665 for IEC motor sizes 80 to 315. The results for all motors shall be within the "R" (reduced) limits.

6.4.11 Tests

Each motor shall be factory tested and shall undergo a test at site. The following tests shall be performed under full responsibility of the Contractor.

- Workshop Tests:
- Measurement of winding resistances
- No-load and short-circuit measurements
- Measurement of starting current and torque
- Efficiency measurement (type test)
- Heat test run
- Dielectric test
- Measurement of insulating resistance

- Over speed test
- Site Tests:
- Measurement of insulation resistance
- Measurement of motor vibrations
- Measurement of starting time.

DATA SHEET-A

CABLE DETAILS OF LT XLPE POWER CABLES

1.0	Type of Cable	Flame Retardant Low Smoke (FR-LSH)
2.0	Standard applicable in general(Latest amendment to be referred if any)	IS:7098 (Part-1), IS:8130, IS:5831, IS:10810, IS:3975, ASTMD:2843, ASTMD:2863, IEC-754-1,IEC:60332-3-23, IEEE:60383,IS-10418
3.0	Voltage Grade	1.1kV
4.0	Number of cores, cross sectional area of conductors and quantities	As per BOQ cum price schedule
5.0	**FAULT CHARACTERISTICS**	
	Fault Level	*50kA*
	Fault Clearing Time	1 sec
6.0	**CONDUCTOR**	
(a)	Material	Aluminium (With Tensile strength more than 100N/sq.mm.)
	Grade and Class	Stranded, H2, Class 2
(b)	Standard Applicable	IS: 8130
(c)	Shape	Compacted Circular / shaped as per IS
(d)	Min. number and diameter of strands for main and neutral conductor [Neutral conductor cross section w.r.t main conductor shall be as per Table-2 of IS: 7098 (Part-1)]	As per Table-2 of IS: 8130
7.0	**INSULATION**	
(a)	Material	Cross-Linked Polyethylene(XLPE)
(b)	Standard Applicable	IS: 7098 (Part-1)
(c)	Continuous withstand temperature	90°C
(d)	Short-circuit withstand temperature	250°C
(e)	Method of application	By extrusion; sleeve extrusion not permitted.
(f)	Nominal Thickness of insulation	As per IS: 7098 (Part-1)
8.0	**CORE IDENTIFICATION**	Following colour scheme shall be adopted. 1 core - Red, Black, Yellow or Blue 2 core - Red & Black 3 core - Red, Yellow & Blue 4 core - Red, Yellow, Blue and Black. For reduced neutral conductors, the core shall be black.
9.0	**INNER SHEATH**	
(a)	Material	PVC Type ST-2
(b)	Standard Applicable	IS: 7098 (Part-1) & IS: 5831
(c)	Colour	*Black*
(d)	Whether FR-LSH	*NO*

(e)	Inner sheath applicable for single core cable	*NO*
(f)	Fillers	Acceptable
(g)	Material of fillers (if permitted)	Same as inner sheath (Material of filler to be compatible with that of inner sheath)
(h)	Method of application	
(1)	Multi-core cables:	
(i)	With fillers	*Pressure/Vacuum extruded*
(ii)	Without fillers	*Pressure extruded*
(2)	Single-core cables:	*NA*
10.0	***ARMOUR***	
(a)	*Applicable*	**Yes**
(b)	Material:	
(i)	Single core cables	NA
(ii)	*Multi-core cables*	Galvanised Steel Round Wire OR Galvanised Steel Formed Wire/Strip, conforming to (i) Type 'b' as per Table-6 of IS 7098 Part-I and (ii) IS 3975 (as specified in BOQ cum price schedule)
(iii)	Standard Applicable	Dimension as per IS: 7098 (Part-1) Table-6 and tolerance on dimension as per IS:3975
(c)	Minimum Coverage	90%
(d)	Gap between armour wires	Shall not exceed one armour wire space (No cross-over/ over-riding)
(e)	Breaking load of joint	95 % of normal armour Zinc rich paint shall be applied on armour joint surface of G.S. wire / formed wire
11.0	**OUTERSHEATH**	
(a)	Material	PVC Type ST2 as per IS: 5831
(b)	Colour	*Black*
(c)	Whether FR-LSH	Yes
(d)	Method of application	Extruded
(e)	Thickness of outer sheath	As per Table-8 of IS: 7098 (Part-1)
(f)	Marking	*Cable size (cross section area and no. of cores) and voltage grade @ 5m (by embossing)* *Word "XLPE" "FR-LSH" etc, @ 5m (by embossing)* *Manufacturer's name and/ or trade name, and year of manufacture @ 5m (by embossing)* *'BHEL-PEM' and 'UJVUNL' Name @5m (by embossing)* *Progressive sequential marking @ 1m (by embossing/ printing).The embossing shall be progressive, automatic, in line and marking shall be legible and indelible.*
12.0	**FR-LSH CHARACTERISTICS**	
(a)	Oxygen index	Min 29 (As per IS 10810 part-58), ASTMD 2863
(b)	Temperature index	Min. 250^{o}C(As per ASTMD 2863)
(c)	Acid gas generation	Max. 20% by weight (As per IEC-60754-1)
(d)	Smoke density rating	Max. 60% (As per ASTM D 2843)
(e)	**Flammability Test**	
(i)	*Flammability test for all cables*	*As per: IEC-60332 Part-3, CAT-B*

13.0	**TOLERANCE ON OUTER DIAMETER**	± 2mm
14.0	**MINIMUM BENDING RADIUS**	
(a)	Single core cables	15 x O.D.
(b)	Multi core cables	12 x O.D.
15.0	**SAFE PULLING FORCE**	
(a)	Aluminium conductor cable	30 N/ sq. mm.
(b)	Copper conductor cable	50 N/ sq. mm.
16.0	**CABLE DRUMS**	
(a)	*Type of Drum*	Wooden as per IS 10418.
(b)	Standard drum length	500m (±) 5% or as specified in the BOQ cum price schedule
(c)	Painting	Entire surface to be painted
(d)	Wooden Drum	The surface of the drum and the outer most cable layer shall be covered with water proof cover. Both the ends of the cables shall be properly sealed with heat shrinkable PVC/ rubber caps secured by 'U' nails so as to eliminate ingress of water during transportation, storage and erection. Wood preservative anti-termite treatment shall be applied to the entire drum.
(e)	Particular information on Drum	Each drum shall carry manufacturer's name, purchaser's name, address and contract no., item no. & type, size & length of cable and net gross weight stencilled on both sides of drum. A tag containing same information shall be attached to the leading end of the cable. An arrow & suitable accompanying wording shall be marked on one end of the reel indicating the direction in which it should be rolled.

	TECHNICAL SPECIFICATION LT PVC CONTROL CABLE		Issue No: 01 Rev. No. 00
TECHNICAL DATA SHEET- A			
SL.NO	**DESCRIPTION**	**UOM**	**DETAIL**
1.0	**DESIGN CODES & STANDARDS**		
1.1	Standard applicable in general (Latest amendment to be referred if any)		IS:1554 (Part-1)
1.2	Current rating of cables		As per IS:3961 (P-2)
1.3	Short circuit rating		IEC 60949
1.4	Conductor		IS: 8130
1.5	PVC Insulation		IS 1554 (Part-1)
1.6	Inner sheath		IS 1554 (Part-1)
1.7	Outer sheath		IS 1554 (Part-1)
1.8	Core Identification (Upto 5 core)		Colour coding as per IS 1554 (Part-1)
1.9	Core Identification (Above 5 core)		By numbering as per IS 1554 (Part-1). Insulation to have black colour.
1.10	Armour		Galvanised Steel Round Wire/ Galvanised Steel Formed Wire Conforming to : (i) Type 'b' as per Table-5 of IS 1554-I and (ii) IS 3975; as per project requirements.
2.0	**DESIGN /SYSTEM PARAMETERS**		
2.1	Type of Cable		Flame Retardant-Low Smoke (FR-LSH) LT CABLE
2.2	Voltage Grade		1.1 kV
2.3	INSTALLATION CONDITIONS AT SITE		
2.3.1	Ambient air temperature	deg. C	50
2.3.2	Ground temperature	deg. C	30
3.0	**CONSTRUCTION FEATURES**		
3.1	CONDUCTOR		
3.1.1	Material type		Annealed Bare Copper (ABC)
3.1.2	Grade		Annealed high conductivity
3.1.3	Class		Class 2 (Stranded)
3.1.4	Shape		Circular

3.1.5	Compaction		Compacted
3.1.6	Cable Size	sq.mm	As per unpriced 'price schedule'
3.2	PVC INSULATION		
3.2.1	Nominal thickness of insulation	mm	As per IS: 1554 (Part-1) Table-2
3.2.2	Material		Extruded PVC Type-A
3.2.3.1	Continuous withstand temperature	deg. C	70
3.2.3.2	Short-circuit withstand temperature	deg. C	160
3.2.4	Volume Resistivity	ohm cm	$1X10^{13}$ ohm cm at 27 deg C $1X10^{10}$ ohm cm at 70 deg C
3.3	Extrusion		Sleeve extrusion not permitted.
3.3.1	Method of extrusion		Pressure Extruded / Vacuum Extruded
3.4	CORE IDENTIFICATION		As per IS
3.5	INNERSHEATH		
3.5.1	Thickness of inner sheath		As per IS 1554 (Part-1) Table-4
3.5.2	Material		Extruded PVC Type ST-1
3.5.3	Colour		Black
3.5.4	Whether FR-LSH		NO
3.5.5	Material of fillers (for multicore cables)		Same as inner sheath
3.5.6	Method of application		Extrusion
3.5.6.1	Multi-core cables:		Pressure extruded / Vacuum extruded
3.6	Armour (Applicability per BOQ mentioned in Unpriced 'Price Schedule')		
3.6.1	Dimension		As per IS: 1554 Part-1 and tolerance as per IS:3975
3.6.2	Material		
3.6.2.2	Multi core		Galvanised steel round wire / Galvanised steel formed wire
3.6.3	Gap between armour wire		Not more than one armour wire space (No cross over / No over riding)
3.6.4	Paint on joint		Zinc rich paint shall be applied on armour joint surface of G.S.wire / formed wire
	Minimum Coverage		90%
3.6.5	Breaking load of Joint		95% of normal armour

3.7	OUTERSHEATH		
3.7.1	Thickness of outer sheath		As per Table-7 of IS: 1554 (Part-1)
3.7.2	Material		Extruded PVC Type ST1 as per IS: 5831.
3.7.3	Colour		Black/ Grey (Project specific requirement shall be informed during detailed engineering)
3.7.4	Whether FR-LSH		YES
3.7.5	Method of application		Extruded
3.7.6	Marking/ Embossing on Outer sheath		
3.7.6.1	At every 5 Meters		(i) Owner's Name (project specific) (ii) Manufacturer’s name and trade mark (iii) Year of manufacture (iv) Type of cable and voltage class (v) Nominal cross section area of conductor and no. of cores (vi) ‘BHEL-UNIT NAME’ (Shall be informed during detailed engineering) (vii) 'FRLS'/ FRLSH
3.7.6.2	At every 1 Meters by embossing/ printing		Progressive Sequential length.Drum no. shall also be embossed/ printed.
3.8	FR-LSH CHARACTERISTICS		
3.8.1	Oxygen index		Minimum 29 as per ASTMD 2863
3.8.2	Temperature index		Minimum 250º C as per ASTMD 2863
3.8.3	Acid gas generation		Maximum 20% by weight as per IEC 60754-1
3.8.4	Smoke density rating		Maximum 60% as per ASTMD 2863
3.8.5	Flame retardance test for single cable (for cable OD ≤ 35mm)		As per IS 10810 Part 61
3.8.6	Flame retardance test for bunched cables		As per IS 10810 Part 62/ IEC-332 Part-3 (Category -B)
3.9	DIAMETERS		
3.9.1	Tolerance on overall diameter	mm	(±) 2 mm over the declared value

3.10	CABLE DRUM DETAILS		
3.10.1	Type		Steel
3.10.2	Standard drum length		AS per BOQ cum Un-priced schedule
3.10.3	Tolerance on drum length		(±) 5%
3.10.4	Details of marking on Drum		a) Manufacturer's name or trade make, address & contract no. b) Type of cable & voltage grade. c) Year of manufacture. d) Type of insulation. e) No. of core and sizes of cables. f) Cable code - FRLS. g) Single length of cable on drum. h) Direction of rotation, by arrow. i) Approx. gross mass.(on both sides of drum) j) Drum no. k) 'BHEL-UNIT NAME' (Shall be informed during detailed engineering)
4.0	**INSPECTION/TESTING**		
4.1	Type test conduction required	No* (* : Refer Sl. No. 4.2 below)	
4.2	Validity of type test report	As per Quality Plan vendor to furnish Type Test Certificate of specified Type Test which has been conducted within period of 10 years i.e. from 07/10/2024 up to 08/07/2014 . These reports should be for the tests conducted on the cable identical in all respects to those proposed to be supplied under this contract and test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client. In absence of valid Type Test report vendor to conduct the same without any commercial & delivery implication to BHEL.	
4.3	Acceptance & Routine test	All acceptance and routine tests as per Quality plan shall be carried out. Charges for these shall be deemed to be included in the cable price.	

TECHNICAL DATA SHEET

OF

INSTRUMENTATION CABLE

PROJECT - CHILLA RMU (4X39 MW)

CUSTOMER – UJVNL, UTTARAKHAND

UJVNL

BHARAT HEAVY ELECTRICALS LTD. BHOPAL (INDIA)
(A GOVERNMENT OF INDIA ENTERPRISE)

	NAME	SIGN	DATE
PREP.	E.KUJUR	-SD-	06.02.2025
CHD.	S.JUNEJA	-SD-	06.02.2025
APPD.	S.SHARMA	-SD-	06.02.2025

HPE (415)

TITLE: -		REV.
TECHNICAL DATA SHEET OF INSTRUMENTATION CABLE	**BHEL Doc. No: HPE/CHIL/INST_CABLE/GTP**	**01**

UJVN LTD
APPROVED
Contractual Conditions to be strictly Adhered to
Date 13 FEB 2025
Dy. GM (M&U-Ganga Valley)
GANGA BHAWAN
DEHRADUN

एडवीन कुजूर / EDWIN KUJUR
वरि. प्रबंधक(अभिकल्प) / Sr. Manager (Design)
एच पी ई विभाग / HPE Division
बी.एच.इ.एल., भोपाल / B.H.E.L. BHOPAL

ITEM DESCRIPTION: SIGNAL CABLE , 2 PAIR X 1.50 SQ.MM			
Sr.	PARAMETER DESCRIPTION	UNIT	SIZE OF CABLE
1	Manufacturer & Place of Manufacturing		
2	**Reference Standards**		Generally conforming to IS 7098 Part 1&2, BS 5308 Part II,BS EN 50288 Part-7, BS EN 50290-2-29,IS 8130, IS 5831, IS:3975, IS:2633, IS 1554(I), IEC754-1, ASTMD 2863, 2843, SS4241475 Cl. F3 IEC-60332-III, VDE-207(P-6)
3	**Voltage Grade**	V	650/1100V
4	**Electrical Characteristics**		
•	Power frequency test voltage (Spark Test)		As per BS 5099
•	Max. A.C. Resistance of conductor at Temp. 90°C	Ohm/Km	17.3
•	Max. D.C. Resistance at Temp. 20°C	Ohm/km	12.5
•	Highest voltage for equipment (Um)	KV	2Kv
•	Test voltage at site after laying	KV	1.5 KV for 1 Minute for core to core / 1.0 KV for 1 minute for core screen
5	**Conductor**		
•	Material		Stranded Annealed Tinned high conductivity copper class-2 of IS -8130
•	Grade & purity	%	Electrolytic &99.9
•	No. of strands /Dia. (mm) of each strand Nom.	mm	7/ 0.53
•	Area of Cross Section	Sq.mm	1.50
•	Shape of Conductor		Stranded - Circular
6	**Insulation**		
•	Material Type & Grade		XLPE
•	Thickness Of Insulation (Min)	mm	As per IS 7098 (0.40 MM)
•	Thickness Of Insulation (Nom.)	mm	As per IS 7098 (0.55 MM)
•	Method Of Application		Extruded
•	Diameter Over Insulation Approx.	mm	2.80 MM
•	Pair Twisting Lay (If Application)		100mm max , 10 Twist / Meter min,
•	Pair Colour		White & Blue
7	**Individual Screening**		
•	Material		Aluminium Mylar Tape
•	Type		Helical
•	Thickness	mm	0.06 (Nom.)
•	Coverage & Overlap	%	100%&25%
•	Drain Wire (If Applicable)		
•	Material		Annealed Tinned Copper
•	Cross Section	sq.mm	0.5
•	No of Stands / Dia. (Mm) Of Each Strand Nom.	mm	7/0.3
8	**Overall Screening**		
•	Material		Aluminium Mylar Tape
•	Type		Helical
•	Thickness	mm	0.075 (min)
•	Coverage & Overlap	%	100% & 25%
•	Drain Wire (If Applicable)		
•	Material		Annealed Tinned Copper
•	Cross Section	sq.mm	0.5
•	No. of Stand / Dia. (Mm) Of Each Strand Nom.	mm	7/0.3
9	**Inner Sheath**		
•	Material		HR PVC Type ST-2 Of IS-5831
•	Type		Extruded
•	Thickness	mm	Thickness as per IS 7098
•	Dia. Over Outer Sheath Approx	mm	13MM
•	Colour		Black
10	**Outer Sheath**		
•	Material		HR PVC Type ST-2 of IS -5831 with FRLS Properties
•	Type		Extruded
•	Thickness	mm	Thickness as per IS 7098
•	Colour		Blue
11	**Armouring**		Galvanized round steel wire
•	Thickness Of Armour (Dia.)		As per IS 7098-1-Table -6
12	**Nom Overall Outer Dia. Of Cable App. (± 2mm)**	Mm	18 mm (±) 1mm
13	**Net Weight Approx.**	Kg/Km	720 kg
14	**Recommended Min. Bending Radius**		12XOD of cable
15	**Classification Of Cables For Improved Fire Performance (Category No. /Name)**		Category C2
16	**FRLS Properties (For Outer Sheath)**		
•	Smoke Density Rating		Max 60 % as per ASTM D2843
•	Oxygen Index At Room Temp.		Min 29% as per ASTMD2863
•	Temperature Index		Min 250°C as per ASTM D2863
•	HCL Emission (Acid Gas Generation)		Max 20% (by weight) as per IEC 754(I)
•	Fire Resistance Test		As per IEEE-383,IEC-60332-PART-III CAT-A, SS-424-1475
17	**High Voltage Test At Factor With Duration**	KV_{rms}	CORE to Core -1.5 KV for 1 minute / Core to shield -1KV for 1 minute
18	**Cable Drum**		
•	Approx Gross Weight Of Drum	Kg/Km	70 Kg
•	Net Weight Of Drums Approx	Kg/ km	800 kg
•	Standard Length Of Cable (Subject To A Manufacture Of (+/-5%)	Meter	1000 ± 5%
19	Suitability With Regard To Moisture, Ozone, Acid ,Oil & Alkaline Surroundings		Confirmed
20	**Printing On The Outer Sheath Of Cable**		REVTI® MAKE SIGNAL CABLE PAIR X SIZE , 1.1KV , MONTH YEAR , 000 M , BHEL BHOPAL , UJVNL
21	**Additional Information**		
•	Min. Cross Talk At 0.8khz	dB	60
•	Mutual Capacitance At 1khz Core To Core (Max)	nF/km	115
•	Mutual Capacitance At 1khz Core To Screen (Max)	nF/km	400
•	Mutual Inductance @ 1khz	mH/Km	1mH/km
•	L/R Ratio (Max) Micro Henry /Ohm	µH/Ω	40(for 1.5sq.mm)
•	Max Attenuation At 1 Khz (dB/Km)	(dB/Km)	80 dB
•	Min Insulation Resistance At 20 Deg° C	Mohm/Km	100 Mohm/Km