Corrigendum - V dated 15/07/2026 to CPC Tender No. BHEL/CPC/CTAN/EPC-CHP-LHP/27/021 - EPC PACKAGE FOR COAL HANDLING PLANT AND LIMESTONE HANDLING PLANT FOR BCGCL COAL TO 2000 TPD AMMONIUM NITRATE PROJECT AT LAKHANPUR AREA, JHARSUGUDA, ODISHA."

A) Some of the Bidders had asked queries in the published tender specification. The clarifications issued by BHEL are as below;

Sl. No.	Section/ Clause No	Specification/ Existing Provision	Bidder's Query	BHEL's Clarification
1	NIT-Vol-I Clause 37.0: Order of Precedence: Page No 17 of 43	37.0 Order of Precedence In the event of any ambiguity or conflict between the Tender Documents, the order of precedence shall be in the order below: a. Contract agreement with its Amendments b. Letter of Award with its Amendments c. Amendments/Clarifications/Corrigenda/Errata etc. issued in respect of the tender documents by BHEL d. Notice Inviting Tender (NIT) e. Price Bid f. Technical Conditions of Contract (TCC)—Volume-IA g. Special Conditions of Contract (SCC)—Volume-IB h. General Conditions of Contract (GCC)—Volume-IC i. Forms and Procedures—Volume-ID It may please be noted that guidelines/ circulars/ amendments/ govt. directives issued from time to time shall also be applicable. Clause 37.0 specifies the documents that shall constitute the Contract between BHEL and the successful bidder. However, the tender also includes the Customer's GCC and SCC, which are not listed as Contract Documents under Clause 37.0. Forms & Procedures (Volume-1D)	Please clarify whether the End user's (BCGCL) GCC and SCC are applicable to the bidder. If applicable, kindly confirm the contractual precedence of these documents and the basis of their applicability, as they are not included in the list of documents forming the Contract under Clause 37.0 of the NIT. In addition to above documents, Erection Conditions of Contracts (ECC) is also provided to us but the same is not the part of the document forming the '**Contract'** Forms & Procedures (Volume-1D) are not available with the tender documents. Kindly provide the same.	**1)** BCGCL GCC and SCC are applicable to the bidder as part of the Customer Specifications and forms the part of TCC Volume-1A. 2) Refer Chapter-X, Clause no 10.1 for applicability of ECC. 3) "Forms-and-Procedure-Volume-ID.pdf" is already available with the tender documents.

B) Clarifications in TECHNICAL CONDITIONS OF CONTRACT (TCC): The following clause of existing TCC are being clarified/Revised as below;

Sl. No.	Technical Specification/ Existing Provision	BHEL Clarification	
		Existing TCC Annexures	**Revised as**
1	TCC, Chapter-X: Enclosures, Clause No.- 10.01 (g) PART-E – revised as Rev-01 through **Sl. No.-A)-3 of Corrigendum-IV dated-09/07/2026**	PART-E: Electrical and C&I Specification Rev No:01 Date: 01-07-2026 (826 pages).	PART-E: Electrical and C&I Specification **REVISION-02 Dated-13.07.2026**. ('Rev No.-01' to be read as 'Rev No.-02', wherever mentioned in this document) This TCC Annexure document is attached herewith (**827 pages**).

Enclosed:

a) Revised TCC Annexure – "PART-E: Electrical and C&I Specification" REVISION-02 Dated 13.07.2026 (827 Pages).
b) All other terms and conditions against this NIT shall remain unchanged.
c) This corrigendum is to be submitted duly signed and stamped along with the Techno-commercial bid (Part- I).

for BHARAT HEAVY ELECTRICALS LTD
SDGM / Purchase - CPC

Coal to 2000 TPD Ammonium Nitrate, LSTK-1

REVISION-02 Dated 13.07.2026

Electrical and C&I Specification

BHARAT HEAVY ELECTRICALS LIMITED
INDUSTRIAL SYSTEM GROUP
BANGALORE-12

INDEX

Sl No	Description	No Sheets	Rev No
1	Ele. Part-A General Technical Specification	67 Sheets	01
2	Ele. Part-B Technical Specification-Electrical	172 Sheets	01
3	Ele. Part-C Technical Specification-C&I	67 Sheets	00
4	Ele. Part-D E&I INDICATIVE Vendor list	297 Sheets	00
5	Basic Design Memorandum of Electrical and C&I	207 Sheets	01
6	Annexure-Elec-01 E&I Spares for LSKT-1	4 Sheets	00
7	Annexure-Elec-02 Indicative SLD for ref	1 Sheet	00
8	Annexure-Ele-3 and 3A Electrical and CI Scope Matrix for Coal to ammonia-CHP/LHP	7 Sheets	01
9	Annexure_Elec_3B_Space provision for Cable trays (BHEL use) in Bidders Cable /pipe rack /Buildings	1 Sheet	01
10	Annexure_Elec_3C_Scope demarcation of minor civil works pertaining to Electrical C&I facilities	1 Sheet	00
11	Annexure_Elec_3D_tentative road layout for CHP LHP AHP	1 Sheet	00

Note:

1. Basic Design Memorandum of Electrical and C&I is under approval with end customer. Final approved document will be shared to successful bidder after receipt of approval from customer. However, during detailed engineering final approved DBR shall be referred without any cost and time implication on BHEL by bidder.

2. In the event of any ambiguity, discrepancy, inconsistency, or contradiction among the clauses of this Tender Specification, the clause imposing the more stringent requirement shall prevail. The Bidder shall comply with such clause without any additional cost & time implication.

PART-A

General Technical Specification:
DESIGN PHILOSOPHY – ELECTRICAL

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	Scope
2.0	Basis of Design
3.0	Deleted
4.0	System Details and Utilization Voltages
5.0	Power Supply and Distribution
6.0	Sub Station
7.0	Protection & Metering
8.0	Control and Monitoring
9.0	Equipment Specification
10.0	Cabling
11.0	Illumination System
12.0	Earthing and Lightning Protection
13.0	Deleted
14.0	Fire Detection and Alarm System
15.0	Deleted
16.0	Spares
17.0	Vendor's Services
18.0	Testing & Inspection
19.0	Documentation
20.0	Tools & Tackles
21.0	Review of Drawings & Documents by Owner/ Consultant
22.0	Training
23.0	Vendor List
24.0	Installation, Testing and Commissioning
25.0	Testing of Installation after Erection
26.0	Quality Assurance
27.0	Coordination with Other Contractors

1.0 SCOPE

The scope includes work/service for the complete design, engineering, manufacture, testing at works, Third Party Inspection, supply of all electrical equipment, dispatch, storage, handling, erection, testing at site and commissioning of complete electrical system required for 'CHP/LHP And AHP For Coal to Ammonium Nitrate Plant'.

1.1 Although every item of supply and/ or installation might not have been described, the Bidder shall supply anything and everything to complete the project.

1.2 This specification shall be read in conjunction with all drawing and documents attached and other relevant reference as specified therein.

1.3 The scope of work/ services of The Bidder shall comprise complete electrics of the CHP/LHP And AHP For Coal to Ammonium Nitrate Plant. The scope of work/ services shall broadly comprise but not limited to the following:

1.3.1 Design & detailed engineering, Coordination, General Services etc.

a. Basic as well as detailed engineering.

b. Preparation of drawings/ document/ to suit Project implementation schedule. Preparation of drawings/ documents/ calculations/ formats/ test reports/ test certificates; Erection, Testing & Commission Manuals/ Operations & maintenance Manuals/ Reports/ QAP etc for approval/ Review/ reference/ record and/ or for any other requirement; submission to Owner/ Consultant in requisite sets, getting approval from Owner/ Consultant, making approved copies available to manufacturers, inspectors, erection & commissioning engineers, supervisors, owner/ Consultant etc as required in requisite sets well before those are actually required by them to fulfil their obligations.

c. Design, manufacture, testing of equipment/ cables/ cable trays/ earthing and other erection materials etc at manufacturer's works, submission of documents with manufacturer's test reports/ type test reports to Owner/ Consultant prior to inspection call.

d. Quality Assurance at each stage of manufacture including procurement of raw materials/ bought out items and arranging inspections by Owner/ Consultant/ Third Party.

e. Obtaining dispatch clearance from Owner in writing.

f. Packing, loading, forwarding, delivery at site/ store, loading/ unloading, storage as per manufacturer's recommendation; shifting from stores and handling in store as well as at site for erection.

g. Arrangement of testing/ checking instruments/ kits/ sets/ apparatus with valid calibration certificates issued by duly accredited laboratories/ institutions, to carry out tests stipulated in specification and documents referred therein/ other applicable standards.

h. Deputing electrical contractors, supervisors, electricians, cable jointers etc. on full time basis. for carrying out electrical work.

i. Installations of equipment/ cables/ materials.

j. Conducting pre-energisation tests to ensure that installation is fit to be energized.

k. Erection shall not be considered complete unless pre-energisation tests are carried out, results are tabulated & submitted to owner/ consultant and results are found satisfactory.

l. Conducting functional/ pre-commissioning checks/ Cold trial runs; no-load & load tests

m. Commissioning the installation.

n. Conducting Performance Guarantee tests and taking corrective steps (inclusive of replacement of equipment/ materials if required) till results are satisfactory/ acceptable.

o. Conducting Pre-Acceptance Tests/ checks and tabulating the results/ observations

p. Liquidations of defects/ discrepancies/ observations noted during erection, pre-energisation tests, commissioning, trial runs, performance guarantee tests, Pre-acceptance tests/ checks etc.

q. Submissions of all final/ 'As built' drawings/ documents after incorporation of changes made in soft as well as hard copies, duly certified by The Bidder to the effect that those are 'Final' and/ or 'As built'

r. Conducting Final Acceptance Tests/ Checks.

s. Co-ordinate with the Owner/ Consultant, other contractors/ agencies working at site as required for proper, smooth and timely execution of work/ implementation of the project

t. Preparation of drawings/ documents, applications for getting the installation inspected and approved by Electrical Inspectorate of state and/ or Central Electricity Authority and all coordination for getting the installation approved for energisation & use. Carrying out all modifications/ alterations required by statutory authorities. All expenses on these activities shall be carried out and borne by The Bidder. The obligation of owner shall be limited to "**Signing of Application as owner of the installation and payment of fee for inspection of installation**"

Approved drawings and certificates shall be submitted to the Owner/Consultants well ahead of schedule so that the actual commissioning of equipment does not get delayed for want of inspection and approval by the Electrical Inspectorate and other statutory bodies. The actual inspection work by the Electrical Inspector shall be arranged by the The Bidder and necessary coordination and liaison work in this regard shall be the responsibility of the The Bidder.

1.3.2 Manufacture, testing at works, getting inspected by Owner and/ or their consultant/ Third Party, packing, transportation and delivery to site in well packed condition, insurance during transit and till commissioning & handing over, storing at site as per recommendation of manufacturer/ supplier/ direction of supervising engineer of Owner/ Consultant until required for erection, transportation to work place. Erection, testing & commissioning, handing over of complete electrical system of 'CHP/LHP And AHP For Coal to Ammonium Nitrate Plant'' (hereinafter referred as Plant in short) but not limited to:

a. Bus Ducts

b. Transformers viz.

- 11/3.45, 11or 3.3/0.433 kV Transformers, as required
- Lighting/Welding Transformers

c. Switchgears:

- 11 kV Switchgears/ switchboards, as required
- 3.3 kV Switchgears/ switchboards, as required.
- 415 Volt Switchgears/ switchboards including PMCCs, MCCs, EPMCCs MLDBs, ASPBs (welding receptacle & other non-plant / non-critical loads are generally feed through ASPBs), LSDB, PDB, Junction boxes etc as required.
- Local control Panels, Local Control stations, Switch Sockets.
- Variable Frequency Drive Panels / Soft starters, as required

d. 11kV, 3.3kV, 415V Motors and other special application/ voltage motors as required.

e. All Cables viz

- Power Cables (11kV, 3.3kV and 1.1kV)

- Control Cables, Earthing Cable
- Signal cables,
- Optical fibre cables
- Data Cables
- Communication cables
- Special application cables

f. Erection/ installation & all sundry materials for installation, testing & commissioning of equipment/ panels/ fittings/ cables (including jointing & termination of cables) comprising (but not limited to) following:

- Foundations,
- Brackets, support structures, erection materials & accessories, as required
- Cable trays, racks, pipes, ducts, cable channels etc as required.
- Testing checking kits/ instruments

g. Illumination system - AC Normal, AC Emergency and Evacuation Lighting (on 220V DC)

h. Area Lighting

i. Aviation lighting, as required.

j. Neutral Earthing Resistor, NER.

k. Below grade earthing systems to be added in the scope along with connectivity at two points from existing facility.

l. Earthing of equipment & structures.

m. Protection against lightning.

n. 220V DC Batteries, Battery Charger and DC Distribution Boards.

o. 240V AC UPS Panels with batteries & UPS & UPS Power Distribution Boards.

p. Complete Electrics for Air Conditioning and Ventilation systems.

q. Complete Electrics for firefighting system,

r. Complete Electrics for EOT Crane, Hoists,

s. Fire Detection & Alarm System for Plant and Interface & Seamless Integration same with Centralised Fire Detection & Alarm System.

t. Cable trench/Cable tray with supporting structure.

u. Switchgear Building along with Transformer Rooms.

v. The scope shall also include the erection, testing, commissioning of above equipment's.

w. The contractor shall clear the site after commissioning of the equipment's / system and obtain the Site Clearance Certificate from Owner's Engineer-in-charge.

a. Any and all other Materials, Equipment and Services so as to make a totally integrated and functional system together with all accessories and associated equipment, ensuring safety, maintainability and reliability in compliance with all applicable codes, standards, guidelines, statutory regulations and safety requirements in force.

b. Any other equipment, not specified, but required for safe, proper, trouble free and efficient operation of the system

c. The Bidder shall consider any other requirement which is not covered in this NIT, but required for successful operation of the plant.

d. Spares & consumables for complete Contractor shall as per ANNEXURE-5A: 2 YEARS O&M SPARE AND OTHER SPARES(E&I)

e. Provide recommended spares (other than above spare) for all the equipment (item wise) with recommended quantity.

- Spares and consumables required and first oil fills including short fall during erection, testing, cold trials, commissioning, performance evaluation tests, guarantee tests etc and till handing over of installation shall be supplied by the Contractor as part of contract.

f. Tools & Tackles.

g. Testing Equipment's/ instruments

h. Arranging services of major equipment suppliers during installation and commissioning.

i. Training of Owner's Personnel for Operation & Maintenance of the Plant.

j. Any and all other items/ facilities/ services not specifically mentioned but essential/ required for completeness of the systems/ equipment's/ facilities.

1.4 Normal power supply shall be tapped from 2 Nos.11KV feeders. Further, downstream distribution shall be in The Bidder's scope.

This design philosophy contains specifications of the major equipment's to indicate the basic requirement and serve as a guideline. However, it shall be the responsibility of the contractor to offer a complete quality electrical system of superior quality, even if the specifications of certain items are not given. The items for which technical specifications are not indicated herein shall be of IS/IEC standard and specifications of these shall be subject to owner's approval in case of order.

1.5 The bidder shall offer the best and proven most suitable type of energy efficient equipment's manufactured by well-known reputed manufacturers having proven performance track record of minimum 2 years, as per vendor list appended in this bid package. However, for the sake of standardization of the electrical equipment and material used for the electrical installation, the

The Bidder shall supply all items of a particular type or make for whole plant of the same manufacturing company for ease of maintenance and less spares inventory.

1.6 Construction Power shall be made available at one location. Tapping of Construction Power (on chargeable basis) from this feeder (including supply & erection of all required materials like structural supports for cable tray, cable trays, power cables, control cables, protection & metering, cable termination etc. as well as underground cabling work) and further distribution shall be in The Bidder's scope.

In construction Power, The Bidder shall ensure that the minimum power factor of 0.9 shall be maintained at their end by providing suitable power factor improvement devices.

The Bidder shall have to distribute construction power with adequately rated distribution and sub distribution boards/feeder pillars, power supply cables and other associated materials for feeding loads to carry out construction and fabrication activities at his own cost.

However, during non-availability of construction power, The Bidder shall have to arrange emergency power, if required, through DG set at their own cost.

1.7 Contractor shall provide adequate area lighting at site of construction, fabrication yards, storage yard and office etc. by means of suitable lighting fixture, lighting masts, flood lighting poles etc. which are to be supplied and maintained by the contractor as per safety aspect.

1.8 Load Flow, Motor starting study, Transient stability, Short ckt. Study, Relay Co-ordination, Relay Settings (for each switch board) with existing system etc. Of the entire electrical installation of

CHP/LHP And AHP for coal to ammonium nitrate plant 'shall be conducted by the Bidder using latest software preferably ETAP at appropriate stage of design engineering.

All the Electrical equipment's shall be designed and selected according to the Short Circuit Study Report. In case equipment is ordered before studies are completed and revision of rating or design is required as a result of Electrical System Study then inclusion of such revisions shall be in The Bidder's scope without any cost and time implication. Contractor to share editable E tap file with all libraries.

1.9 The Bidder has to provide the required multifunctional dual channel transducers, Digital Multi-function Meters, latest version numerical/Communicable type protective relays with non-volatile memory, comprehensive unit providing protection, metering, control & communication with communication port & interlinked with Online Energy/Load Management System and required microprocessor based devices if any in panels , communicable door mounted Motor Protection Relays in all motor feeders of PMCC & MCC, proper communication facility in supplied UPS, Battery Chargers, VFD, Soft starter ,MOV and other critical equipment for proper communication with ECMS and DCS & ESD system. The interface of electrical equipment's with ECMS and DCS, ESD system shall be through IEC 61850 communication protocol for Numerical relays and IEC 61850/Modbus for Multifunction Digital Meters and MODBUS TCIP/IP for battery Charger, UPS, VFD, Motor Protection Relay (MPR) etc., Ethernet communication module shall also be used. 100% redundancy shall be provided for communication i.e. the relay should have minimum 2 Nos. IEC-61850 communication port in addition to Front Port.

All connection of numerical relays to Ethernet / Network Switch and looping of MFMs to Network / Ethernet Switches inside the switchboards and Network / Ethernet Switches, as required, for interfacing shall be in The Bidder's scope.

All communication cables and all hardwiring cables (for DI, DO, AI, AO etc.) from Switchboards Ethernet/Network Switches to respective Switchgear Building ECMS cabinets, DCS, ESD I/O Racks shall be in The Bidder's scope.

Data concentrator panel shall also to be included.

1.9.1 All cables (FO/Multipair control/any other cable), termination, all accessories etc. from Ethernet switches to LMS/ECMS, DCS, ESD I/O rack shall be in LSTK bidder's scope.

1.9.2 The Bidder shall provide separate room for local ECMS, DCS, ESD equipment's in Switchgear Buildings. Provision of future expansion of Data Concentrator Panels etc. shall also be considered while designing separate room.

1.10 The scope shall also include obtaining all required statutory approvals from all statutory bodies. Contractor shall carry out all modifications/alterations required by statutory bodies.

All approvals for permanent installations shall be obtained in the name of Owner. Approval for equipment & installation for Construction Power shall be in The Bidder's name.

1.11 In the event of any ambiguity, discrepancy, inconsistency, or contradiction among the clauses of this Tender Specification, the clause imposing the more stringent requirement shall prevail. The Bidder shall comply with such clause without any additional cost & time implication.

1.12 Final location of equipment's as well as route of cable trays shall be finalised during detailed engineering.

1.13 All electrical works associated with the followings but not limited to, shall be considered

a) Air conditioning and Ventilation systems
b) Firefighting system,
c) Fire protection system
d) Cranes, Hoist, elevators
e) Pollution control and monitoring equipment

f) All auxiliary building & associated electrical building/rooms.

1.14 Following Interface & Integrations are envisaging presently of The Bidder;

- Control & Protection for outgoing feeders of 11 kV Switchboard at Owner Switchgear Building to The Bidder Switchboard (Inter tripping, Cable Protection etc.)
- Interface and Seamless Integration with Centralised Fire Detection & Alarm System.

However, any other interface and Seamless Integration requirement or any other unforeseen which may arise during detailed engineering/ execution stage, same shall also be in the Bidder's scope without any cost and time implication.

1.15 All the Switchgear Buildings shall be provided with following equipment:

- CO_2 fire extinguishers (4.5 litre capacity) as per applicable NFPA.
- DCP fire extinguishers as per applicable NFPA
- Synthetic insulating mats on front and back side of all the switchboards. as per latest IS.
- Framed single line diagram in Aluminum frame with glass,
- Do's & Don't chart as per Indian Electricity Rules in Aluminium frame with glass.
- Shock treatment chart written in English and Local language duly framed and approved by engineer-in-charge.
- Caution boards / dangers boards written in ENGLISH & HINDI for all the voltage levels.
- CPR (CARDIO PULMONARY RESUSCITATION) Charts.
- High Voltage / Low Voltage danger signage (Skull & bones).
- Exit Route / Emergency Exit Route Signage.
- Cable Route Marker, wherever cable is in underground.
- Sets of Sand buckets with stand (each with at least 3 sand buckets) for Switchgear Buildings and transformer yards.
- HT and LT hand Gloves (3 Sets each for each Switchgear Building).
- A Type FRP ladder 3 feet & 8 feet – 2 no each type for each Switchgear Building. -First Aid Box

Other requirement or any other unforeseen which may arise during detailed engineering shall also be in The Bidder's scope.

2.0 BASIS OF DESIGN

2.1 General

2.1.1 The electrical installation shall be designed to provide:

- Necessary amount of power
- Flexibility
- Service reliability
- Ease of expansion
- Ease of operation and maintenance & inter changeability of equipment
- Safety of personnel

The design of electrical installation shall ensure provision of a safe, efficient and reliable supply of electricity at all times including adverse system conditions. Safe conditions shall be ensured under all operating conditions including those associated with start-up and shut down of plant as well as those arising out of failure of electrical equipment. The isolation of part of system of electrical equipment due to either maintenance or shut down shall not compromise safety aspects.

2.1.2 The design of electrical installation shall ensure provision of a safe and reliable supply of electricity at all times. Safe conditions shall be ensured under all operating conditions including those associated with start-up and shut down of plant as well as those arising out of failure of electrical equipment, climatic conditions like lightning and earthquake etc. The isolation of part of system of electrical equipment due to either maintenance or shut down shall not compromise safety. All electrical equipment's shall be of proven design and technology.

System shall be designed considering following aspects in general: -

- To facilitate inspection, cleaning and maintenance with the care to safety in operation and personnel protection.
- To minimize turnaround time.
- To provide safety, reliability and flexibility of service.
- Adequate provision for future extension and modification.
- Maximum inter-changeability of equipment.
- Desired level of operator interface to achieve coordinated efficient and fail-safe operation, data logging and maintenance of the equipment.
- To decide redundancy, stand by, spares and overload capacities to achieve desired reliability and flexibility requirement.

2.1.3 All the electrical consumers within the battery limit shall be identified and listed to have complete details of rating, efficiency, power factor, operating duty cycle (continuous, intermittent, standby), category of supply required (emergency, normal, critical) etc.

2.1.4 Required redundancy (based on specific process/operating needs) shall be built in Switchgear Building which feeds power supply to process units/important facilities so that in case of tripping of one feeder, the unit may not be adversely affected and continuity in operation at full capacity is achieved.

2.1.5 While sizing the system necessary consideration shall be given to restrict the system voltage drop within permissible limits during starting of large rated motors. At the same time, the short circuit current shall be kept within limits keeping in view of the market availability of switchgears rating. For this purpose, current limiting reactors/unit ratio transformers if required may be used.

2.1.6 The Bidder while performing design and engineering activities shall adhere to following guidelines.

a) If any equipment is not covered in this design philosophy but required for successful operation of the project, The Bidder shall prepare additional specifications for equipment or bulk material taking reference of Indian/International Codes and good engineering practices prevalent in fertilizer industry and obtain owner's approval for the same.

b) The standard drawings attached with this package define the basic system design and distribution philosophy for the package. This is for guidance purpose only. The Bidder shall develop detailed drawings and submit for owner's approval.

c) The Bidder shall be responsible to verify the rating and consider providing equipment with adequate rating but not less than the specified rating. Compliance should be without any extra cost and time implications.

d) The Bidder shall consider any other requirement which is not covered in this bid package, but required for successful operation of the plants without any extra cost and time implications.

e) Contractor shall obtain approval from all statutory authorities such as Central Electricity Authority (CEA)/Electrical Inspectorate, Chief Controller of Explosives (CCoE), CPCB etc. for all electrical facilities including electrical switchboards & panels supplied and installed by The Bidder.

f) The Bidder shall Liaison and in all interface coordination with contractors of other units of project at construction, erection, testing & commissioning phase for any common facility and for smooth execution.

g) Equipment specification sheet/data sheets for all equipment shall be prepared by the Bidder based on relevant codes and Technical specifications/ Data sheets attached as reference. Data sheet shall contain all technical data and information which are essential for review and technical acceptability, detailed engineering, installation, testing, repair and maintenance, replacement etc.

h) The Bidder shall clearly specify in their purchase specifications the requirement of conducting special tests/type tests, which are envisaged for various electrical equipment which shall have no impact on cost and time.

i) Bidder shall must visit the site and collect all relevant information required for designing of complete system before quoting. Bidder shall make themselves familiar with the work actually involved and actual site conditions. Failure to do so shall not absolve the Bidder of their responsibilities based on adverse site conditions.

j) All the electrical equipment's shall be of proven design and technology.

k) Load details (rating of all motor, Lighting, Switch socket etc.) load shall be submitted.

l) Load Summary shall be prepared by The Bidder to determine ratings of electrical equipment's (transformer, switchgears, cables etc.), to evenly distribute plant loads among the various Switchgear Buildings and switchgear, and to evaluate the need for power factor correction. All calculation shall be necessarily reviewed / approved by Owner/Consultant. The maximum normal running load and the peak load shall be calculated as follows:

Maximum Normal Running Load = (100% of sum of all continuous load) + (40% of sum of all intermittent loads or largest intermittent load, whichever is higher)

Electrical System shall be designed for maximum normal running Load operation.

All the electrical equipment's shall be designed / sized considering motor input power (i.e. BKW divided by motor efficiency).

Margin for future requirement shall be as per clause 2.1.6 m over the above.

All the electrical equipment's like Transformers, Switchboards etc. shall be suitable for starting of the largest motor, while other loads are running, considering peak load condition.

m) Electrical equipment's to be designed by The Bidder i.e. Transformers, Switchgears, MCCs, PCCs etc. shall have capacity for future requirements. The Margin shall be as follows:

i) For HV transformer 10% design margin on Maximum Normal Running Loads to be considered and for LV transformer 10% design margin on Maximum Normal Running Load to be considered

ii) Switchgear: Switchgear bus bar current rating as well as breaker shall be equivalent (nearer or higher standard rating size) to full load current of upstream Transformer.

iii) Switchboards and MCCs fed from other switchboards: shall be rated for Maximum Normal Running Loads on that board plus 10% design margin

n) The actual fault levels shall be arrived at on the basis of incoming power source, transformers, contribution of motors, etc.

o) Prospective touch and step voltages shall not be adverse to the stipulations of relevant publications of Bureau of Indian Standards / IEC/IEEE-80.

p) Sizing calculations for all the electrical equipment's shall be submitted for review/approval, in case of award of order. Owner/Consultant's Comments, if any on the same shall also be considered and modification in any equipment shall be done accordingly, without any time and price implication.

q) Seismic zone as applicable shall be considered for design of all electrical equipment.

2.3 Statutory requirement Codes and Standards

2.3.1 The design, installation, testing & commissioning shall conform to compliance of following statutory requirements:

- Indian Electricity Act
- Indian Electricity Rules
- The Indian Factories Act
- The Indian Explosives Act.
- Statutory requirement of Govt of Odisha and Govt. of India.
- Guidelines, instructions, directions issued by Pollution control Boards of state as well as central government. Guidelines, instructions, directions issued by Chief Controller of Explosives (CCoE), CPCB, CMRI, DGMS, CEA etc.
- Guidelines of Tariff Advisory Committee - Guidelines of Insurance Companies Association. - Any other applicable Rules/Acts/Regulations.

The design, installation, testing & commissioning shall be in accordance with established codes, good engineering practices and latest versions of following documents valid/ applicable on the date of acceptance of bid. The stipulations in these documents shall be considered as minimum requirements:

- Indian Standard Specification or equivalent IEC Standards
- Publications of IEEE
- API Standards
- National Electrical safety Code (NESC)
- Standards of Underwrites laboratory (UL)
- American Society for Testing Material (ASTM)
- American National Standards Institute (ANSI)
- Other International Standards

The Bidder shall be responsible for obtaining necessary statutory approvals from all the statutory bodies/authorities e.g. Electrical Inspectorate, PESO (earlier CCoE) as applicable before commissioning of electrical facilities. The CEA clearance for electrical equipment and components thereof shall be obtained by the contractor.

The Bidder shall carry out all modifications / alterations required by all statutory bodies. However, necessary statutory fee shall be deposited by the Owner.

2.4 Some of the bare minimum relevant Indian Standards are as listed below. However, system/equipment design shall be in line with latest edition of all applicable standards.

IS: 325, IEC:60034	Three phase induction motors
IS: 335	New insulating oil for transformers and switchgears
IS: 722	AC electricity meters
IS: 732	Code of practice for electrical wiring installations system voltages not exceeding 650V
IS: 737	Specification for wrought aluminum and aluminum alloys, sheet and strip (for engineering purpose)
IS: 996, IEC:60034	Single phase AC motors
IS:1248	Direct acting analogue electrical measuring instruments and their accessories:
IS: 1367 Part13	Hot dip galvanised coatings on threaded fasteners.
IS: 1646	Code of practice for fire safety of buildings and electrical installations
IS: 1913	General and safety requirements for Luminaries (Tubular fluorescent Lamp)
IS: 2071	Method of high voltage testing
IS: 2099	High voltage porcelain bushings
IEC:62305	Code of practice for the protection of buildings and allied structures against lightning
IS/IEC60079	Electrical apparatus for Explosive gas atmosphere
IS: 11171	Specification for dry type transformers.
IS: 2544	Porcelain post Insulators for system with normal voltage greater than 1000 volts
IS: 2633	Methods of testing uniformity of coating on zinc coated articles
IS: 2705	Current Transformers
IS: 3034	Code of practice for fire safety of industrial buildings, electrical generating distributing stations.
IS: 3043	Code of practice for earthing
IEC 61869-1	Instrument transformers — General requirements
IEC 61869-2	Additional requirements for current transformers

IEC 61869-3	Additional requirements for inductive voltage transformers
IS: 3177 IEC60034	Crane duty motors
IS: 3347	Dimensions for porcelain transformer bushings
IS: 3637	Gas operated relays
IS: 3639	Fittings and accessories for power transformers
IS: 3646	Interior illumination: Part I & Part II
IS: 3716	Application guide for insulation co-ordination
IS/IEC:60529	Degree of protection provided by enclosure for rotating electrical machinery.
IS: 4722	DC motors

IS: 4759	Hot dip zinc coating on structural steel and allied products
IS: 5082	Specification for wrought Aluminum alloys bars, rods, tubes and sections for electrical purposes
IS: 5561	Electric power connectors
IS: 5578	Guide for marking of insulated conductors (1st rev)
IS: 6362	Designation of methods of cooling of rotating electrical machines
IS: 6600	Guide for loading of oil immersed transformers
IS: 6665	Code of practice for Industrial lighting
IS: 7689	Guide for control of undesirable static electricity
IS: 8084	Interconnecting Bus bars for AC voltage above 1 KV upto and including 36 KV
IS: 9676	Reference ambient temperature for electrical equipment
IS: 10028	Code of practice for selection, installation and maintenance of transformers
IS: 10322-1	Specification for Luminaries, Part-1, General requirements
IS: 11353	Guide for uniform system of marking & identification of conductor & apparatus terminals
IS: 11448	Application Guide for AC electricity meters
IS: 12360	Voltage bands for electrical installations including preferred voltage and Frequency
IS: 12459	Code of practice for fire protection of cable runs
IS: 12615	Energy efficient motors

IS: 13234	Guide for short circuit calculations
IS: 13346	General requirements for electrical apparatus for explosive gas atmosphere.
IS: 13408	Code of practice for the selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres
IEC: 60255	Electrical Relays
IS/IEC: 60947	Low voltage switchgear and control gear
IS: 60034-5	Degree of protection provided by Integral design of rotating electrical machines
IS: 60079-0	Explosive atmospheres, Equipment General Requirements
IS: 60079-1	Explosive gas atmospheres – Part-1 Equipment protection by Flame proof enclosures “d”.
IS: 60079-7	Equipment protection by increased safety “e”
SP: 30	National Electrical Codes (NEC) - BIS Publication
IS/IEC 62271	HV Switchboard.
IEC 61439-1/2	LV switchboard (PCC/PMCC/MCC) for TOTAL TYPE TESTED (TTA). Type Test Certificates for short circuit withstand of 50kA for 1 sec. along with ACB mounted in the Switchboards shall apply.
IEC 61641	Switch Board with INTERNAL ARC CONTAINMENT test.
ANSI C-37:23	Metal enclosed bus
ANSI C-37:24	Effect of Solar radiation on metal enclosed bus.
IEC 60034	Rotating Electrical Machinery
IEC 61131	Programmable controllers
IEC 60871-1 /IS 13925	Shunt Capacitors for AC power Systems Specifications

Any other standard may be followed provided it is equivalent or more stringent than the standards specified above.

2.5 In case of any conflict/deviation amongst various documents the order of precedence shall be as follows:

- Statutory rules/regulation
- Design Philosophy
- Data sheets
- Technical specification/Installation Standards, etc.
- Applicable IS/IES standards

In case of contradiction / conflict among documents and statutory requirement, The Bidder shall refer to Owner for clarification. However, most stringent specification shall be followed with Owner’s approval. Owner decision shall be considered as final.

2.6 Site Conditions

The equipment shall be designed for the following site conditions: -

- Minimum ambient Temperature As per site ambient temp.
- Maximum ambient Temperature 46. degC
- Design Reference Temperature 50. degC
- Relative Humidity 100%
- Altitude above mean sea level Lower than 1000 Mtrs.
- Atmospheric pollution Dusty due to presence of Coal Dust and corrosive due to presence vapours of Ammonia.

Equipment/ cables selected shall be derated for (a) higher ambient temperature, (b) restriction in temperature rise (c) variation in voltage, (d) variation in frequency (e) installation conditions viz. proximity to heat sources, bunching, layering, separation from others/ laying in conduits etc. with respect to the conditions for which it was designed & manufactured. Various de-rating factors considered shall be informed with supporting documents.

Equipment to be installed in MCC rooms/ Electrical Rooms/ Control rooms shall be designed for + 50º C so that in case of failure of Air-conditioning/ ventilation facilities, the operation/ functioning of equipment is not be affected.

3.0 Deleted

4.0 SYSTEM DETAILS AND UTILIZATION VOLTAGES

4.1 The various voltage levels for in plant power distribution shall be as follows:

A. Normal Power	11KV ± 10%, 50Hz ± 5%, 3Ph, 3 W
B. Emergency Power	Voltage Variation ± 5%, 50Hz ± 3%, 3Ph, 3 W
C. Distribution Equipment	a) 11KV ± 10%, 50 Hz ± 5%, 3 Ph, 3 W with resistance earthed neutral b) 3.3KV ± 10%, 50 Hz ± 5%, 3 Ph, 3 W with resistance earthed neutral c) 415V±10%, 3 Ph, 4 W/240V ± 10%, 1 Ph, 2W, 50 Hz ± 5% solidly grounded neutral.
Combined variation in voltage & frequency	± 10%
Control Supply for: - 415V motors - Switch Gear Breaker controlled feeders: a. Closing, tripping & spring charging motor b. Auxiliary power	AC 240V ± 10%, 50 Hz ± 5%, 1Ph (For contactor-controlled motors) 240V AC tapped from boards only with 415/240V control transformer. DC 220V ± 5% (For breaker-controlled motors) – Battery Charger DC 220V ± 5%, 2 W - Battery Charger AC 240V ± 10%, 50 Hz ± 5%, 1Ph, 2W
- Instrumentation and Automation, DCS & Auxiliaries	AC 240 V ± 10%, 50 Hz ± 3% 1Ph, 2W – Instrumentation UPS located at Control Room

Voltage Ratings- - Motors including1500 KW and above - Motors above 160 KW Below 1500 KW. -Motors up to and including 160 KW	 11 KV, 3 Ph AC 3.3 KV, 3 Ph AC 415 V, 3 Ph AC
- Space heaters - Lighting - Panic Lights - Power Sockets/Receptacle	240V, 1 Ph AC 415V/240V AC 220V DC 415V, 3 Ph AC/240V, 1 Ph AC

4.2 The actual fault levels shall be arrived at on the basis of incoming power source, transformers, contribution of motors, etc. and shall be indicated.

All switch boards of the same voltage shall be rated for identical fault level. Minimum fault level to be considered for design and selection of equipment shall be as follows:
11 kV Switchgear – 40kA for 3 Seconds.
3.3 kV Switchgear – 40kA for 3 Seconds.

The fault level for 415V switchboards shall be 50kA for 1 sec.

Impedance of transformers shall be selected suitably (tap position at principal) without comprising voltage drop at receiving end.
11kV/0.433kV Oil type(outdoor)/ dry type (Indoor) Transformer rating shall not be more than 2500kVA
Fault level of DC System shall be decided by the Bidder after substantiating the same by calculation.

4.3 System Earthing

The neutral of 11 KV and 3.3 KV systems shall be non-effectively earthed through resistance. The earth fault current of 11 KV and 3.3 KV shall be limited to full load current of the transformer or 400 A, whichever is less. Suitable protection system to be designed to have proper sensitive Earth fault protection.

The neutral of 415V supply system shall be solidly earthed.

The DC system shall ungrounded system. Prospective touch voltage earthing shall comply with the requirements of relevant Indian/IEC standards.

5.0 POWER SUPPLY AND DISTRIBUTION.

5.1 Power supply from 11 KV switch boards in owner's Switchgear Building.

5.1.1 2 Nos. 11 kV Normal power Feeders shall be made available in owner's 11 kV Switchboard at owner's Switchgear Building. Tapping of power supply from 11 kV Switchboards) at owner's Switchgear Building (including supply of all required material), structural supports for cable tray, cable trays, cables, cable termination at both ends etc. shall be in The Bidder's scope. Further distribution to equipment at 11 KV, 3.3 KV, 415/240 V, 240 V (UPS, Inst.) AC, 220 V DC etc. through proper type and size of cables, their supply, erection, testing and commissioning etc. shall be in The Bidder's scope.

The Bidder shall consider 11kV/3.45kV, 3.3kV/0.433kV transformers for downstream distribution. The supply system shall be designed for maximum power requirement.t.

The Bidder shall indicate details of power requirement and the Rating of 11kV Feeders in the Bid.

5.1.2 The electrical system layout and interconnections (power as well as control) shall be such that the problem in electrical system of one plant should not affect the electrical system of other plant and vice versa.

5.1.3 The insulation system of cable, 11 kV & 3.3 kV equipment's shall be based on unearthed system only.

5.1.4 The outgoing feeders shall be sized for the nominal load. Breaker rating of all the outgoing feeders of 11KV switchboards & & 3.3 KV switchboards shall be same considering provision of inter-changeability. Incomer/ Bus Coupler rating shall be same as the Bus Bar rating.

5.1.5 Primary connections of transformers shall be provided with cables of suitable size and secondary connections shall be through cables/bus duct.

5.1.6 The entry of cables in all the switchboards shall be from bottom only.

5.1.7 All switchboards shall be provided with minimum two incoming feeders and one bus tie having auto/manual changeover facility.

5.1.8 It shall be possible to have momentary paralleling of power sources at 11 kV, 3.3 kV switchboards and 415V PMCC /PCC/MCC and trip the desired circuit breakers.

5.1.9 The normal operation of the 11 kV, 3.3 kV Switchgears, Power & Motor Control Centre (PMCC) and Motor Control Centre (MCC) shall be as under:

i. Bus-coupler shall be provided between all the sources. Incomer and Bus-coupler breaker rating shall be same for all the switchboards. Each incoming feeder shall independently feed the loads on respective buses with full rated bus tie breaker open and the load on each bus balanced. In order to ensure maximum degree of reliability and continuity, automatic transfer from one incoming feeder to other shall be possible through auto/manual closing of bus tie breaker in case of sustained loss of power on any bus section.

ii. The bus tie breaker shall be provided with auto/manual selection. The bus tie breaker shall be independent in manual mode. In auto selection mode, the bus tie breaker is electrically interlocked with incoming circuit breakers, so that it cannot be closed unless one of the incoming breakers is open.

iii. When one of the incoming feeder trips, the bus tie breaker is closed automatically based on the philosophy described and the total load is transferred to another healthy incoming feeder which is capable of carrying the entire load. Sufficient switchgear capacity is to be provided. Time for changeover is suitably selected based on downstream system requirement of reacceleration of motors etc.

iv. Auto Change Over scheme shall be provided for incomer feeders and bus coupler feeder of 11kV switchboard, 3.3kV Switchboards and 415V Switchboards. Under normal operating conditions, incomer-1 and incomer-2 breakers shall be closed and bus coupler breaker shall remain open with 'Local-Remote-Off' switch in 'Remote' position. The bus coupler breaker shall close automatically under the following conditions being fulfilled:
   - Either of the incoming breaker trips due to under voltage (70% or below).
   - Voltage on the healthy bus is more than 80% for the set period.
   - Residual voltage on the bus with no power supply comes down to 30% or below. Required nos. of bus PT, line PT and under voltage relays shall be provided to achieve the desired automatic changeover.

v. Auto transfer shall take place only on sustained loss of power on either of bus sections. Auto transfer shall be blocked in case of fault on either of bus sections or no power on both incomers.

vi. Paralleling of two incoming feeders is not foreseen. However, facility for momentary paralleling shall be provided for intentional changeover without interruption of supply with

synchro check relay in Bus Coupler panel. There shall also be provision of selective tripping of one feeder out of three feeders with a Delay (two incoming feeders and one Bus Coupler).

5.1.10 PMCC & MCC shall have 2 Nos. Normal Power Incomers feeding non-critical loads. DC Battery Charger, UPS System etc. shall be fed from PMCC. PMCC shall fed breaker-controlled feeders and various power feeders whereas MCC shall fed contactor-controlled load and various power feeders. PMCC and MCC shall be separate.

5.1.11 Auxiliary Services Power Board (ASPB) shall be provided in the plant for supplying power to welding switch sockets, lighting load, EOT crane and other auxiliary loads.

5.1.12 Separate MCCs be provided for Air-conditioning and Ventilation systems.

5.2 Instrumentation Power

5.2.1 The power supply for instrument shall be 240V, 1Ph from UPS System.

5.2.2 Provision for 240V, 1 Ph power for lighting of instrument panels shall be provided from LSDB.

5.2.3 All instrument panels shall have two UPS incomer supply (one from different bus of UPS DBs) to avoid any type of power obstruction in case of failure of one supply.

5.3 Lighting Distribution

Separate MLDB (with transformer) with double incomer for AC normal lighting shall be provided. Lighting Transformer rating shall be 100/50/25kVA, 415/433V with +/5% tapping on secondary side.. MLDB shall have fault level of Min. 50 kA for 1sec.

Lights at strategic location for safe evacuation shall be provided as panic light (DC Emergency Lights on 220V DC), in case of complete shutdown.

Indoor and Outdoor lights shall be fed from Separate Lighting Sub Distribution board (or Lighting Panel). Outdoor lights shall be fed from Lighting Sub Distribution board having Photocell / digital clock Timer through contactor.

5.3.2 All outdoor lighting fixtures and outside lighting of Sub-Stations, Offices, Control Rooms etc., shall receive power from Separate Lighting Sub Distribution board (or Lighting Panel) having Photocell and Timer through contactor

5.3.3 Electronic Timer and Contactor shall be provided for Outdoor Bus Section.

5.3.4 Main Lighting Distribution Board shall feed Lighting Sub Distribution board having 63A 4 Pole MCB and ELCB as incomer, 20Amp DP RCBO as outgoing. The outgoing RCBO shall have rating of 300 /100 mA.

5.3.5 Welding outlets shall be fed from WDB (with single transformer) 3 phase supply for welding connection. All welding outlets shall be provided with CBCT ELCB of 100 mA.

5.4 DC Power

5.4.1 220 V DC system shall be provided for control of circuit breaker feeders and panic lighting. It shall be obtained from Ni-Cd batteries.

5.4.2 The battery shall be provided with SCR controlled automatic rectifier-cum battery chargers and shall consist of Main Float cum Load charger, Standby Float cum Load charger and Boost Charger and 2 Nos. Battery Bank

5.4.3 Each rectifier-cum - battery charger shall have independent power supply to be fed from the normal source.

5.4.4 220V DCDB shall have 2 sources with auto changeover facility in case of failure of 1 source.

5.4.6 Battery end cell voltage shall 1.14V. Aging factor shall consider 125% and Design margin of 20%.

5.4.7 For Temperature derating factor shall be based upon Minimum Ambient Temperature shall be decided during detailed engineering.

5.4.8 Battery Charger shall have at least 30% additional capacity for Owner Use. Battery Charger shall have 220 V DC system.

5.4.9 Separate Rectifier-Cum-Battery Charger with DC Distribution Board and Battery Bank shall be provided for each Switchgear Building.

5.4.10 The battery and charger combinations shall be such as to ensure continuity of D.C. supply at load terminals without even momentary interruption.

5.4.11 AC Ammeter and AC Voltmeter on Charger Input; DC Ammeter, DC Voltmeter for charger output/ battery voltage and on demand type Battery Charge / Discharge Ammeter shall be provided.

6.0 SUB-STATION/Switchgears Room

6.1 Elevated with trays in cable cellar : Yes

6.2 Complete Switchgear Building : UPS, Charger, VFD panels etc. shall be air conditioned.

6.3 Roof slab for

a Power transformer : No

b Distribution transformer : Yes

6.4 Batteries in Switchgear Building and control Rooms: Separate room

6.5 Switchgear room : Ventilated

6.6 Battery charger in Switchgear Building : Air conditioned

6.7 UPS Systems : Air conditioned

6.8 Nickel- Cadmium Battery : Separate room (Ventilated)

6.9 Variable speed drive panels : Air-conditioned

6.10 Thyristor controlled panels : Air-conditioned

6.11 Annunciation panel (HMI) : Operator Room in Switchgear Building

6.12 The Sub-Stations shall be located near the load centres but away from hazardous areas as per IS/IEC. Actual size of Switchgear Buildings shall be based on the final dimensions of Switchgear Building equipment's. Each Switchgear Building shall include Maintenance Room, Engineer Room, Shift Office (Staff Room), Gents toilet (both Indian and western WC), Ladies toilet (both Indian and western WC) etc.

6.13 The sub-station building shall have double storey construction. The ground floor shall have cable gallery and first floor shall have all switchboards, control panels etc. The switch room shall have Epoxy flooring. False ceiling shall be provided in Switchgear Building except Switchgear Room.

6.14 Clear height of 2.1M shall be provided in Walkways envisaged in Cable cellar room and shall be closed on all 4 sides with two entries, preferably on opposite sides. It shall house all cable trays and their supports.

6.15 Transformer floor shall be at least 300 mm above the finished floor level of cable cellar room.

6.16 In addition to the entry to Switchgear Building for operating personnel, a separate entry of minimum 3.5M (H) X 3M(W) with rolling shutter shall be provided for all equipment entry. The rolling shutters should be manually operated with gear box. The Sub-station shall also have an emergency door opening outwards.

6.17 Sub-station wall adjacent to the transformer bays and walls separating transformers shall be 355 mm thick (inclusive of plastering) in case of brick construction or 240 mm thick in case of RCC construction up to roof slab. RCC roof slab shall be provided for Transformer, Series Reactor, capacitor etc. The gate of Transformers shall be designed to prohibit bird entry.

6.18 Adequate number of Portable Fire Extinguishers of Dry Chemical Powder and Carbon dioxide shall be provided in suitable location in Switchgear Building, Transformer bays, Control room building
etc. in addition to sand bucket as per CEA requirement. These extinguishers will be used during the early phase of fire to prevent its spread and costly damage. All extinguishers shall be supplied with initial charge and accessories as required. Portable type extinguishers shall be provided with suitable clamps for mounting on walls or columns. All extinguishers shall be painted with durable enamel paint of fire red colour conforming to relevant Indian Standards.
Dry chemical powder type extinguisher shall conform to IS: 2171.

Carbon Dioxide type extinguisher shall conform to IS: 2878.

6.19 Sub-station building shall be without any columns within the switchgear room to ensure optimum space utilization.

6.20 The layout of equipment shall be such that it shall have adequate space for installation, operation, maintenance and future expansion. The clearance of equipment from the walls/other equipment shall be adequate to ensure safety of working personnel. Generally, the following norms shall be maintained for 11 KV/3.3 KV/415 V Switchboards:

a) The clear space of 1.5 M at rear side of 11kV/3.3 kV Switchboard.
b) A clear space of 1.5M behind the double front switchboards and 1M for single front.
c) A clear space of 2.5M/2.0M between the two MV/LV boards facing each other.
d) A clear space of 2.5M on either side at entrance/exit.
e) A clear space of 1.0M between two boards in same line after future panel space of switchboard.
f) A clear space of 1M in switch room from top of equipment.

6.21 The Switchgear Building Switchgear Room shall be Ventilated, UPS & Battery Charger room, ECMS room, Control Room, Maintenance Room, Engineer Room, and Shift Office shall be fully air conditioned through centralised HVAC system (as per Design Philosophy – HVAC System) with proper ducting arrangement for uniform cooling, however all the equipment shall be suitable for operation under specified ambient condition even on failure of air conditioning system. The Switchgear Building shall have HVAC system, so that, the temperature inside the Switchgear Building is maintained at 25 Deg.C in all conditions. Provision for remote alarm on failure of air conditioning system shall be provided. Indication of Switchgear Building and control room temperature shall be provided. Heat load to be calculated on the basis of heat generation in the Switchgear Building during peak summer period. Fire damper to be provided in the ventilation duct of the HVAC. There should be a separate room for installation of the HVAC Units located at ground floor.

6.22 Epoxy flooring of minimum thickness of 5 mm shall be done to reduce the heat load and improve the aesthetic look.

6.23 The battery room shall form a part of the sub-station. Battery room shall be provided with minimum n+1 exhaust fans and louvered opening in opposite wall/door. A sink with water tap shall be provided with water connection. Eye wash shower shall also be provided. Floor of the battery room and walls up to 2 M height shall have acid/alkali resistant protective epoxy

6.24 Light fittings, exhaust fan, on/off switches etc. in this room shall be chemical resistant type only

6.25 Location of battery charger shall be nearer to battery room.

6.26 To the extent possible Bus duct shall be in straight position. Bending of bus duct shall be avoided.

6.27 Electric Hoisting Arrangement shall be provided for lifting heavy equipment to be brought into the sub-station.

6.28 Sufficient nos. of entrances in line with National Building Code (min. 2) shall be provided for each floor.

a. All doors of sub-station shall be air-tight fire proof steel doors except doors of control rooms/ PLC rooms which may have anodised aluminium frame with toughened glass panel. All doors shall open towards exit.
b. Windows shall have anodised aluminium frame and provided with toughened glass.
c. In case height is more than 10 meters, elevators (of capacity for 10 persons) shall be provided. Elevator shall be suitable for the area of installation.
d. 1000 mm wide insulating mat as per latest IS standard of appropriate voltage grade shall be provided in front as well as rear of each panel.

6.30 The Sub-stations shall also have an emergency door opening outwards as per latest edition of National Building Code.

6.31 The sub-station shall house all the electrical power, control and monitoring equipment except those required for operation in the field. The equipment shall broadly include the following: -

- Transformers located in separate Bay/Room.
- High Voltage Switch Boards
- Power Control Centres
- Power & Motor control centres
- Emergency Power & Motor control centres
- Motor Control Centres
- Auxiliary Service Panel Boards
- Lighting Transformer (Indoor / Outdoor as per requirement)
- Main Light Distribution Board
- Lighting Distribution Boards
- Lighting Sub-Distribution Boards
- Battery Sets
- Rectifier-Cum-Battery Charger
- Cell Booster
- DC Distribution Boards
- Rectifier-inverter Sets
- 240 V AC UPS System alongwith UPS distribution board.
- Neutral Earthling Resistors (Indoor / Outdoor as per requirement)
- Input / Output Panels
- VFD System
- PA System (Space only)
- HVAC System
- Any other equipment required

6.32 All static devices such as Rectifier-Cum-Battery Chargers, Variable Speed Drive Panels, Soft Starter etc., shall be housed in a separate room. Heat load for panel to be taken by panel manufacturer.

6.33 Separation walls between transformers in all Switchgear Buildings and safe inter transformer distances for switchyard transformers shall be provided.

6.34 Transformers shall be located in bays adjacent to the sub-station building. All bays shall have oil drained floor, surfaced with gravel or other suitable material.

6.35 In order to prevent leaking oil from reaching and polluting the water bearing stratum, transformers shall have the following provisions, depending on the oil capacity of the transformer.

Oil Capacity up to 2,000 litres: Transformers installed adjacent to sub-station shall be provided with oil soak pit with a layer of pebbles of about 40 mm granulation.

Oil Capacity exceeding 2,000 litres: Transformers installed adjacent to sub-station shall be provided with oil collection pit and sump pit for draining away of any oil, which may escape or leak from the tanks, to a waste oil tank.

6.36 A clear space of at least 1.5 meter shall be maintained all around the transformers after installation of HVWS System.

6.37 High Velocity Water Spray (HVWS) System shall be provided for transformers fire protection having oil capacity more than 2000 Liters.

6.38 Separate common oil pits are required for Transformers.

The volume of common oil pit will be 125% of the volume of oil of the transformer, which contains the largest volume of oil in transformers.

The oil pit will be closed type of water-proof concrete construction.

The oil pit will be connected to individual pit under each transformer and drain line of each transformer will be at least 150 mm dia pipe with a minimum slope of 1:96 as per TAC Regulation.

Transformer fire/drainage of oil will be considered for only one transformer at a time.

Level of pit will be so selected that there would not be accumulation of oil/water/oil-water mixture in the pit under each transformer.

Pit shall be provided with 2 x 100% sump pump for common oil sump.1 No. Portable sump pump shall also be provided.

Oil Pit under Transformer and its Cooler Bank: Gravel filled open oil pit will be provided under each transformer and its cooler bank. The pit shall be such that it can take oil/water surge of 20% of the volume of the transformer oil. Level of pit shall be such that there will not be accumulation of oil/water in the pit. The gravel size will be 60 mm. Each pit will be connected to the drain line leading to new common oil pit.

6.39 In all Switchgear Buildings/MCC rooms, space for future extension of switchboards shall be provided.

One panel extension space on each side (for each bus section) shall be provided for all HV Switchboards, PCCs. One panel extension space on each side (for each bus section) or two panel extension space on one side (in exceptional cases) shall be provided for all PMCCs, MCCs and ASPBs.
The HV switch boards and power control centres shall have sufficient number of spare feeders to the extent of 20% or 1 No., whichever is higher for each type & rating.

For other boards (PMCCs, MCCs, MLDBs, ASPBs, DCDBs etc.) sufficient number of spare feeders to the extent of 20% or 1 No., whichever is higher, for each type & rating shall be provided.

6.40 Fire protection for Switchgear Buildings shall be provided to comply with requirements of relevant BIS (Bureau of Indian Standards) and other Indian/ International standards, as applicable. In case Indian standards are not available for any equipment, standards issued by IEC/ BS/ VDE/ IEEE/ NEMA/NFPA or equivalent agency shall be applicable.

In case of contradiction / conflict, most stringent specification shall be followed.

Switchgear Buildings shall be provided with smoke detectors and fire alarm system as specified elsewhere in the NIT and as per relevant Indian Standard.

6.41 Fire barriers shall be provided at cable/bus-duct entry/exit point. Cable shall have fire protection paint for 1 m length at building entry points and Panel entry points for above ground cables.

7.0 PROTECTION & METERING

7.1 Selection and co-ordination of protection and metering system shall be such as to ensure:

- Selective, sensitive and reliable protection of equipment against damage due to internal or external faults or atmospheric discharge.
- Isolation of fault in the shortest possible time.
- Simplicity of the scheme with maximum protection.
- Uninterrupted operation of healthy system.
- Personnel & plant safety.

7.2 Protective relays shall be of latest version, numerical / communicable type with non-volatile memory, comprehensive unit providing protection, metering, control and communicable with communication port for interlinking with online energy/Load Management System. 100% redundancy shall be provided for communication i.e. the Relay should have minimum 2 Nos. IEC-61850 communication port in addition to Front Port. Numerical Relay shall have communication on IEC-61850 protocol in redundant mode and meters shall have communication on MODBUS protocol. Relay shall have 4 CT input for O/C and E/F protection. There should be option for derivation of E/F internally.

Relay shall meet the requirement for withstanding electromagnetic interference according to relevant parts of IEC 60255 / IEC 61850. Failure of single component within the equipment shall neither cause unwanted operation nor lead to a complete system breakdown.

The relay should support (tested for) IEC 61850 Edition 2 with parallel redundancy protocol as per IEC 62439-3 with two nos. of port and one additional port at front for local communication. Use of any type of converter is not acceptable.

7.3 The Numerical relay shall be provided with integral (no separate unit) arc flash protection system based on both current & light detection method. Relay should have provision of 3 nos. arc sensor, each for cable chamber, busbar chamber & circuit breaker chamber. Sensor shall cover any flash over occurring in the respective chambers. Facility should be there to adapt selective logic schemes for tripping only respective breaker or Incomer breaker.

7.4 The relay should support (tested for) IEC 61850 Edition 2 with parallel redundancy protocol as per IEC 62439-3 with two nos. of port and one additional port at front for local communication. Use of any type of converter is not acceptable.

7.5 Numerical relay shall indicate MWH, MVAR, MVA, V, A, Hz, PF. It shall have future provision for connecting with Switchgear Building HMI. Separate multifunction meter with communication (for centralized energy monitoring) shall be used and shall not be part of protective device.

7.6 Relays shall support features like remote relay parameterization, disturbance recorder etc. It shall be possible to set/operate the relay from the front facia. Lock out relay shall be conventional type with hand reset facility.

7.7 The Bidder shall supply licensed (lifetime) software along with required communication cables for Parameterization and viewing of disturbances, events, etc. through Laptop for all Make and models of Numerical relays. 1 No. Laptop complete (Minimum 8GB RAM, Minimum 1 TB hard Disk, latest processor) with all required software and accessories complete in all respect shall also be provided.

7.8 Special protection if required for any feeder such as differential, restricted earth fault, directional distance power relays etc. shall also be through numerical relay having serial port for monitoring.

7.9 In general, all protection shall be through microprocessor based numerical relay. However high-speed tripping relay shall be separate.

7.10 All Auto-changeover logic to be built in Numerical Relay. Numerical Relays shall have sufficient I/O to cater the same and there should be minimum 10 % spare I/O for future use. External I/O Card/ Module are not acceptable.

7.11 All Process Stop and other important Parameters shall be routed through Numerical relays for recording and Time-stamping. Hardware Annunciator is not required. Common Audio-Visual Alarm for each Bus section of Switchboard shall be provided through Numerical relays.

7.12 Bare minimum protection for power distribution system shall be as indicated below. However, The Bidder shall provide any other necessary protection required for complete protection of system:

Protection devices for power distribution system shall be as indicated below (Figure inside bracket refers to note below) (YES – Applicable)

Sl. No.	Relay Description	Relay No.	HV Tr. Fdr. Sec Wdg. Volt=> 3.3 KV	HV Tr. Fdr. Sec Wdg. Volt< 3.3 KV	HV /LV Motor Fdr., HV Breaker controlled contactor controlled	O/G Bkr. HV Plant Fdr.	O/G Bkr. MV PMCC	I/C HV	I/C MV PMCC
1.	IDMTL Over-Current Relay	51	YES	YES	-------	YES	YES	YES (2)	YES
2.	IDMTL Earth-Fault Relay	51N	YES (4)	YES	-------	YES	YES	YES (2)	YES
3.	Standby / Backup Earth Fault Relay (earthed neutral)	51G (10)	YES (22)	YES (22)	-------	-------	-------	-------	-------
4.	Motor Protection Relay with (50, 50N, 46, 49, 50L/R, 95)	99	-------	-------	YES	-------	YES	-------	-------
5.	Instantaneous Restricted Earth Fault Relay (Earthed side)	64R (10)	-------	-------	-------	-------	-------	YES (22)	YES
6.	Instantaneous Over current Relay	50	YES	YES	-------	-------	-------	-------	-------
7.	Instantaneous Earth Fault Relay	50N	YES (5)	YES	-------	-------	-------	-------	-------
8.	Differential Protection Relay	87	YES (6)	-------	YES (7)	YES	-------	YES	-------
9.	High speed tripping relay	86 (18)	YES	YES	YES	YES	YES	YES	YES
10.	Trip Circuit Supervision Relay	95	YES	YES	YES	YES	YES	YES	YES
11.	Transformer Auxiliary Relay	63	YES	YES	-------	-------	-------	-------	-------
12.	Under Voltage Relay with timer	27 / 2	-------	-------	YES	-------	-------	YES (16)	YES (16)
13.	Check Synchronisation Relay	25	-------	-------	-------	-------	-------	YES (8)	YES (8)
14.									

Notes for Relay Protection Philosophy

1. All the numerical relays shall be of communicable type and connected to ECMS on IEC 61850 (Ethernet based) communication protocol with time stamping and time synchronization.
2. In case of HV switchboards with continuous parallel operation of incomers, following additional relays shall be provided:

a. One set of 87B (Bus differential) and 95 B (Bus wire supervision) for each bus section.
b. 32 (Directional IDMTL over current and earth fault) relays for the incomers.

3. In case of grid power supply EHV incomer following additional relays shall also be provided:
   a. Relay 21 for distance protection, Relay 59 for overvoltage protection with timer, Relay 67 for directional over current protection, Relay 67N for directional earth fault protection, Relay 81 for under frequency / df/dt protection and Relay 98 as dead bus charging relay.
   b. Minimum protection relays for EHV Transformer shall be 50, 50N, 51, 51G, 51N, 63TX, 64R, 86, 87T, 87F & 95.
4. Instantaneous earth fault (50N) shall be provided only for transformer with delta primary.
5. Directional IDMTL earth fault (67N) shall be provided for transformer with star primary.
6. For transformers rated 5 MVA and above.
7. For motors rated 1500 kW and above, excluding VFD fed motors.
8. Wherever auto-transfer feature is provided.
9. For switchgears where continuous or momentary paralleling of Incomers is envisaged, check synchronizing relay shall be provided.
10. 51G and 64R relays for input transformer of VFD system shall be decided by VFD Manufacturer.
11. The bus tie feeders in HV switchboards shall be provided with 51, 51N, 86 and 95 relays.
12. HV capacitor bank feeders shall be provided with 51, 51N, 59 (over voltage), 60 (Neutral displacement), 86 and 95 relays.
13. The following feeders shall be provided with timers for delayed tripping on bus under voltage while the under-voltage relay shall be common for the bus a. HV and MV capacitor feeders.
    b. HV and MV breaker-controlled motor feeders.
    c. Contactor controlled motor feeders with DC control supply.

    Numerical relays where ever provided for motor and capacitor feeders shall use in built under voltage relay and timer for delayed tripping on bus under voltage.
14. One no. DC supply supervision relay (80) shall be provided for each incoming DC supply to the switchboard.
15. In case of numerical relays, all relays shall be comprehensive units including all protection, metering and control.
16. Under voltage and over voltage function along with associated timer shall be part of the numerical relays.
17. Auto changeover scheme control & logic between Incomers and bus coupler shall be built in the numerical relay.
18. Tripping relays (86) shall be separate relay. There shall be two nos. high speed tripping relay for motor feeder. One for electrical fault and one for process fault. Electrical fault relay shall be hand reset type and process fault relay shall be self-reset.
19. Breaker control switch shall be hardwired type.
20. Stand by earth fault relay 51G shall be provided in the incomer of switchboard fed from transformers where transformer & switchboard both are located remotely from HV Switchgear Building as well as in same HV Switchgear Building.
21. For transformers located remotely away from HV Switchgear Building, a local power isolating device in the form of breaker panel without any protection relay shall be provided before transformer. A local emergency stops push button (Lockable) shall also be provided in transformer bay for tripping remote breaker.
22. Restricted earth fault relay 64R shall be provided for transformer rating >= 1 MVA in the incomer of switchboard fed from transformers having secondary winding star connected. This shall trip the HV side breaker.
23. Relay 87 and 64R shall be separate numerical relay. Hence shall not be part of main comprehensive numerical relay. CT for 87 and 64R can be clubbed, as two cores of single CT.
24. Accuracy class of the current transformers shall be - Class PS for differential and special requirements.
    - Class 0.5 / 0.2 S for metering purpose.

- Class 5P20 for protection purpose

All the CTs shall have rated burden of minimum 15 VA and secondary rated current of 1 A.

25. Accuracy class of the potential / voltage transformers shall be - Class 5P for protection purpose.
    - Class 0.5 / 0.2 S for metering purpose.
    All the PTs shall have secondary voltage 110 V or 110 V / sqrt.3 and rated burden of minimum 50 VA per phase for both metering and protection core.
26. All the incoming, outgoing and tie breaker feeders of any HV & MV Switchboard shall be provided with numerical relays only with communication facility as protection devices. Releases shall not be acceptable in any case.
27. Numerical relays in all HV motor feeders shall be suitable for RTD / BTD inputs.
28. Each bus section shall be provided with separate under voltage relays.
29. Multifunction meter shall be provided to keep a record of power consumption and supervision of all concerned parameters like current, voltage, power, frequency, power factor etc. as specified. All the metering instruments shall be flush mounted.
30. Separate Communicable Digital Multifunctional meters shall be provided in all feeders with Numerical Relays for communication with ECMS system.
31. Motors shall also be provided with Unbalanced (-Ve) Sequence Protection Relay (46), as required.
32. Numerical under voltage relays (27) with time delay relay including VT fuse failure relay shall be provided for Bus VTs.
33. All Motor feeders of PMCC & MCC (irrespective of Rating) shall have door mounted communicable (Modbus / Profibus) type Motor Protection relay (MPR) with display.
34. No Meters, transducers or measuring equipment's to be installed in the Protection CT circuit.
35. Cable Differential relays for both the end to be supplied by Downstream user contractor i.e. The Bidder. Cable Differential relay will be of Fiber Optic Cable based communication only.
36. All required Alarms and Trips shall be incorporated in the Numerical relays. Sufficient LED shall be available in the Relays.
37. Trip Circuit Supervision relay shall be part of Numerical relay.
38. CBCT and Earth fault relay should be for HT Motor and transformer feeder only. For LT motor feeder this will not be required.
39. Capacitor Feeder: 59, 27,50, 51, 50N, 51N, 60, CBFP etc.
40. Main HV (33KV/11KV/ 3.3KV) Incoming Panel in each Switchgear Building shall be provided with line differential protection between sending end and receiving end.
41. All accessories and connecting equipment required for FO cable connection shall be provided in switch board.
42. Ethernet Switch in cubicle of both buses shall be provided and all relays shall be connected to Ethernet Switch.

7.13 Metering instruments shall be provided to keep record of power consumption and supervision of all concerned parameters like current, voltage, power (Active, Apparent and Reactive), frequency, power factor, Energy (Active & Reactive) etc. All the instruments shall be flush mounted. All meters shall be digital multifunctional meters with communication port for Load management at remote location. Additionally, digital type ammeter, voltmeter and Hour Meter shall be provided separately for various feeders as indicated below:

The metering devices in HV and MV switchboards shall be as below:

- Type of metering: Analogue/As part of the Numerical relay

(Figure inside bracket refers to note below) (YES - Applicable)

Sl. No.	Feeder type	A	V	Hz	PF	MW	MWH	HM	MVAR	MVAH	MVA
1.	HV Incomer	YES	YES	YES	YES	YES	YES	----	YES	YES	YES (1)

2.	HV Bus Tie	YES	----	----	----	----	----	----	----	----	----
3.	HV Transformer	YES	----	----	----	YES	YES	----	----	----	----
4.	HV Bus PT	----	YES	----	----	----	----	----	----	----	----
5.	HV Plant Feeder	YES	----	----	----	----	YES	----	----	----	----
6.	HV Motor	YES	----	----	----	----	YES (kWh)	YES	----	----	----
7.	HV Capacitor	YES	YES	----	----	----	----	----	YES	----	----
8.	PMCC Incomer	YES	YES	----	YES	----	YES (kWh)	----	----	----	----
9.	PMCC Bus Tie	YES	----	----	----	----	----	----	----	----	----
10.	PMCC Bus PT	----	YES	----	----	----	----	----	----	----	----
11.	ACB Outgoing (Non-Motor)	YES	----	----	----	----	YES (kWh)	----	----	----	----
12.	MV Motor (>55 KW)	YES	----	----	----	----	----	----	----	----	----
13.	MCC / ASB Incomer	YES	YES	----	----	----	----	----	----	----	----
14.	MCCB O/G (250A and above)	YES	----	----	----	----	YES (kWh)	----	----	----	----
15.	MLDB Incomer	YES	YES	----	----	----	YES (kWh)	----	----	----	----

Notes for Metering: -

1. MVA meter in external power supply incomers shall include maximum demand indication also.
2. Separate analogue type voltmeters with voltmeter selector switch and analogue type ammeters with ammeter selector switch shall be provided for incomers of all switchboards.
3. Ammeter (size 48mm x 48mm) shall be provided in space heater circuit of breaker fed HV & MV motors.
4. Apart from metering which shall be part of the numerical relays, Communicable digital multi-function meters of Accuracy Class 0.5 / 0.2(for Incomers only with suitable Metering CT shall be provided in all the breaker feeders of HV & MV Switchboard i.e. in incomers, bus coupler, outgoing plant feeders, transformer feeders, motor feeders, capacitor bank feeders, etc.
5. Multi-function meters with serial communication over RS-485 or fiber optic cable, preferably with IEC protocol shall be provided in all the breaker feeders.
6. Power factor meter shall be provided for synchronous motors in addition to the metering provided for induction motors.
7. For current feedback to DCS/PLC and VFD feeders motor current transducers shall be provided and mounted in switchgear panel.
8. CT operated Ammeter for all motor feeders above 5.5 KW, all MOV and LOPs shall be provided at both LCS and feeder end of switchboard.
9. All ammeters for LV motors shall be connected through CT. Only HV motors shall have 3 ammeters or ammeter selector switch or Voltmeter and Voltmeter Selector Switch.
10. Hour run meter shall be provided in all breaker-controlled motor feeder.

8.0 CONTROL AND MONITORING

The following provision shall be made for control and monitoring of following electrical equipment's.

8.1 Transformers

- TNC switch in primary & secondary side of switchgear.
- Emergency trip from secondary side for tripping primary side of transformer.
- VCB with all required protection to be considered in all the 11kV & 3.3kV switchboards.
- Lockable 'OFF' push button in transformer room to trip sending end switchgear.
- Indication lamp for 'ON' 'OFF' 'Auto-trip, 'Non-trip' and 'Trip Circuit Healthy', 'Ready to Close', 'Ready for Service', 'Test', 'Service', 'Space Heater ON'.
- Ammeter and voltmeter on both primary and secondary side.
- Load break switch with Earthing Switch on transformer primary side (only where primary side circuit breaker is not located in the same sub-station).

8.2 Motors Controlled Through Circuit Breakers

- TNC switch, L/R Switch with Ammeter on LCS
- Current monitoring at DCS/PLC through Dual Channel Current Transducer with Display facility installed at switchgear end, where required from process point of view.
- Indication Lamps in switchgear for 'ON', 'OFF', 'Auto-trip' and 'Trip Circuit Healthy', 'Ready to Start', 'Ready for Service', 'Test', 'Service', 'Space Heater ON, 'Space Heater ON for Motors' Emergency trip in switchgear.
- Winding and bearing temperatures of motors shall be available at DCS in control room.
- Process interlock in CCR, where required.
- Control and Feedback for Motor Start & Stop command, Trip Indication, ON Indication, OFF Indication, Local / Remote Indication and Ready to Start Indication in remote (DCS/PLC etc.)
- Motors controlled through Circuit breakers should also be provided with ammeter, KVAh, KWH and running hour counter. Theses shall be incorporated in Numerical relay Or Multifunction Meter.

8.3 Medium Voltage Motors Controlled Through Contactors

- Start & Stop Push Button (Mushroom Stay Put Type) with Ammeter, Local/Remote switch on LCS.
- Current monitoring in DCS, where required from process point of view.
- Emergency Trip in PMCC/MCC.
- Process interlock in CCR, where required shall be wired through separate auxiliary relay.
- Indication lamp for 'ON', 'OFF', 'Ready to Start' and 'Fault' in switchgear.
- Control and Feedback for Motor Start & Stop command, Trip Indication, ON Indication, OFF Indication, Local / Remote Indication and Ready to Start Indication in remote (DCS/PLC etc.) Motor space heater & Panel board space heater shall be provided with Ammeter & LED in Switchgear.
- All Motor feeders of PMCC & MCC (irrespective of Rating) shall have door mounted communicable (Modbus / Profibus) type Motor Protection relay (MPR) with Earth fault protection and display.

9.0 EQUIPMENT SPECIFICATION

9.1 General Features

9.1.1 The equipment shall be suitable for tropical climate conditions and corrosive and saline atmosphere.

All electrical equipment accessories and wiring shall have fungus protection involving special treatment of insulation and metal against fungus, insects and corrosion.

Fine mesh screen of corrosion resistant material, preferably SS shall be furnish on all ventilating openings to prevent entry of insects.

9.1.2 The equipment to be installed in indoor plant area shall be enclosed in dust, damp and vermin proof enclosure equivalent to IP 54 as per relevant Indian Standards/IEC.

9.1.3 The equipment including motors to be installed in outdoor plant area shall have IP 55 enclosure.

9.1.4 4 mm FRP (fire retardant and UV stabilized) canopies shall be provided for all outdoor equipment's like motors, starters, LCS, SDBs, sw. sockets etc.

9.1.5 All the water plants being highly corrosive - Cable tray, LCS, Junction boxes, Lighting JB and Lighting poles in plant area shall be strictly of FRP with SS fasteners only to avoid corrosion

9.1.6 All switchboards shall be of dust-proof and vermin-proof construction and shall be provided with a degree of protection of IP: 5X as per IS/IEC 60947. However, the busbar chambers having a degree of protection of IP: 42 are also acceptable where continuous busbar rating is 1600A and above. Provision shall be made in all compartments for providing IP: 5X degree of protection, when circuit - breaker or module trolley has been removed. Equipment requiring ventilation opening such as battery charger/UPS etc. located in air conditioning room may have IP 43 enclosure however, opening for the ventilation shall be covered with fine wire mesh.

9.1.7 Creepage distance shall be 31mm/kV (for highest system voltage) for all equipment.

9.1.8 All the electrical equipment shall be provided with rolled aluminium/stainless steel heavy duty double compression type cable glands and crimping lugs for the cable terminations

9.1.9 The outside surface of all equipment shall be painted after suitable pre-treatment by the application of two coats of anti-rust and corrosion resisting epoxy based paints.

9.1.10 All similar equipment (viz. HV Switchboard, LV Switchboard – PCC, PMCC, MCC, EPMCC, ASB, LDB, DCDB, Transformers, Numerical relays, UPS, Battery Chargers, Motors, etc.) supplied against a package should be of single Make only – for ease of O&M and spare management.

9.2 Power Transformers

9.2.1 The transformers shall be double wound, copper conductor, and Dyn11 type. Transformers shall rated for 11/3.45 kV, 11/0.433 kV, 3.3/0.433 kV, as required. Transformer with 3.45 KV Secondary winding shall be considered for the Switchgear Building only, where 3.3 KV switchboard is to be installed for feeding 3.3 KV motors.

9.2.2 The rating of power transformers shall be selected on the basis of load and future load growth. For future load growth the following provision shall be made: -
For HV transformer 10% design margin on continuous loads to be considered and for LV transformer 10% design margin on continuous loads to be considered. .

9.2.3 The rating of power transformers shall be selected keeping following into considerations:

(a) Duty : Continuous

(b) Outdoor type : ONAN/ONAF (ONAN rating shall have 25% spare capacity above continuous peak load. ONAF rating shall be minimum 15% above ONAN rating).

(c) Indoor type : Dry Type
Epoxy cast resin/ resin encapsulated type

(d) Maximum loading : 80% when one of the transformers is out of service

(e) Peak efficiency at : 35% - 40% of load

(f) Class of Insulation : B or better for oil filled
: F or better for dry type

9.2.4 Maximum temperature rise over ambient of 50 Degree Celsius shall be limited to:

(a) Outdoor transformers:

Top oil (measured by thermometer) : 50 ^{0} C

Winding (measured by resistance) : 55 ^{0} C

(b) Indoor transformers:

Winding (by resistance method) : 90 ^{0} C or lower as permissible for class of insulation offered

9.2.5 Special consideration shall be given in specifying the percentage impedance of the transformers to suit the switchgear short-circuit capacity available.

9.2.6 Transformers generally up to 10 MVA shall have ONAN cooling, while ratings above 10 MVA shall be ONAN/ONAF cooled. Bare minimum protection devices for transformer have been as indicated below; however, The Bidder shall provide any other necessary protection relays required for complete protection of system.

Primary Side.

IDMTL Over Current, IDMTL Earth Fault, High Set Over Current, Instantaneous Earth Fault, Standby Earth Fault, Restricted Earth Fault , Differential (for sizes of 5 MVA and above), *Buchholz Alarm and Trip,*Winding Temperature Alarm,* Trip, *Oil Temperature Alarm, *Oil Level Alarm & Trip, *Trip for Winding Temperature and Oil Temperature. All protection except REF shall be provided on secondary side, if the primary side circuit breaker is located in other sub-station. REF protection shall trip the primary Inter-tripping of primary and secondary circuit breaker of transformer shall be provided for all faults through lockout relays.

CT for Restricted Earth Fault protection shall be provided inside the transformer.

9.2.7 High Velocity Water Spray (HVWS) System shall be provided for transformers fire protection having oil capacity more than 2000 Liters and rating up to 20MVA.

9.2.8 Following Push buttons shall be provided for transformers:

- Lockable ‘OFF’ push button in transformer room to trip the breakers on primary side.
- Push button shall be provided on breaker on secondary side for permission to close breaker on primary side
- Emergency trip PB on breaker on secondary side for tripping breaker on primary side of transformer.

9.2.9 The instruments such as OTI/WTI, Buchholz relay and MOG shall have Magnetic Reed Switches. The mercury switch contacts are not acceptable.

9.2.10 For all transformers, conservators shall be provided with Magnetic Oil Gauge (MOG) having 1NO contact activated on Low oil level. For transformers above 2000KVA , Air cell shall be provided in the conservator.

9.2.11 Power transformer and other oil filled transformer shall be kept in open. Only dry type transformer shall have roof slab/room

9.2.12 Routine test on all transformers and heat run test on one transformer of each rating shall be performed in presence of Owner/Consultant.

9.2.13 All Routine, Heat Run Tests shall be performed in compliance with B.S.171, IEC publication No.60076, IS 2026 (parts I to V), CBIP and IS: 2026 (Part III) including SFRA Test before

dispatch from Manufacturer's works and at erection site during commissioning or latest editions or any other authoritative standard. Certificates for Type Tests on similar type Transformers shall be submitted.

9.2.14 All Power transformers above 5 MVA shall have facility for Remote display (in ECMS) of Oil Temperature, Winding temperature, Conservator Oil Level and moisture ppm of Oil through 420 mA signal / Modbus communication.

9.2.15 Transformers shall be Energy Efficiency Level 2.

9.2.16 For all other specification refer PC288-TS-0803.

9.3 Neutral Earthing Resistor (NER)

9.3.1 The NER shall be provided to earth the neutral of 11 kV and 3.3 kV systems. Neutral of 415V supply system shall be solidly earthed.

9.3.2 Neutral earthing resistor shall be outdoor type made of AISI 304/406 punched stainless steel grid element. The earth fault current of 11 kV & 3.3 kV shall be limited to full load current of transformer or 400 A, whichever is less.

9.3.3 All NER not requiring operation shall be provided with isolator.

9.3.4 For all other specification refer PC288-TS-0804.

9.4 Switchboards

9.4.1 General

9.4.1.1. There shall be three positions for Breaker/Contactor trolley: - Service, Test and Isolate. In service position, the power connections shall be made; but in test and isolate mode, the power connection of bus bars shall be automatically removed.

ACB feeder for PCC, PMCC & MCC shall be single front for ease of operation & maintenance. Non-ACB feeders for motors or power may be double front type.

Breaker duty cycle shall be O-0.3sec-CO-3min-CO.

Separate CT shall be provided for differential/REF protection.

LV circuit breaker shall be 4 Pole type except for outgoing motor feeders which shall be 3 Pole type.

9.4.1.2. Suitable shutter arrangement shall be provided to protect the person from accidental contact with live bus in trolley chamber.

9.4.1.3. Ethernet switch with 10% spare ports on each bus of each switch board & all internal wiring up to Ethernet switch shall be provided in each switch board.

9.4.1.4. It shall be compatible with connection to Plant LMS/ECMS system.

9.4.1.5. All switchboards shall be of dust-proof and vermin-proof construction and shall be provided with a degree of protection of IP: 5X as per IS/IEC 60947. However, the busbar chambers having a degree of protection of IP: 42 are also acceptable where continuous busbar rating is 1600A and above. Provision shall be made in all compartments for providing IP: 5X degree of protection, when circuit - breaker or module trolley has been removed

9.4.1.6. All HV, MV & LV Switchboards shall be LOTO compliance.

9.4.1.6.1. 11 kV & 3.3 kV Switchboard shall conform to IS/IEC 62271-200, IAC-A FLR-50KA/40KA 1 Sec, PM, LSC 2B which means that the switchgear panels shall be four side internal arc tested, shall have metal partitions and shall confirm to loss of service continuity. LV switchboard shall conform to IEC 60947. All 3 compartments (Busbars, Circuit breaker & Cable compartment) shall be tested for Internal arc for the said rating.

9.4.1.6.2. The observation window on the CB compartment door shall be made of special toughened/ laminated glass substantiated in type test reports as proving it arc proof. Observation window shall be of same material and construction as the type tested design/construction as specified in IEC.

9.4.1.6.3. Each cubicle shall be equipped with anti-condensation heater controlled by thermostat.

9.4.1.6.7. Each HV compartment should have individual exhaust channel / pressure relief flaps to let out over-pressurized hot gases at the top of the switchboard in case of an internal fault.

Suitable factory fitted arc duct arrangement shall be provided for vending out the arc out of the switchgear room.

9.4.1.7. Front access doors with single action operator will be provided to the HV circuit breaker compartment and LT Relay compartment. Bolted type CB door locking arrangement shall not be accepted.

9.4.1.8. The switchgear shall have integral making type earth switch with proper Mechanical & Electrical interlock. .

9.4.1.9. An electro-mechanical device shall be provided to ensure the auxiliary circuits have been securely connected between the fixed and moving portions of the switchgear, before allowing closing operation of the circuit breaker. The voltage rating of the device shall be the same as the voltage used for the closing circuit.

9.4.1.10. Tripping and closing coils shall be of continuous rated type to ensure longer life. All Feeders of 11 KV shall have Double Trip coil for safety.

9.4.1.11. Circuit breakers shall be provided with a mechanically operated visual indicating device to display the circuit breaker switching state and a mechanical operation counter.

9.4.1.12. The circuit breaker operations of closing and opening shall be possible with the circuit breaker compartment door closed.

9.4.1.13. It shall be possible to trip the circuit breaker locally by mechanical means. Voltage Transformer (VT) shall be cast-resin with built-in primary fuses, VT's shall be draw out type.

9.4.1.14. Voltage transformer shall be independent of circuit breaker carriage

9.4.1.15. Electrical interlocks and castle key interlocks shall be provided between Bus-bar Earthing Switches and all Bus-bar Isolators of each Bus-bar Section in such a way that Bus-bar Earthing Switches cannot be closed when the Bus-bar Isolator of any circuit in the section is closed.

9.4.1.16. Bus VT Miniature Circuit Breaker (MCB) ON auxiliary contacts and under voltage relay contacts shall be monitored in the interlocking scheme to confirm the dead bus condition.

9.4.1.17. All CT & PT must be suitable for continuous operation of min. 20 % overload and for service under all rated and fault conditions.

9.4.1.18. Current transformers shall be in accordance with IEC 61869-1 & 61869-2. The rated output shall match the requirements of the equipment connected. The secondary current rating shall be 1 A, unless otherwise specified, cores for measuring instruments shall have accuracy classes of not more than 0.5 % and saturation factors less than 5.

9.4.1.19. Secondary terminals of current transformers shall be wired up to a terminal block with shortcircuiting links, located at an accessible place. At this terminal block one side of each transformer shall be connected to earth.

9.4.1.20. The CT rating plate and the terminals must be accessible after the Power cables have been installed.

9.4.1.21. LV switchboard (EPMCC/PMCC/MCC) shall be TOTAL TYPE TESTED (TTA) design as per IEC 61439-1/2. Type Test Certificates for short circuit withstand of 50kA for 1 sec along with ACB mounted in the Switchboards shall be provided.

9.4.1.22. LV switchboard (PMCC/EPMCC/MCC) shall comply with Internal Arc Containment test as per IEC 61641.

9.4.1.23. The busbars and connection shall be made of electrolytic grade copper / Aluminium.All busbars of 11kV & 3.3kV switchgear including bus duct shall have Raychem sleeving suitable for Line to line voltage. Proper shroud to be provided in the joints.

9.4.1.24. Tripping and closing coils shall be of continuous rating type.

9.4.1.25. Clearance between gland plate to cable termination point in all switchboards shall be adequate but not less than 300mm to ensure proper cable termination.

9.4.1.26. FRP supports shall be used for bus bars with adequate clearances and creepage distance to prevent flash over due to effect of dust moisture.

9.4.1.27. Protective relays shall be mounted on the front of the switchgear panel.

9.4.1.28. All logic like, Auto/Manual changeover etc. shall be built-in the Numerical relay. Adequate number of I/Os shall be provided to meet the requirement. 10% spare I/Os shall also be provided. External I/O Card/ Module are not acceptable.

9.4.1.29. All relays used for protection shall be microprocessor based numerical type only with latest communication protocol IEC-61850 and shall have large graphical display. All relays shall have coating for protection against harsh environment conditions. All numerical relays shall be of one make only. Selected models of numerical relays shall have metering, control, status and protective functions. It shall be possible to save minimum 5 records of each event. Important functions and features, in addition to the fault measuring capabilities, shall include:

- Programmable scheme logic,
- Remote communication interface for setting / interrogation from ECMS,
- Local communication interface (HMI-keypad and / or serial PC communication),
- Time-tagged events, fault and disturbance records,
- Display of measured/processed quantities,
- Self-monitoring (Hardware / Software),
- Inter-protection communication,
- Electronic transducer communication

9.4.1.30. All protection relays shall be provided with test plugs and all CT, VT wiring shall be wired through the test plugs in HV, MV & LV Switchboards.

9.4.1.31. The protection scheme(s) shall include all hardware and software to permit remote setting / interrogation / fault evaluation from the ECMS (engineering) workstation or from the computer monitoring system.

9.4.1.32. All protection relays shall be equipped with communication port using IEC protocols to work as an integrated part of the ECMS hierarchy. Should the relay schemes be offered from multiple Bidders / Contractors, all third-party user interface software products shall be supplied to the ECMS platform to bring together all types of protective relaying into a unified control system hierarchy.

9.4.1.33. Completely separate and isolated circuits shall be used for Switchgear control, tripping / protection, alarms, and auxiliary devices. These circuits shall have separate control power buses and feeders, suitably protected, for each power bus section.

9.4.1.34. Each control circuit shall be protected by a two-pole miniature circuit breaker with auxiliary N/C contact. The auxiliary contacts of all MCB's of the same circuit type, e.g. circuit breaker motor control, disconnector switch motor control, alarm, space heater, trip, etc., shall be wired in series to a group / common alarm terminal.

9.4.1.35. Each 11kV & 3.3kV outgoing/incoming and transformer feeder control panel shall include voltage detectors to indicate phases "ALIVE". The voltage detectors shall be connected to each phase on the cable side.

9.4.1.36. The Bidder shall supply minimum 1 No. laptops with licensed software for communication & configuration of all make & Type of Numerical Relays.

9.4.1.37. GPS system and associated hardware & software shall be provided for synchronisation of clocks of numerical relay and metering LA & ECMS

9.4.1.38. All meters shall be digital multifunctional meters with backlight LCD display and communication port. Additionally, digital type ammeter, voltmeter and Hour Meter shall be provided separately for various feeders as indicated above.

9.4.1.39. All the motor / capacitor feeders controlled through vacuum circuit breakers shall be provided with surge arrestors. Lightning Arrestor (LA) shall be provided on each bus of 11KV Switchboard.

9.4.1.40. A continuous ground bus shall be provided at the bottom of the switchgear and in cable connection side for grounding the switchgear, breaker trolley as well as to ground the cable glands.

9.4.1.41. Control supply bus and space heater supply bus-bars (Copper) of adequate rating shall be provided throughout the length of switchboards with as many sections as sections in power bus-bars.

9.4.1.42. Control supply shall be tapped from control bus in each cubicle/ panel itself through DP MCB of suitable rating.

9.4.1.43. The minimum thickness of sheet steel used in HV and LV switchgear including charger, UPS, ASPB etc. shall be as under: -

- Base Channel minimum 2.0 mm
- Load Bearing Members minimum 2.0 mm
- Doors and covers minimum 1.6 mm

9.4.1.44. A bottom channel of not less than 75 mm shall be provided.

9.4.1.45. The maximum height of the switchboard and other control panels shall be limited to 2400MM. Maximum height of component requiring operation shall be limited to 1800MM .

9.4.1.46. The switchboards shall have adequate short-circuit ratings and be suitably sized for the load and spare capacity foreseen. The short time rating of bus bar shall be 3 seconds for HV switch boards and 1 second for other boards.

9.4.1.47. The HV switch boards and power control centres shall normally have four spare circuit breaker panel (size shall be as per largest outgoing feeder breaker), two on each side of bus-section.

9.4.1.48. For other boards (PMCCs, MCCs, MLDBs, ASPBs, DCDBs etc.) sufficient number of spare feeders to the extent of min. 20% for each type & rating shall be provided.

9.4.1.49. The 415V switch boards shall have PVC insulated bus bar system suitable for rated voltage. At joints of these bus bars removable shrouds shall be provided.

9.4.1.50. All HV & LV Switchgear, UPS, Battery Charger etc. shall have Ethernet/Network Switches and other communication equipment's.

9.4.1.51. For interfacing with DCS system, separate marshalling panels (with 20% spare terminals) shall be provided on each bus section in all HV & MV switchboards in the same panel lineup. The marshalling panels shall be of full height same as that of switchboards. The horizontal bus bar chamber at the top shall be continuous through this marshalling panel also, for future extension of the MV switchboard. All critical control signals for DCS interface shall be hardwired between Switchgear Buildings and DCS. Other non-critical data of Electrical system will be sent to DCS with redundant communication facility between DCS and ECMS.

Hardwired signals (with minimum requirement specified below) from various Motor feeders of a bus section for DCS interface shall be wired and terminated in the marshalling cabinet:

- DCS Start permissive
- Process Start command (Auto)
- Remote Start command (Manual)
- Process Stop command
- Process Trip command (for breaker-controlled motor feeder)
- Breaker/Contactor 'ON' indication
- Breaker/Contactor 'OFF' indication
- Ready to Start indication
- Electrical Fault Trip indication

9.4.1.52. Following monitoring signals, as a minimum, shall be taken from Switchgear Building to DCS interface, through redundant MODBUS SERIAL LINK communication from ECMS system.

- Load Data viz. KW, PF, A, etc.
- L/R indication
- Process Trip indication
- Electrical Fault Trip indication
- Trip Details

9.4.1.53. Auto changeover scheme shall be provided for incomers and bus couplers on all 11 KV switch boards, 3.3 KV switch boards and PMCCs/PCCs/ MCCs. Under normal operating conditions, incomer-1 and incomer-2 breakers would be closed and bus coupler breaker would remain open with 'auto-manual' switch in 'auto' position. The bus coupler switch would close automatically under the following condition being fulfilled: -

i. Either of the incoming breaker trips due to under voltage (70% or below).

ii. Voltage on the healthy bus is more than 80% for the set period. iii. Residual

voltage on the bus with no power supply comes down to 30%.

iv. Auto change over shall be locked on loss of power on both the incomers.

Auto changeover shall also be provided on switchboards catering to emergency loads.

9.4.1.54. Paralleling of two incoming feeders is not foreseen. However, facility for momentary paralleling shall be provided for intentional changeover without interruption of supply.

9.4.1.55. Every enclosure door that provides access to live parts operating at 240 V AC and above shall be mechanically interlocked with a circuit interrupting device on the supply side such that when the door is open, the equipment is de energised.

9.4.1.56. Separate redundant AC and DC control supply shall be provided for each Switchboard.

9.4.1.57. Control supply for motor feeders having MCCB in PMCC/MCC/ASPB etc. and VFD panels etc. shall be feed from 240V UPS (Electrical) and motor controlled with breaker shall have 220 V DC control supply irrespective of its being HV or LV.

9.4.1.58. For motors with auto-starting provision, trip of a running motor shall start standby motor automatically.

9.4.1.59. All the HV/LV switchgear shall be fed through two separate transformers, each transformer having capability to take care of 100% load of the associated switchgear and shall have the facility of auto changeover in case of failure of one transformer as well as option of manual changeover for maintenance purpose.

9.4.1.60. Max. 3 runs of 400 sq.mm power HV cable shall be terminated in single panel. For more than 3 runs of cable complete dummy/adaptor panel shall be provided.

9.4.1.61. The CB ON and OFF lamp shall be provided at rear and front side of 11kV/3.3kV switchboards.

9.4.1.62. All breakers service ON/OFF contact multiplier contactors shall be mechanically latched type and independent of control supply. Loss of supply and restoring the supply shall not affect the status of the relay/ contactor.

9.4.1.63. All breakers shall be electrically operable and mechanical operation from the breaker shall be possible locally. Manual breakers are not acceptable.

9.4.1.64. Separate Ammeter shall be provided for panel and motor feeder Space heater circuit for each panel.

9.4.1.65. The terminal strips used shall be of stud and nut type and control wiring shall be done with ring tong lugs only.

9.4.1.66. Dual channel output with display type current transducer for all HV and LV switchboard feeder shall be provided requiring Ammeter at control panel.

9.4.1.67. CBCT and Earth fault relay should be for HT Motor and transformer feeder only. For LT motor feeder this will not be required.

9.4.1.68. All external hardware shall be of stainless steel only.

9.4.1.69. The control compartment and power compartment shall be separate.

9.4.1.70. Following Set of accessories as detailed below shall be provided for each 11kV/3.3 kV Switchboard:

a) Breaker handling trolley – 2 Nos.

Following Set of accessories as listed below shall be provided for each 415 V Switchboard:

a) Breaker lifting and handling trolley: Minimum 2 nos.
b) Test cabinet with coupling cables for testing the breaker in draw out position: Minimum 1 No.
c) Racking in/out handle for breakers: Minimum 4 nos.
d) Racking in/out handle for draw out MCC modules: Minimum 2 for each MCC

9.4.1.71. Alarm relays with reverse flag shall be provided to annunciate failure of main incoming A.C. and D.C. power supplies and annunciation D.C. supply in each panel. Lamp indications shall be provided individually for main D.C. supply-1 fail, main D.C. supply-2 fail, and panel annunciation D.C. supply fail. A common A.C. electric bell shall be provided to give an audible alarm in case of failure of D.C. supply-1/D.C. supply-2/annunciation D.C. supply in any panel. A common push-button shall also be provided for cancellation of lamp indications and audible alarm.

9.4.1.72. Gland plate for single core cables shall be non-magnetic.

9.4.1.73. For all other specifications, refer PC288-TS-0805, PC288-TS-0806, PC288-TS- 0808 and PC288-TS-0809.

9.4.1.74. Separate panel shall be considered for incomer Line PT & Bus PT (11 kV & 3.3 kV Switchboards) and PT shall be draw out type. 4 pole MCB shall be provided on LV side of Bus & Line PT.

9.4.1.75. Inspection window shall be provided for HV termination in the switchboard for carrying out thermography, provided internal arc test certificates for this design is available with the bidder.

9.4.1.76. All Incomers and bus couplers shall be provided with synchronising facility. Synchro check relay shall be provided in each bus PT & contacts shall be multiplied and wired in each outgoing feeders of each bus section.

9.4.1.77. All 11kV, 3.3. kV and 415 V Switchboards shall preferably be of same make for ease of operation & maintenance.

9.4.1.78. Supervision of installation, testing and commissioning including testing of Relays of all switchboards shall be done through OEM only.

9.4.1.79. All Cable Differential Relays shall be FO Cable type only. Supply & termination of the FO cable & associated HDPE duct, as required, for feeder differential protection shall be included The Bidder's scope.

9.4.1.80. All Numerical Relays shall be of same Make and Model (series).

9.4.1.81. 11kV & 3.3kV Circuit Breaker shall have integrated earth Switch with proper Mechanical & Electrical Interlocks& Electrical Interlocks.

9.4.1.82. 11kV & 3.3kV Breaker rack in rack out facility should be operable only when breaker panel door is closed position.

9.4.1.83. LV Switchgear design shall be such that the feeder doors should not open in locked out tagged out condition.

9.4.2 DELETED

9.4.3 DELETED

9.4.4 Low Voltage Switchgears

9.4.4.1 415 V switchboards shall include the following:

a) Power Control Centres (PCCs)

b) Power-cum-Motor Control Centres (PMCCs)

c) Motor Control Centres (MCCs)

d) Main Lighting Distribution Boards (MLDBs)

e) Auxiliary Services Power Boards (ASPBs)

9.4.4.2 Low voltage switchboards shall be metal clad, arranged with self-supporting units and assembled together in a row.

9.4.4.3 Internal physical separation / segregation of 415 V Switchboards shall be 3 B for Non-ACB feeders and 4 B for ACB feeders.

9.4.4.4 The switchboards shall be suitable for extension at both the ends.

9.4.4.5 Bus bars shall be of uniform cross section and supported on non-hydroscopic FRP insulators with adequate clearances and creepage distance to prevent flash over due to effect of dust/moisture.

9.4.4.6 The horizontal busbars as well as vertical droppers of LV switchboards shall have heat shrinkable insulated sleeves.

9.4.4.7 Sufficient bus supports shall be given to give adequate mechanical strength during short circuits.

9.4.4.8 A continuous ground bus shall be provided at the bottom in the PCC/PMCC/MCC for grounding the PCC/PMCC/MCC.

9.4.4.9 Rated short circuit breaking capacity shall be 50 KA for 1 sec.

9.4.4.10 The PCC, PMCC, EPMCC MCC and auxiliary services power board shall be provided with withdraw able air circuit breakers for incoming feeders and bus ties. Main lighting distribution board shall have MCCB as incomer and outgoing Feeders with fixed type.

9.4.4.11 All feeders of 415 V switchboards shall be provided with MCCB except feeder rated more than 400A, for which ACB shall be provided. All outgoing feeders shall be draw-out type in all the switchboards.

9.4.4.12 All ACBs shall be electrically operated- EDO type only. Manual breakers are not acceptable. Each electrically operated breaker shall be provided with antipumping (94), Breaker fail (52BF) and trip free feature, trip annunciation (30) and lockout (86) relays. Lockout relay shall be hand reset type.

9.4.4.13 All ACBs shall be without any internal releases. The required protections shall be wired by means of external numerical relays.

9.4.4.14 Motor feeders below 75 KW rating shall be contactor controlled and 75 KW & above, these shall be ACB controlled with combined motor protection relay. All other feeders of 415 V switchboards shall be provided with MCCB except feeder rated more than 400A, for which ACB shall be provided. All outgoing feeders shall be draw-out type in all the switchboards.

9.4.4.15 Switchboards shall be provided with thermostatically controlled anti-condensation heaters.

9.4.4.16 All units in the MCC shall be completely accessible and removable from front. Both power and control connections shall be stab-in type.

9.4.4.17 Bus bar clearances shall conform to relevant Indian Standard/IEC for equipment voltages up to and including 500 V AC.

9.4.4.18 The switchboards shall be compartmentalized and individual feeder modules shall be draw-out type. Fixed type modules shall not be acceptable.

9.4.4.19 The draw out modules shall be standardized and it shall be possible to interchange any module with a module of same size. The components to control the equipment like MCCB, starter, auxiliary relay etc. shall be wired as a unit on the individual module. Safety shutter shall be provided to prevent direct access to live parts when the chassis is removed.

9.4.4.20 The entire draw out construction should be designed for safe operation during placement or removal of chassis. An earthing arrangement shall be provided which will make contact first before the power contacts are made and break last. Each module shall control one motor in general.

9.4.4.21 The door shall be interlocked so that it cannot be opened unless the isolating switch on that module is OFF. However, it shall be provided with a door defect mechanism for intentional opening when on line for testing and inspection purpose.

9.4.4.22 Control switches for breaker control shall be provided in each breaker cubicle. Circuit breaker shall be interlocked to prevent withdrawal of a closed breaker or insertion of a closed breaker. Each breaker shall be provided with anti pumping device.

9.4.4.23 Provisions shall be made to manually close/trip circuit breakers on loss of control voltage.

9.4.4.24 LV motor and power feeder above 100A shall have CBCT and Digital earth leakage relay.

9.4.4.25 All external hardware shall be of stainless steel only.

9.4.4.26 The control compartment and power compartment shall be separate.

9.4.4.27 Breaker control supply shall be 220V DC.

9.4.4.28 All low voltage switchboards shall be provided with 20% spare outgoing feeders or minimum 1 No. of each rating & type (fully wired) and with all the components.

9.4.4.29 The timers shall be electronic type only. Pneumatic or synchronous type timers are not acceptable.

9.4.4.30 Each outgoing motor feeder shall consist of a number of components mounted in a module duly wired. In general, outgoing feeder rated below 75 KW shall consist of: a) MCCB.

b) Control supply ON/Off switch and fuse

c) Power Contactor

d) Electronic Digital Motor Protection Relay with built-in Earth Fault, Overload, Stalling, Single phase protection, etc. Thermal Overload Relay is not acceptable. e) C.T for metering

f) Overload reset button.

g) Process Trip / ON / OFF indicating lamp with separate indicator fuse.

h) Auxiliary contactors for multiplication / control.

i) Test position limit switch and test PB

j) CT operated Ammeter for all motor feeders above1.5 KW, all MOV and LOPs at both LCS and Feeder end.

k) Selector switches as per requirement.

9.4.4.31 Following potential free contact shall be available for each Motor feeders for indication in ECMS in addition to process requirement:

- Motor ON
- Motor OFF
- Ready to Start
- Motor Process Trip
- Motor Elect Trip

9.4.4.32 Provision for indication of minimum following electrical parameters in 415V PCC / PMCC/ MCC shall be made:

a) ON OFF, TRIP, TRIP CIRCUIT HEALTHY, TEST, SERVICE Position, indication in ACB feeders.

b) The KWH meters on incomers shall have provisions for sealing for tariff purpose, as required.

c) MCC shall conform to the following as a minimum:

- Motor starters rated for utilisation category AC3 and protection equipment with a minimum of type 2 co-ordination.
- The number of modules per tier shall not exceed 6.
- MCC incomer sizes and configurations rationalised to minimise spares holdings.

9.4.5 Auxiliary Supply Power Board

The ASPB shall generally be single front, floor mounted draw out type having essential and non-essential bus. Non-essential bus shall be disconnected in case of failure of normal supply through a contactor. Switchgear Building station shall have ASPB. Additional 2 Nos.63A Feeders shall be provided for Owner's use.

9.4.6 Lighting Sub Distribution Boards

The Distribution Boards shall be single front, non-draw out wall mounted type.

9.4.7 UPS Distribution Boards

9.4.7.1 The UPS Distribution Boards shall be single front, floor mounted non-draw out type for supply of 240 V AC / 240 V AC UPS Distribution Boards shall have 20% spare outgoing feeders of each rating & Type (fully wired) and with all the components

9.4.8 Direct Current Distribution Boards

9.4.8.1 The Direct Current Distribution Boards (DCDBs) shall be single front, floor mounted non-draw out type for supply of 220 V DC control power to switchgears and panic lighting. Each Switchgear Building station shall have separate DCDB. DCDB shall have 20% spare outgoing feeders of each rating & Type (fully wired) and with all the components

9.5 Motors

9.5.1 The rating of LV and HV motors shall be selected from the sizes as recommended in relevant Indian Standard/IEC.

9.5.2 All electric motors shall meet the standard IEC 60034-30-1.

9.5.3 The margin between the installed power and absorbed power shall be as recommended by the driven machine supplier but shall not be less than the following: -

Motor Rating	Margin Above Driven M/C Absorbed Power
Less than 22 KW	25%
22 KW to 55 KW	15%
75 KW and above	10%

9.5.4 Voltage Ratings:

Voltage rating for the motors of different ratings shall be as below:

Including & below 160 KW: 415 V, 3-phase, 50 Hz AC

Above 160 KW – below1500 KW: 3.3 KV, 3-phase, 50 Hz AC

Including & Above 1500 KW: 11 KV, 3-phase, 50 Hz AC All motors shall be designed for 3-Phase supply only.

9.5.5 The motors shall have maximum continuous rated duty S1 as per relevant Indian Standard/IEC. Rated duty for special duty motors wherever required e.g. cranes etc. Shall be considered as per driven equipment requirement.

9.5.6 All LV motors shall be TEFC type as per relevant Indian Standards/IEC while HV motors shall be TEFC/CACA type. All motors shall be Class-F insulated with temperature rise limited to that of Class-B.

9.5.7 Normally the motors shall be suitable for DOL starting. However, motors started through VFD shall be suitable to run at 30% to 100% of rated speed and compatible with the VFD.

9.5.8 All motors 30 KW and above shall have space heater provision.

9.5.9 All HV motors shall have winding, hot air and bearing RTDs. All the temperature signals shall be terminated to DCS as well as ECMS.

9.5.10 All LV motors shall be of efficiency class 'IE3' as per latest applicable version of IS: 12615. All HV Motors shall be of high efficient and high power factor type.

9.5.11 The starting current i.e. breakaway current of 415 V Motors shall not exceed the values indicated in IS: 12615. Also, there shall be no further positive tolerance on the values of breakaway current.

9.5.12 The starting current of 11 KV & 3.3 KV motors shall not exceed 550% of FLC. No positive tolerance is acceptable over 550% FLC.

9.5.13 Type test certificate of similar motor for use in specified hazardous area (if applicable) shall be furnished.

9.5.14 The duty cycle of the motor shall meet the process and driven machine requirement.

9.5.15 In case of 11 KV & 3.3 KV motor, the terminal box shall be suitably designed for proper termination of XLPE insulated Aluminium cables through heat shrink termination kit.

9.5.16 The mechanical parameters such as duty, mounting type, shaft extension, direction of rotation, starting torque requirements etc. shall be adequate for the application. Sleeve or anti friction type bearings shall be used. Vertical motors shall have thrust bearings suitable for the load imposed by the driven machinery. Motors with sleeve bearings may require proximity probes to measure shaft vibration adjacent and relative to the bearings.

9.5.17 Motor rated above 30 KW shall have on line greasing provision and for motor rated above 45 KW, grease outlet feature shall be provided.

9.5.18 All HV motors shall have safety factor not less than 1.1.

9.5.19 Motors rated 1000 kW and above shall have suitable measures to prevent flow of shaft currents and shall have 2 sets (i.e. 6 nos.) of PS class CTs for differential protection.

9.5.20 The motor shall be capable of withstanding the electro dynamic stress and heating imposed if it is started along with the driven equipment at voltage of 110% of the rated value.

9.5.21 During starting of large motor, the voltage may drop to 80% of the rated voltage for a period of 60 seconds. All electrical equipment, while running, shall successfully ride over such period without affecting system performance.

9.5.22 D.C. motor provided for emergency service shall be shunt/compound wound type. Motor shall be sized for operation with fixed resistance starter for maximum reliability.

DC starters shall be complete with MCCB, contactors, resistors, relays, meters, push-buttons, lamps, etc. DC contactor shall be Class I – Category DC3. Switch Duty shall be DC22. The resistor enclosure shall be provided with ventilating louvers and wire mesh guard and shall have a degree of protection IP-23.

9.5.23 The motor may be subjected to sudden application of 150% rated voltage during bus transfer, due to the phase difference between the incoming voltage and motor residual voltage. The motor shall be designed to withstand any torsional and/or high current stresses, which may result, without experiencing any deterioration in the normal life and performance characteristics.

9.5.24 Shaft voltage shall be limited to 200 mV.

9.5.25 For all other specifications, refer PC288-TS-0810.

9.6 Rectifier-cum-Battery Charger

9.6.1 The Rectifier-Cum-Battery Charger shall be fully automatic using silicon-controlled rectifier and shall consist of units as described below: -

i) Main Float cum Load charger: To supply continuous load and keep the battery in healthy state.

ii) Standby Float cum Load charger: To supply continuous load & keep the battery in healthy state in case any abnormality in Main charger.

iii) Boost charger: To charge the battery set initially and recharge (after meeting emergency or sudden application of heavy loads.)

9.6.2 Switchgear Building shall be provided with redundant battery charger with 2x100% battery banks and connected to each Charger.

9.6.3 The battery and charger combinations shall be such as to ensure continuity of D.C. supply at load terminals without even momentary interruption.

9.6.4 AC Ammeter and AC Voltmeter on Charger Input; DC Ammeter, DC Voltmeter for charger output/ battery voltage and on demand type Battery Charge / Discharge Ammeter shall be provided.

9.6.5 Following analog signals through suitable transducer shall also be provided for hook-up in ECMS:

- Status of charging current (float & boost charging)
- Battery current
- Incoming voltage

9.6.6 Following potential free contacts shall also be provided for hook-up in ECMS

- DC under voltage
- DC overvoltage
- DC earth leakage
- AC incoming power supply failure
- AC input fuse blown-off
- Thyristor/ diode failure
- DC output fuse blown-off
- DC battery fuse blown-off
- Filter Capacitor fuse blown-off
- Load on Battery (using current direction sensing with time delay)
- Battery undervoltage/ Disconnected during discharge (using zero current sensing) Cubicle fan failure/ cubicle temperature high (for chargers with forced cooling).

9.6.7 For all other specifications, refer PC288-TS-0813.

9.7 **Battery Sets.**

9.7.1 These shall be Ni-Cd Battery Sets shall be rated to meet the total DC power requirement for 1hour (60 Min) after complete power failure.

9.7.2 Spare capacity of 20% for future use shall be considered.

9.7.3 Battery shall be designed with minimum temperature as per site ambient temperature.

9.7.4 Load Test of all Battery to be done at site. Battery will be accepted based on load test only.

9.7.5 For all other specifications, refer PC288-TS-0814.

9.8 Uninterruptible Power Supply System (UPS)

9.8.1 240 V AC UPS System with UPS Distribution Board shall be provided to feed 240 V AC, 50 Hz, 1Phase power supply to the instrumentation system, DCS, ECMS Equipment, Fire Detection & Alarm System etc. This UPS System along with associated Battery and UPS distribution Board shall be located at Control Room.

Block Diagram of 240 V UPS System shall be followed but with 240 V in place of 115 V
240 V AC UPS System complete with Battery, UPS Distribution Board etc. shall be separate.
UPS shall have with 20% margin for future use.

9.8.2 The UPS System shall have IGBT type with touch screen LCD display and shall be backed up by nickel cadmium (Ni-Cd) battery rated for 1 hour at rated capacity of the UPS. Battery (100% Capacity) shall be separate for each Inverter.

9.8.3 UPS system construction shall be such that each charger, inverter module can be made fully isolated for maintenance. No common devices/wiring shall be installed. Further there shall be no common device between main & redundant units (e.g. master oscillators etc.) in order to ensure that the failure of the same does not cause shutdown of more than one unit.

9.8.4 UPS system shall have facility for built in Online battery bank monitoring & testing facility for displaying/calculating expected battery bank back-up time (during testing if battery bank does not have sufficient back up time, test shall be terminated & load shall be shifted to charger automatically).

9.8.5 UPS shall be suitable for 100% step load.

9.8.6 Battery Load cycle test shall be carried out by the vendor at site.

9.8.7 The UPS rating shall be such that in any case the load on the individual UPS shall not exceed 70% (after considering 20% future margin) of the rated capacity.

9.8.8 UPS Configuration shall be as per attached Block Diagram. The over load capacity of UPS shall be 200% for 10 cycles, 150% for 60sec & 125% for 10min.

9.8.9 All four sections, i.e. Rectifier-I, Rectifier-II, Bypass – I and Bypass - II shall be fed through four separate feeders of emergency/ normal bus of PMCC.

9.8.10 UPS shall be PWM based using IGBT. Each charger and SCVS shall have isolating transformer at the input.

9.8.11 The salient features of the UPS shall be as under:

a) High Efficiency

b) Compatible to feed nonlinear, high crest factor loads

c) Microprocessor based monitoring system for UPS status and fault indications

d) High transient performance

e) Low audible noise

9.8.12 Each UPS shall be provided with SNMP software so that all the parameters of UPS and alarms/faults can be viewed into the remote computer. These logs/trends of load can later be printed. Web based parameter and status monitoring shall be used. It shall be hooked to ECMS and DCS System.

9.8.13 The transfer time of UPS from inverter to bypass, in case of failure of both inverters, shall be so selected that during this transition period, instrumentation/DCS etc. which leads to tripping of plant shall not fail. Typically, it shall be as below:

In synchronism : No break transfer i.e. within 6 milliseconds (Maximum) In asynchronous mode : Within 16 milliseconds (Maximum).

9.8.14 The technical parameters of UPS shall be as under:

Input

a) Rated Voltage 415 V ± 10%

b) Rated Frequency 50 Hz ± 5%

Output

a) Rated Voltage 115 V AC / 240 V AC

Voltage regulation:

Static (0-100% load) ±1%

Dynamic for 100% load change: ±5%

9.8.15 Following potential free contacts shall be made available on the UPS,

- Rectifier ON
- Inverter ON
- Battery CBB ON - Load on Inverter

- Inverter fail
- Rectifier Fail
- Inverter O/P undervoltage - Inverter Sync.
- Load on battery
- Bypass Fail
- Load on bypass
- Load transferred. etc

Note: A separate common potential free contact for all the faults/alarms (in UPS / SCVS) shall be made available

9.8.16 Operation Philosophy of UPS:

- 2 sets of rectifiers and inverter shall be provided. Under normal conditions, when AC mains power is available, both the rectifiers shall operate in parallel and supply DC power for float/rapid charging the 2X50% batteries and simultaneously to inverters. In case of failure in one rectifier, the other rectifier shall feed the complete load and the batteries without any interruption.
- In case of Incoming supply failure or failure of both rectifiers the 2X50% batteries shall feed the inverters without any interruption. Each rectifier shall be designed for simultaneously feeding complete inverter load and float/rapid charging of the 2X50% batteries to its rapid capacity. Each rectifier shall be equipped with “On Line” automatic as well as manual charging facility.
- Normally both the inverters will be synchronised with each other and with stabilised bypass supply. Both inverters shall operate in parallel and share the load equally.
- The load sharing controls shall not be subject to common mode failure and any failure of the load sharing controls shall not result in the loss of the vital power.
- When a disturbance/fault occurs in any of the inverters, the faulty unit shall automatically get disconnected and the entire load shall be fed from the other inverter without interruption.
- In case both the inverters develop a fault, the complete load shall be transferred to stabilized bypass supply through the static switches and retransfer of the load from the stabilized bypass supply to the inverter shall be possible in auto as well as in manual mode without interruption.

9.8.17 All alarms & status of UPS shall be communicable through Modbus / Ethernet protocol to ECMS.

Following minimum shall be considered:

- Load on Inverter
- Load on Bypass
- Load on Battery
- Battery on float/ boost charging mode. Charger failure.
- Inverter failure
- AC mains failure
- DC under voltage
- DC Over voltage
- Automatic retransfer of load to inverter inhibited.
- Fan failure
- AC Voltage, current & frequency of each inverter AC incoming power supply Voltage & voltage.
- DC current at each rectifier output.

9.8.18 For all other specifications, refer PC288-TS-0802.

9.9 Variable Speed Drives (VSD/VFD)

9.9.1 Microprocessor based variable speed drive shall be communicable type and shall be able to communicate with ECMS/DCS. It shall be possible to set speed from process DCS for optimum performance through 4-20 mA signal. Speed/current/status feedback to DCS shall be provided. Drive will run at preset speed in the event of loss of signal from DCS.

9.9.2 System shall be highly reliable, efficient and shall provide high power factor, low harmonic distortion, low noise level etc.

9.9.3 System shall be provided with complete by pass circuit to ensure the power supply reliability in case of VSD/VFD failure. It shall be possible to start the motor in DOL mode through by-pass system in case there is any problem/fault in the VFD. The Electrical system and the process should be capable to operate the Motor in fixed speed (without VFD).

9.9.4 The system shall be suitable for load characteristics, continuous speed control. Drive shall be able to accelerate the load over the full speed range (0 – 100 %) with incoming line voltage regulation of 10%.

9.9.5 The system shall be designed for 150% over current withstand for 1 minute. The system shall be equipped with an automatic restart facility which will restart the system in case of voltage dip over 20% or power interruptions less than 4 seconds and recovery of voltage to 95% with a facility to block the automatic restart.

9.9.6 The system shall be suitably designed with due care for long length of cables, output filters, chokes, motor insulation, cable voltage grades etc.

9.9.7 The VSD panel shall be located in the clean air-conditioned room in the Switchgear Building. Required local control equipment shall have start, stop speed raise and lower push buttons, ammeter, speed indicator, ON/OFF/READY status selector switches as required and shall be installed near the motor.

9.9.8 The VFD shall be provided with Input and Output transformer.

9.9.9 "Auto Restart" facility for drive system within pre-set time, typically 0-15 seconds, in case of supply system dip or complete loss of power shall be provided.

9.9.10 Preferably screened type cables or cables as recommended by VSD/VFD vendors shall be used for VSD/VFD systems.

9.9.11 The VSD/VFD panels to be supplied shall be of proven model.

9.9.12 Training of VSD/VFD shall be provided to owner personnel.

9.9.13 For all other specifications, refer PC288-TS-0820A and PC288-TS-0820B.

9.10 Local Control Stations

9.10.1 Local Control Stations shall be provided for all motors for testing and maintenance purpose when the selection is made is "LOCAL MODE" Operation. The essential features of the LCS shall be as given below:

9.10.2 LCS shall be pressure die cast aluminium housing (preferably), dust & vermin proof, weatherproof, suitable for wall or pedestal mounting with equipment mounted on a base plate inside and behind a front cover (bolted type).

9.10.3 Provision for pad locking in OFF position shall be provided.

9.10.4 Local control stations for breaker controlled HV and LV motors shall be provided with T-N-C switch, Ready to Start Indication, ON indication, Space Heater ON Indication, Trip Indication, Local-OFF-Remote Control switch and ammeter. Moreover, space heater ON indication lamp, trip indication lamp shall also be provided at the switchgear panel.

9.10.5 Local control stations for contactor-controlled LV motors shall be provided with start/stop push buttons, ammeters and Space Heater ON Indication (for motor rated 30KW and above), ON indication, Local-Remote switch (as required) for the motors having rating 5.5 KW and above. If required from process point of view, ammeter shall be provided for motors below 5.5 KW also.

9.10.6 Each element for start and stop shall be provided with 1 NO + 1 NC contact. The push button construction shall be such to avoid mal-operation due to vibrations.

9.10.7 All local control stations shall have weather proof IP-65 enclosure. Canopies of suitable size shall be provided with all local control stations.

9.10.8 All components shall be completely wired up to terminal block and also provided with earthing terminals.

9.10.9 Inscriptions on corrosion resistant metal strips giving drive description, mechanism number and functional requirement shall be provided.

9.10.10 Two numbers of LCS shall be provided for the motors, which are installed at elevated platforms. One shall be installed at ground level and the other near the motor.

9.10.11 The ammeter shall be flush mounting, moving iron spring-controlled type, of accuracy class 1.5 as per IS: 1248, with square face of minimum size 72 mm × 72 mm having scale range 090 degree. The ammeter shall be provided with uniform scale up to CT primary current and compressed end scale up to the 8 times the C.T. primary current. Adjustable red pointer shall be provided to indicate the full load current of the motors. Zero adjusters shall be provided for operation from the front of the meter. All ammeters shall be operated through 1 Amp. CTs only.

9.10.12 Complete Push Button along with its actuator mounted on the cover with wiring done through flexible cables with proper protection.

9.10.13 Preferably Ring Type lug and suitable TB to be used for connection, to avoid loose connection.

9.10.14 All spare hole to be plugged with suitable metal plugs.

9.10.15 For all other specifications, refer PC288-TS-0817.

9.11 DELETED

9.12 **Conduits** 9.12.1 Conduits shall be of heavy gauge with minimum wall thickness of 1.4 mm (up to 25 mm dia) and 2 mm (above 25 mm dia) rigid steel, hot-dip galvanized, cut square, reamed, threaded and screwed tight at all joints.

9.12.2 Conduits entrances to pull boxes and switches shall have double lock nuts & insulating bushings. No running thread shall be used.

9.12.3 Flexible metallic conduit shall be used for connection to equipment which are subject to vibration and also for connection to level /limit/pressure switches. Conduit runs shall be supported at an interval of 750 mm for vertical run and 1000 mm for horizontal run.

Conduits shall be sized so that conduit fill (ratio of total cable area to conduit area) shall not exceed the following

One Cable: 53%

Two Cable: 31%

Three Cables & Up: 40%

Wiring installation in CCR Room, Control Room, Switchgear Rooms, Pump Houses, DG Room, Compressor House will be done by multi-stranded, PVC insulated, colour coded wires laid in GI conduits of 20 mm dia size (minimum) conforming to IS-9537. The thickness of conduits up to & including 25 mm dia will be 16 SWG and conduits above 25 mm will be 14SWG.

Conduits will be heavy-duty type hot dip galvanised steel conforming to IS-9537. Conduit accessories will be hot dip galvanised. In corrosive area, conduits will have suitable epoxy coating additionally.

Flexible conduits made with bright, cold rolled annealed and electro galvanised mild steel strips and coated with PVC will be used where required.
Conduits in control room, service building, laboratory building and other air-conditioned areas will be surface mounted on the roof above false ceiling, however vertical drops of conduits will be concealed along walls and finally plastered for better aesthetics.

Filling area of wires in conduit shall not exceed 40% of the conduit area. Wiring for AC Normal and DC Emergency services will run in separate conduits. Lighting and receptacles will be fed from separate circuits. No two different phase circuits will be run in the same conduit. However, different circuits of same phase may be laid in the same conduit.

Wiring shall be designed for the uniformly distributed spread of luminaires on each phase i.e. R, Y, B. Distribution of luminaires on these phases shall be such so that there is generally uniform light intensity in the event of failure of one or two phases.

Following sizes of 1100 V grade, PVC insulated single core stranded copper conductor wires/ PVC insulated Stranded 2 Core copper/aluminium conductor cable will be used:

	Wire	Cable
Lighting Panel to Fixtures:	2.5 sq. mm (Cu)	3Cx 2.5 sq. mm (Cu)
Lighting Panel to JBs/ Switches:	2.5 sq. mm (Cu)	3Cx 2.5 sq. mm (Cu)
JBs/ switches to Fixtures:	4.0 sq. mm (Cu)	3Cx 2.5 sq. mm (Cu)
Panel to First receptacles:	4.0 sq. mm (Cu)	3Cx 4 sq.mm (Cu)
First receptacles to looping other receptacles:	4.0 sq. mm (Cu)	3Cx 4 sq.mm (Cu)
In case of only one receptacle in ckt., Panel to receptacles	4.0 sq. mm (Cu)	3Cx 4 sq.mm (Cu)
Panel/ JBs to flood light fixtures	2 x 2.5 sq. mm (Cu)	2.5 sq. mm (Cu)

9.13 Bus-Duct

9.13.1 The bus bars and connection shall be made of electrolytic grade copper / Aluminium. All busbars shall be insulated with Raychem sleeving.

9.13.2 It shall be suitably supported at regular intervals and both bus bars and supports shall be adequately sized and clamped to withstand rated short circuit current without permanent deformation.

9.13.3 The bus bar insulators shall be non-hygroscopic, non-inflammable material. Earth bus shall run along the full length of bus duct without any break.

9.13.4 Outdoor bus-duct shall be weatherproof to IP-55(W) and shall be provided with canopy, silica gel breather. Construction of outdoor Bus duct shall be such that water gets drain off easily. Extra thickness shall be provided at the corners where water accumulation is likely to happen.

9.13.5 Bus duct shall be supplied with bus bar flexible links for connection at both the ends and expansion joints for every 3M of bus-duct and bus duct support materials.

9.13.6 Openings with cover at suitable locations shall be provided on bus duct for accessing the bus bars for maintenance.

9.13.7 Silica-gel breather shall be provided on both indoor and outdoor portions of the busduct. (shall not be required for pressurized busduct).

9.13.8 Proper sealing shall be done between Outdoor & Indoor section of the Bus Duct.

9.13.9 For all other specifications refer, PC288-TS-0807.

9.14 **DELETED**

9.15 **Junction Boxes**

9.15.1 Junction boxes shall be provided on the machine body, where the terminal block of electrical equipment is not adequate for the termination of aluminium cables or to terminate an external multi-core control cable.

9.15.2 Separate junction boxes shall be provided for power and control cables. These shall be mounted at convenient and easily accessible locations.

9.15.3 These shall be of cast aluminium enclosure having IP65 degree of protection and adequately sized, with terminal blocks, cable lugs and cable glands as required.

9.15.4 The cabling between these junction boxes and electrical equipment shall be in The Bidder's scope of work.

10.0 CABLING

10.1 Cables

10.1.1 All HV & LV power and control cables for HV/LV switchgear shall be supplied and laid by the contractor. Terminations at switchgear end and at the equipment end shall be in contractor's scope. Supporting and laying of these cables shall also be in contractor's scope. Termination of HV/LV cables at HV/LV motor end and HV switch gear end including supply of heat shrink type termination kit for HV cables shall be in contractor's scope. Supply and execution of heat shrink type straight through jointing kits for HV cables shall be in the scope of the Bidder.

10.1.2 Cables shall be sized considering the following factors.

- Short circuit withstand capacity
- Maximum continuous load current
- Voltage drops
- System voltage
- Laying conditions
- De rating due to ambient air temperature, ground temperature, grouping and proximity of cables with each other, thermal resistivity of soil etc. shall be considered

10.1.3 All HV power cables shall be made of stranded aluminium conductor with XLPE insulation, PVC inner sheathed FRLS type, armoured, PVC outer sheathed FRLS type, conductor screen, insulation screen and construction as per IS: 7098 (Part 2). HV cables shall be of unearthed type. Single core HV Power cable shall be of aluminium conductor. The construction of same shall be as per above.

10.1.4 All LV power cables shall be with stranded aluminium/copper conductor with XLPE insulation, PVC inner sheathed FRLS type, armoured, PVC outer sheathed FRLS type and construction as per IS: 7098 (Part 1). Power cables with conductor size upto and including 6.0 sq. mm shall be with copper conductor, conductor size 10 sq. mm and above shall be aluminium conductor. Single core LV Power cable shall be of aluminium conductor. The construction of same shall be as per above

10.1.5 All control cables shall be with 1.5 sq. mm stranded copper conductor except for CT & PT connection. For CT & PT, 2.5 sq.mm stranded copper conductor will be applicable, all cables shall be XLPE insulation, PVC inner sheathed FRLS type, armoured, PVC outer sheathed.

FRLS type and construction as per IS: 7098 (Part 1). Control cables shall be twisted pair or shielded wherever electro-magnetic/electrostatic interference is anticipated.

10.1.6 All control cables shall have 20 % spare cores. All cores shall be identified with numerical core numbers printed on core in addition to colour coding.

10.1.7 All cables shall be armoured and shall have extruded inner and outer sheath.

10.1.8 Cables connected in parallel shall be of the same type, cross section and terminations.

10.1.9 All power and control cables shall be in continuous lengths (except for very long feeders) without any joints. The cables used for lighting and wires in conduits shall have appropriate junction boxes with adequately sized terminals. Cable joints in hazardous areas shall not be permitted.

10.1.10 The maximum voltage drops in various cables of the electrical system shall be within limits stated in the following table:

Sl.No.	System Element	Maximum Permissible Voltage Drop
a)	High voltage cables for general distribution	1 %
b)	Bus duct / Cable between transformer secondary and Switchboards	0.5%
c)	Cable between PMCC and MCC or auxiliary switchboard i) MCC / Auxiliary Switchboard near PMCC ii) MCC / Auxiliary Switchboard situated remote	0.5% Note-3b
	from PMCC	2 to 2.5% Note-3a
d)	Cables between HV Switchboard and HV Motor (during running)	3%
e)	Cable between PMCC and motor (during running)	5%
f)	Cable between MCC (situated near PMCC) and motors	5%
g)	Cable between MCC (situated remote from PMCC) and motors	3%
h)	Cable between Auxiliary Switchboard / MLDB and Lighting Panel / Power Panel	1 to 1.5% (Note-2)
i)	Circuit between lighting panels and lighting points	1.5% (Note-2)
j)	DC Supply Circuit (electrical Controls)	5% and/or as per instrumentation requirement
k)	DCDB to Control Room	2% (Note-1)
l)	UPS outgoing circuit	5% (Note-1)

Note-1

Minimum voltage available across any instrument in the field / control room / satellite rack room shall be as per instrumentation design basis. Distribution system for instrumentation supplies shall be designed accordingly. In case of any conflict between electrical equipment specification sheet and instrumentation design basis report, the latter shall govern regarding instrumentation power supplies.

Note-2

In case of difficulty in achieving specified voltage drops in cables up to lighting panel, 3% drop from Auxiliary Switchboard / MLDB up to lighting points may be permitted.

Note-3

a) Higher voltage drop may be permitted between PMCC and remote mounted MCC / ASB; if overall voltage drops up to motor (from PMCC) is limited within 5.5%.

b) For large Switchgear Buildings 1% drop may be permitted.

The maximum voltage drop at various buses during start-up of large motor and / or motor reacceleration conditions shall be within the limits stated below: -

Sl. No.	System Element	Operating Condition	Maximum Permissible Voltage Drop
a)	At the bus bars of the worst affected Switchboard	Start-up of the large HV motor with other loads on the bus or reacceleration of a group of HV motors (Simultaneous start-up or group reacceleration of HV motors is not envisaged)	10%
b)	At the bus bars of the worst affected MV Switchboard	Start-up of large MV motor with other loads on the bus,	10%
	(PMCC / MCC)	or reacceleration of a gro of ıp MV motors.	
c)	Cables between HV Switchboard and motor	Motor start-up or reacceleration	5%
d)	Cable between MV Switchboard (PMCC / MCC) and motor	Motor start-up or reacceleration	10%

Notes:

a) Soft Starter / VFD Starter shall be considered for starting large HV motors if essential / unavoidable as per system design requirement / equipment design limitation. For cases other than starting limitation, requirement of soft starter / VFD for any drive shall be confirmed by Process Department.

b) Unless otherwise specified as in clause a), all HV motors and MV motors shall be suitable for Direct on Line (DOL) starting.

10.1.11 MINIMUM CABLE SIZES FOR 415V MOTORS

Direct on line (D.O.L) start motors (2/4 pole motors)

MOTOR RATING	CABLE DETAILS			
	NUMBER OF RUNS	NO. OF CORES PER RUN	CONDUCTOR MATERIAL	CONDUCTOR SIZE (MM^2)
Below 3.7 KW	1	3	Cu	2.5
3.7 KW	1	3	Cu	2.5
5.5 KW	1	3	Cu	2.5
7.5 KW	1	3	Al	10
9.3 KW	1	3	Al	10
11 KW	1	3	Al	10
15 KW	1	3	Al	16
18.5KW	1	3	Al	35
22 KW	1	3	Al	35
30 KW	1	3	Al	50
37 KW	1	3	Al	70
45 KW	1	3	Al	95
55 KW	1	3	Al	120
75 KW	1	3	Al	185
90 KW	2	3	Al	95
110 KW	2	3	Al	120
125/132 KW	2	3	Al	150
160 KW	2	3	Al	185

- Minimum cables sizes as indicated above are for 2/4 poles motors fed from MCCs located near PCCs and PMCCs. Actual cable sizes shall be based on actual distance of motor from switch board.
- Cable sizes for motors not confirming to above table (e.g. for 2/4 poles motors rated up to 150kw & motors with high starting pf), extended distance, reduced voltage starting, low speed motors, VFD driven etc. shall be worked out on case to case basis.
- However, cable sizing calculation shall be submitted for approval.

10.1.13 Design Criteria for Cables/Bus Duct & Short Circuit Withstand Time:

a) Design criteria for cables/bus duct

Sr. No.	Design Criteria	3.3 kV / 11 kV	415 V
1.	Loads beyond 1000A rating and located near the transformer	Bus Duct / 1-core cable	Bus Duct / 1-core cable
2.	Loads located up to 200 M	Cable	Cable
3.	Loads located 200 - 1000 M	1-core cable / 3-core cable	1-core cable / 3.5-core cable

4.	Loads located beyond 1 KM	Cable	Cable
5.	Recommended limiting size of multi-core cable (sq.mm) / Single Core (sqmm)	3 Core x 400 / 1 Core x 630	3.5 Core x 300 / 1 Core x 630
6.	Insulation voltage grade	3.3 kV / 11 kV Unearthed	1100 V Earthed
6.	Type of cable insulation	XLPE	Power: XLPE Control: XLPE
7.	Power, Control & Earthing Cables	Armoured	Armoured

For breaker control motor circuits, the selection of size will be made ensuring that the cable shall withstand a short circuit fault directly for 0.12 sec.
Suitable derating factors based on the site ambient conditions, method of laying and the no. of cables laid together shall also be applied.

b) Short circuit withstand time (seconds) shall be as follows for Breaker controlled feeders.

Bus duct	1 Sec.
Feeders to motors and transformer	0.12 sec
Feeders from PCC/PMCC to MCC	0.6 sec
Main 11 KV primary distribution Feeder	0.7 sec
11 KV cable from transformer to switchboard	1 sec
Incomer from other switchboard	0.6 sec

10.1.14 The minimum size of power cables shall be 2.5 sq. mm (Cu).

10.1.15 The control cables shall be 1.5 sq. mm (Cu). However, wiring in the panel/switch boards may be by means of 1.5 sq. mm (Cu) cables except for CT wiring which shall be 2.5 sq. mm. All the control and power wiring shall be carried by using FRLS wires only.

10.1.16 Deration factor, group laying factor etc. as per Technical Catalogue of Cable Manufacturer (of whose cables shall be supplied) shall also be considered while sizing the cables.

10.2 Cable Laying

10.2.1 The cables shall generally be laid on overhead racks. Pipe racks where available, shall be used to support the cable racks.

HV power cable shall be laid on cable tray in single layer having 1D spacing between the cables. LV power and control cable shall be laid on cable tray in touching formation in single layer.

HV Power, LV Power and Control shall be on separate trays. Instrument and electrical cable trays shall be separate.

Cables shall be clamped properly on the cable rack in such a way that position and layout of a particular cable shall not change throughout the rack so that it can be easily traced during maintenance jobs.

Walkway to be considered for access to Electrical / Instrument cables on pipe rack.

From Switchgear Buildings to various electrical consumers, cable shall be laid overhead. However, wherever overhead cable routing is not feasible The Bidder can go for cable trench / slit as per the site requirement.

Wherever, pipe rack is not available and space for overhead cable laying is possible then dedicated structure for cable shall be made for cable laying and shall be in scope of The Bidder.

10.2.2 The cable racks shall be ladder type, pre-fabricated from suitable hot dip galvanised steel. Maximum cable tray size shall be 600mm wide. Maximum supporting span shall be 2 Mtrs. Cable trays shall be designed considering 25% margin for future use.
All cable racks must be provided with GI flat strip of size 50mm X 6mm as running earth all along the tray.

10.2.3 All FO cable shall be laid through HDPE pipe with all accessories (Connecting arrangement).

10.2.4 All cables shall be terminated using suitable cable lugs.

10.2.5 All HV terminations and joints shall be of reputed make subjected to Customer approval.

10.2.6 Bimetallic lugs shall be provided, as required.

10.2.7 In Control Room (excluding false ceiling) and Switchgear Building, lighting cable shall be laid in concealed conduit.

11.0 ILLUMINATION SYSTEM

11.1 General

11.1.1 LED type lighting shall be provided. The average illumination levels in the various sections of the plants shall be as indicated elsewhere in the specification. All the plants and area lighting shall be energy efficient.

11.1.2 LED type lighting shall be provided for all areas.

LED shall conform to the following types and standards: -

Product Type	Safety Standard	Performance Standard
Self-ballasted LED lamps for general lighting services > 50 V	IEC 62560 Latest Edition	IEC 62612 / PAS Publicly available specification
Control gear for LED modules	IEC 61347-2-13 Latest Edition	IEC 62384 Latest Edition
LED modules for general lighting	IEC 62031 Latest Edition	IEC / PAS 62717 Latest Edition
LED luminaries	IEC 60598-1 Latest Edition	IEC / PAS 62722-2-1 Latest Edition Luminaries performance – Part 2-1: particular requirements for LED
LEDs and LED modules	IEC TS 62504 Terms and Definitions for LEDs and LED modules in general lighting.	

The colour rendering index shall not be less than 80%.

The LED lights shall work satisfactorily at the design temperature of 50 Degree Celsius.

The life assessment of LEDs shall include control gears/ driver as well.

11.1.3 The specified illumination level shall be maintained after considering maintenance factor 0.5 for Coal Dust Area, 0.6 for plant & outdoor areas (other than Coal Dust Area) & 0.7 for indoor areas and utilisation factor as per manufacturer catalogues for size of room & type of fixture.

11.1.4 Separate area wise panic lights, fed from 220 V DCDB, shall be provided at strategic locations for safe evacuation of operation personnel. These shall be switched 'ON' automatically on failure of power supply to main lighting board and shall switch 'OFF' automatically on resumption of mains or after 1 hour of power failure to avoid draining of the battery. Location of these lights

shall be judiciously decided from safety considerations. The outdoor lighting shall be photocell/timer controlled.

11.1.5 Voltage drop at the fixture from the MLDB bus , from WDB to welding receptacle shall not exceed 3%.

11.1.6 Aviation lights shall be provided on tall structures and all isolated structures. Aviation Lighting shall be in accordance with International Civil Aviation Organization (ICAO) Publication Annexure 14 and to Indian Standards, together with the approval of local aviation authority.

LED type Low Intensity Aviation Obstruction Light suitable for 240V, 50 Hz supply. It shall be covered under Indian patent act (Govt of India) No. 188995. Degree of protection shall be IP65.

The illumination intensity of aviation lights and mounting height shall be considered based on vicinity of civilian air terminal within 1 kM radius. Aviation lights at each location shall be fed from two separate and distinct DBs (one fed from normal bus and another fed from emergency/normal bus of MLDB). In case aviation lights are not switched ON for any reason, whatsoever, a signal shall be sent to control room which will sound buzzer and also result in flashing of red light. On acknowledgement, buzzer shall stop but flasher will continue unless aviation lights are turned ON.

The fixtures shall have body of corrosion resistant aluminium alloy casting and shall be suitable for outdoor use and mounting on 40 mm NB G.I. pipe. Necessary electrical threading shall be tapped in the fixture for mounting.

11.1.7 Plant lighting circuits shall be single phase (Phase & Neutral) rated 240 V AC. Each circuit shall be rated to 20A. A minimum of 20% of MCBs of each board shall be left as spares. The load on one lighting sub-circuit of lighting sub-distribution board and junction box shall be limited to 2000W approx. Maximum Loading on each Lighting Distribution Board (LDB) and Sub Distribution Board (or Lighting Panel) shall be 80%.

11.1.8 The lighting sub-distribution board for control of lighting shall be standardized as 18-way, 15way, 12-way, 9-way and 6-way type.

11.1.9 In plant office rooms, wall mounting boards shall be installed to control the lighting. These boards shall include switches for lights, fans, 15A/5A plug sockets and fan regulators etc.

11.1.10 15A plug sockets shall be fed through separate circuit of lighting sub-distribution boards/junction box having ELCB of 30mA.

11.1.11 16A plug sockets shall be fed through separate circuit of lighting sub-distribution boards/ junction box.

11.1.12 Illuminated exit sign shall be provided in Switchgear Building / Control Room.

11.1.13 Power factor of complete fitting shall be 0.9 min. at 230 V.

11.1.14 Lights from LED's shall be soothing to eye and without any bright spots on the floor/objects illuminated by the luminaries.

11.1.15 The driver shall be mounted internally and be replaceable with the aid of commonly available hand tools.

11.1.16 The LED module or array shall be designed in such a way that the failure of one LED shall not affect additional LED's.

11.1.17 Life expectancy of LED Luminaries shall be minimum of 50000 hrs with greater than 70% of rated lumen output.

11.1.18 Min. efficiency of LED driver: The minimum efficiency of LED driver shall be 85% for driver power output rating <=40W and 87% for driver power output rating> 40W.

11.1.19 Short circuit protection /Open load protection shall be required for LED fixtures.

11.1.20 Surge Protection for minimum 2kV for indoor and minimum 3kV for Outdoor LED systems shall be provided. However, if a site is prone to lightning and surges 10kV surge protection shall be required. In case of outdoor luminaries, the Surge Protection Device (SPD) should be series type with fail safe.

11.1.21 Color temperature of LED Luminaries: 5700K

11.1.22 Cover type for outdoor type fittings shall be Toughened glass or UV stabilized polycarbonate whereas, whereas, for indoor and non-weather proof items, UV stabilized Poly Carbonate can be used.

11.1.25 Junction Boxes shall be provided with all type of Lighting Fixtures for looping. Connectors are not acceptable.

11.2 LED Tube Lighting Fixtures (inside Switchgear Buildings)

a) High quality LED fluorescent tube twin batten type complete with 2 X 20W tube eco-friendly, no UV radiation as per the specification tabulated below:

Sl. No.	Parameter	Technical Specification
1.	Degree of Protection	IP-20
2.	Lumen output per Lamp	≥ 2000
3.	CCT	6500K
4.	Luminous efficacy	≥ 100 lm/watt
5.	CRI	>80
6.	Guaranteed Life	≥ 50000 burning hours
7.	PF	>0.9
8.	THD	<10%

11.3 Street Lighting and Security Lighting

11.3.1 Lighting Pole shall be fed from Street Lighting Sub Distribution Board (or Street Lighting Panel) having Photocell and Timer through contactor. Street Lighting Sub Distribution board shall have 3 PH incomer (which in turn shall be fed from Lighting Distribution Board) and 3 Phase 63A outgoing which shall be taken to the TPN Junction Box mounted on pole and looped from pole to pole.

11.3.2 Steel tubular poles of suitable mounting height shall be used for both street light and plant lighting (platforms/ structures/ access ways/ walk ways/ pump house/ pump bay etc.).
For Street Lighting:
11m Street Lighting Pole (PS1) for 1 Luminaire with 1.2m Bracket for Road Width up to 4m (Single Road) with mounting height (MH) from road level 9.5m approx.
11m/13m Street Lighting Pole (PS2) for 1 Luminaire with 1.2/1.8m bracket respectively for Road Width> 4m (single road) with MH 9.5m/11.5m approx. respectively.
13m Street Lighting Pole (PS4) for two Luminaire with 1.8m bracket each for Road Width> 7m (Bi Directional road) with MH 11.5m approx.

11m Flood Lighting Pole (PF1) for one Luminaire and 13m Flood Lighting Pole (PF2) for two luminaires.
The poles shall be subjected to min. following tests:

- Drop test as per IS: 2713.
- Deflection test as per IS: 2713

11.3.3 Hot dip galvanized octagonal high mast lighting shall be used for yard and general area lighting. LED type fittings may be used.

11.3.4 LED Street Lighting Fixtures

a) LED Street Light Fitting with cool white light in Pressure Die Cast Aluminium Housing with UV Stabilized Poly Carbonate Cover Lighting fixture shall have 50000 hrs. Life Time, CRI>75, IP-65.

12.0 EARTHING AND LIGHTNING PROTECTION

12.1 Earthing

12.1.1 Complete earthing installation shall be done as per IS: 3043, IEEE-80, IE Rules and IEC recommendations. The earthing system shall be designed to:

(a) Provide a permanent & continuous path from equipment and conductor enclosures to earth from circuits for flow of fault current.

(b) Provide sufficient current carrying capacity to conduct safely any current liable to be imposed on it.

(c) Provide sufficient low resistance to earth to limit the potential between metalwork and earth within safe limits.

(d) Provide equal distribution of potential and minimum potential difference for safety of personnel.

(e) Ensure sufficient current in case of fault to facilitate the operation of relays, over current devices, fuses etc. provided in the circuit.

12.1.2 Common underground earthing grid shall be provided covering sub-stations, Switchgear room, all buildings, TP's, Conveyor Gallery, Cable/Pipe rack and plants which is further connected to overall Earthing Grid. The common underground earthing grid shall be made from 40mm Dia MS Rod.
The overall earth resistance (dry) shall be limited to 1 ohm.

12.1.3 Sub mat inside Switchgear Room which in turn shall be connected to the common earthing underground grid. Min size of sub mat conductor shall be 65mm×8mm. Refer Chapter SUB-SECTION-B – 10 CABLING, EARTHING AND LIGHTNING PROTECTION for detailed specification

Anti-corrosive bituminous paint shall be provided at each joint of earth flat after necessary finishing and priming treatment.

12.1.4 Earth pit shall be maintenance free type (chemical earth pit) considered.

12.1.5 Chemical earth pits shall be considered instead of conventional earth pits in view of faster dissipation of lightning surges and fault currents, easy installation and maintenance free feature.

12.1.7 Earthing grid/ring shall comprise of buried GI earth strips and GI pipes/electrodes.

12.1.8 Separate earth electrodes shall be provided for system neutral earthing. For equipment earthing, minimum two numbers of electrodes shall be provided around each plant/section. However, all these earth electrodes shall be interconnected.

12.1.9 Inter-connecting pits having an earth bus in an enclosed brick chamber without earth electrode shall be provided in the common underground earthing grid for convenience of taking earth conductors inside the plants.

12.1.10 As far as possible, the reinforcement rods inside concrete column shall be connected to the earthing grid/ring to reduce the overall earth resistance.

12.1.11 Individual electrical equipment shall be earthed by GI strip/GI wire/Cu/Al cable. Earth buses shall be provided in plants for earthing groups of electrical/non-electrical equipment to earthing grid/rings.

12.1.12 All equipment rated above 250 V shall have two external earth connections and those rated up to 250 V shall have one external earth connection. However, for lighting fixtures, earthing shall be done through 3rd core of the cable in safe as well as in hazardous area.

12.1.14 Flameproof equipment, in addition, shall have one internal earth connection. This means that 4 core cables to be used for all the flameproof equipment's and 3.5 core cables to be used for all flameproof motors located at hazardous area.

12.1.15 All steel structures, tanks, vessels, pipes, pipe joints, valves etc. shall be earthed against static charge accumulation by 50x6 mm GI strip. The no. of earth connections shall be as follows:

Equipment having diameter	Hazardous area	Non-hazardous area
30 M	2	2
More than 30 M	3	2

12.1.16 Wherever process equipment's are mounted on steel structures, the structures shall be earthed instead of earthing the individual equipment.

12.1.17 The pipe rack/cable rack/gallery structures shall be earthed at not more than 25M apart.

12.1.18 For all equipment in hazardous area, in addition to external earthing one internal earthing shall be provided.

12.1.19 Minimum sizes of earth conductors to be used shall be as Refer Chapter SUB-SECTION-B – 10 CABLING, EARTHING AND LIGHTNING PROTECTION for detailed specification

All GI conductors shall meet the galvanizing requirement as per IS.

12.1.20 The main ground grid shall be buried in earth at a minimum depth of 1000 mm below finished grade level unless stated otherwise

12.2 Lightning Protection

12.2.1 All structure shall be protected against lightning strikes by suitable lightning protection system to be designed and installed as per IS/IEC-62305.

12.2.2 Bare metallic structures shall not have any air termination rods at the top. The earth connections shall be welded to the bottom of structure at 300 mm above floor level. However, tall metallic columns with insulation at top shall be provided with air termination rods. Separate earth electrodes shall be provided for each down conductor of lightning protection. However, these shall be inter-connected with the other electrodes in main grid.

12.2.3 Air Terminal

The vertical air terminal rods shall be installed at the roof of buildings to protect these objects from lightning strokes.

The vertical air terminal shall be made of 20 mm dia galvanized steel rod. The projected length of the rod shall be as required to protect the object (on which the rod is fixed) from lightning stroke.

The air terminal rod shall be properly fixed on the top of the building/structure to withstand very high wind pressure. In case the air terminal rod is embedded at the top of roof of building: the portion embedded inside the concrete shall not touch the reinforcement bars and shall be duly insulated from them.

All the vertical air terminal rods shall be electrically connected together by means of horizontal conductors of size 50 x 6 mm galvanized steel flats.

The shielding angle for one vertical air termination shall be 45 degrees. For more than one rod, shielding angle between the rods shall be taken as 60 degrees.

Horizontal air termination (i.e. G.S. Flat conductor) shall be so laid that no part of the rood will be more than nine (9) meters from the nearest roof conductor.

12.2.4 Deleted

12.2.5 Down Conductors

The down conductors shall be 50 x 6 mm galvanized steel flats. The connection between each down conductor and earth electrode shall be made via test link located at approximately 1500 mm above ground level.

13.0 Deleted

14.0 FIRE DETECTION AND ALARM SYSTEM

Bidder shall provide all required 415V, 230V UPS and 230V Non-UPS supply source including all the cables, tray etc for powering up all FDA related equipment's applicable for CHP/LHP and AHP system

15.0 Deleted

16.0 SPARES

16.1 Commissioning Spares

The commissioning spares shall form an integral part of the scope of supply. Contractor shall be responsible for the quantification of the commissioning spares for the smooth commissioning start-up of the plant/ package system. Item wise list of commissioning spares with recommended quantity shall be furnished for information. The same shall be Part of LSTK price

16.2 2 years operational spares (Mandatory)

Contractor shall supply Mandatory spares for all equipment's as per Spare Parts of mentioned in NIT. The same shall be Part of Price quoted.

16.3 Recommended Spares (Other than Mandatory spare)

Contractor shall provide recommended spares (other than mandatory spare) for all the equipment (item-wise) with recommended quantity.

16.4 All spare parts shall be identical to the parts used in the equipment's.

16.5 Any other spare parts or special tools not specified, but required, shall also be provided. The same shall be part of Price.

17.0 VENDORS' SERVICES

17.1 The Bidder shall consider the services of major equipment suppliers during installation, testing and commissioning in their scope as required.

17.2 The services of engineers of following equipment's' (OEM)manufacturers are envisaged and required during installation, Testing and commissioning. The Bidder shall arrange for the same without any additional cost implication:

17.3 Site Testing, parameterization and commissioning of the Numerical relays shall be done by OEM expert only.

18.0 TESTING & INSPECTION

18.1 Testing of all electrical equipment's shall be done in accordance with relevant IEC/BIS codes in presence of owner's representative at manufacturer's works before despatch / at site before installation. All such tests shall be arranged by the contractor and testing charges, if any, shall be borne by the contractor.

18.2 The Bidder shall submit the certificates of type tests performed on identical equipment as evidence of the compliance of the equipment with the type tests. All Type Test Certificates shall not be

older more than 5 years except GIS for which Maximum 10 years old Type test Certificates is acceptable subject to no change in Design.

18.3 The Bidder shall submit the certificates of routine and acceptance tests conducted on the purchased equipment's.

18.4 All the routine/acceptance tests shall be performed at the manufacturer's works in the presence of owner's representative.

18.5 Stage Inspection of Electrical Equipment shall be considered. The owner or their representative shall be allowed to visit the manufacturing works for stage inspection during manufacturing stage.

18.6 The equipment shall be dispatched from works only after receipt of Owner written approval of the test reports.

18.7 The Bidder shall intimate the owner 4 weeks in advance of the tests and submit the detailed schedule of tests.

18.8 In addition, the equipment shall be inspected at site for final acceptance.

18.9 Certified reports of all the tests carried out at the works shall be furnished in six (6) copies for approval of the Owner.

18.10 Electrical installation work shall be subjected to inspection by owner / his authorized representative, statutory bodies like Electrical Inspector, Factory Inspector and where applicable by equipment supplier's engineer. The contractor shall carry out without extra cost to owner rectifications / modifications desired by the above authorities to make the installation conforming to I.E. Rules etc.

18.11 The owner may reject any portion of the work considered defective or of poor workmanship and the contractor shall make good these defects without extra cost to owner.

19.0 DOCUMENTATION

19.1 The Bidder shall submit the documents for electrical equipment's (MS-word, MS excel and AutoCAD) as per the drawing and documentation schedule as given in this bid package.

19.2 Sizing of Electrical system and Equipment's shall be submitted during detailed engineering stage.

19.3 The Bidder shall ensure that following shall be mentioned in each sheet of drawings/ documents in the order mentioned below: (a) Logo and Name of the client

(b) Logo and Name of the consultant

(c) Logo and Name of the contractor (The Bidder)

(d) Logo and Name of the Manufacturer on the drawings prepared by manufacturer, if applicable

(e) Name of the Project for which drawings are applicable

(f) Title of the drawing (Title shall indicate the details shown in the drawing)

(g) Drawing/ document number with sheet number and number of total sheets in the drawing (Drawings having different title shall be assigned different drawing number)

(h) All sheets of each drawing shall bear same title, same document number and same revision number

19.4 At the time of handing over of the installation, The Bidder shall supply as built drawings taking into consideration the actual execution carried out at site.

19.5 Erection, testing/ checking (inclusive of calibration check) prior to energisation/ after energisation and commissioning Manuals shall be in bound book format and shall give step by step procedure for:

(a) Storage, Handling and Erection

(b) Checking/ testing after erection and before energisation.

(c) Pre-commissioning tests/ checks and cold trials

(d) Commissioning

(e) Drawings relevant for erection, operation, maintenance and repair of the equipment.

(f) List of instruments/ testing kits/ sets, measuring instruments etc. required for testing/ checking with specification, ratings, ranges etc.

19.6 Operation & Maintenance Manuals for each of the equipment/ system being shall be in bound book format and shall be supplied along with dispatch of equipment and inclusive of following:

(a) Log sheets indicating daily/ hourly recordings of parameters to be noted down by customer's operating personnel.

(b) Procedure for shut down and energisation.

(c) Preventive maintenance schedule.

(d) Safety procedures for safe operation of equipment and complete system.

(e) Specification of equipment installed. Manufacturer’s catalogues operation and maintenance manuals for all types of relays/components used.

(f) Test procedures for site tests/ checks.

(g) Spares list for each equipment/ system for 2 years operation and maintenance.

(h) Relevant calculations and protection relay setting table for the equipment/ system being supplied by him

(i) Instructions for Diagnostic trouble shooting / fault location charts (j) Tests for checking of proper functioning/ Operation.

(k) Storage and re-conservation Manual

(l) Safety Manual

(m) Drawings relevant for operation, maintenance and repair of the equipment

(n) Instructions for Maintenance and Repair

(o) List of spare parts with ordering specifications and manufacturer's catalogues.

(p) List of consumables with specifications, brand names and annual consumption figures.

(q) Manufacturer’s catalogues with ordering specification for all items

(r) List of special tools and tackles

(s) QAP, Internal Test Certificates and Inspection Certificates(t) Procedure for ordering spares.

(u) All as built drawings.

19.7 Drawings/ documents to be submitted with inspection call of equipment:

(a) Type test certificate for identical equipment

(b) Sub-supplier's/ vendor's catalogue/technical literature

(c) Test reports for internal inspection

(d) Test certificates of components

(e) Technical specification & data sheets of equipment

(f) All drawings as applicable of category 'Approved', 'Approved with comments' and drawings 'For information/ Reference' including comments thereon

19.8 The details of equipment layout and cable routing will be designed by the Bidder during detail engineering stage and these shall be subject to approval by Owner/Consultant. Changes as required to achieve a neat layout with adequate working space all around, for better aesthetics as well as to meet statutory regulation and codes shall be done without any time and cost implication.

20.0 TOOLS & TACKLES

The Bidder shall supply at least one set of all special tools for each Switchgear Building required for maintenance of the equipment supplied by them and price shall be included in the offer. List of tools & tackles with quantities shall be mentioned in the offer.

21.0 REVIEW OF DRAWINGS & DOCUMENTS BY OWNER/ CONSULTANT

21.1 The successful Bidder (herein after referred as contractor), shall submit within one month of placement of LOI; list of drawings/ documents/ Manuals that would be submitted by them. The list shall mention Serial Number, Title of the drawing/ document/ manual, Category (For Approval, For review, For Reference, etc) and tentative date of submission. The list shall be prepared taking in to account into consideration stipulations in respect of submission of drawings/ documents and scheduled date for completion.

21.2 Template for name plate of drawings, documents and drawing/ document numbering system shall also be submitted by contractor and approval obtained.

21.3 The Bidder shall ensure that all sheets of the drawings/ documents and top sheet of manual prepared by manufacturer/ vendor/ supplier & submitted by him or by his consortium member or by manufacturer or his consultant, are checked by him/ leader of consortium and vetted by The Bidder / Leader of consortium before submission with stamp ensuring correctness, completeness, suitability of document for subject work and compliance with stipulations of order

21.4 The responsibility for delay in approval/ review of drawings/ documents due to

a. Submission of incomplete drawings/ documents not meeting the requirement of project/ stipulations of order

b. Non-compliance of comments made earlier

c. Drawings are not submitted in requisite copies; and consequent delay in project shall be that of contractor.

21.5 The contractor shall ensure that in case any model number is mentioned in the drawing, detailed technical catalogue, literature, explanatory notes to describe the model and its technical details in full are also submitted along with the drawing. Such drawings/ documents should be assigned Drawing/ Document Number, Number of sheets in the drawing, Rev number etc (Unique Identification). Reference of such drawing/ document number should be mentioned in the drawing.

21.6 The drawings/ documents shall be prepared in such sizes that those can be read easily. Size of font in print submitted shall not less than size10 Arial or equivalent.

21.7 The drawings/ documents shall be submitted in sizes in which those are prepared. Photocopies in reduced sizes shall not be accepted.

21.8 The contractor shall leave space on each sheet for stamping the drawing by Owner/ consultant to avoid stamping on contents of drawing making them unreadable. Submission of drawings in A4 size shall be avoided.

21.9 All sheets of a drawing shall be assigned same title and drawing number. Drawings having different title shall be assigned different drawing numbers.

21.10 GA drawings, schematic diagrams, single line diagrams, bill of material, data sheets, characteristics curves, cable schedules and cable termination diagrams shall be assigned separate drawing numbers.

21.11 Revision shall be clearly marked on all subsequent issue of drawings and documents.

21.12 Inability to incorporate some of the comments shall be clearly stated by contractor with reasons and without delay. However, to accept or reject the non-compliance based on the reasons indicated by contractor shall be discretion of Owner/ their consultant.

21.13 In case alterations are considered necessary by the contractor in the drawings already approved, such drawings shall be resubmitted for approval again stating the considerations necessitating changes/ alterations. In case, alterations/ changes proposed by contractor are approved by the consultant/ Owner; all other drawings and data affected by such alterations/ changes shall be duly revised and re-submitted for the approval as stated above.

21.14 Contractor shall depute their concerned engineers (with the engineers of suppliers, if required) shall visit consultant after submissions of drawings for discussion, modification of drawings and approval so that project is not delayed for want of approval of drawings.

21.15 It will be the responsibility of contractor to submit the drawings and obtain approval to meet the project schedule. Delay in approval of drawings due to following shall be the responsibility of contractor:

a. non-submission of drawings/ documents/ well before those are actually required and/ or

b. delay in incorporation of comments and/ or

c. non-incorporation of comments by contractor and/ or

d. submission of drawings without checking and ensuring requirement stipulated in contract/ order

21.16 Contractor shall note that any approval and/ or clearance accorded by Owner or consultant for manufacture and/ or to proceed further given during discussions or recorded in the minutes of the meetings shall be valid only after the drawings showing relevant details are submitted by contractor and clearance/ approval is accorded by Owner/ Consultant by stamping and signing on the relevant drawings.

21.17 Approval of drawings by Owner / his consultant shall not relieve the contractor of his contractual obligations and responsibility for engineering, design, workmanship, materials and performance of the equipment

21.18 Contractor shall furnish, if requested, additional drawings, calculations, information to the Owner/ Consultant to enable him to examine/ study the drawings submitted.

21.19 Contractor shall note that work shall be carried out exactly as indicated in the approved drawings and no alterations shall be made without the written approval of the Owner/ Consultant.

22.0 TRAINING

22.1 Training shall be imparted to owner's personnel at manufacturer's works as under:

a) AC UPS: Two engineers for one week.

b) Variable Speed Drive: Two engineers for one week.

c) Numerical relay: Two engineers for one week

d) HV & LV Switchboard: Two engineers for one week

e) Fire Detection & Alarm System: Two engineers for one week

23.0 VENDOR LIST

23.1 Make of all electrical equipment shall be as per Vendor List attached with this NIT.

23.2 Any other vendor shall be subject to Owner/Consultant's approval.

23.3 Any other item for which vendors are not mentioned in NIT, The Bidder shall furnish list of proven suppliers with PTR subject to Owner's/ Consultant's approval during detailed engineering. Document (PTR) shall be in English language only.

24.0 INSTALLATION, TESTING AND COMMISSIONING

24.1 The Bidder shall undertake installation of all electrical equipment in accordance with latest code of practices, in conformity with recommendation of the respective equipment manufacturers, drawings approved by the owner or owner's representative, direction of engineer-in-charge, statutory regulations and to the entire satisfaction of the owner.

24.2 The Bidder shall arrange all the necessary erection tools and tackles, testing and measuring instruments and shall supply the required erection materials including structural steel.

24.3 The Bidder shall furnish field inspection and test data sheets for all equipment's for owner's approval.

24.4 The Bidder shall obtain the necessary certificate of compliance/completion certificate with test results from statutory authorities as required. All necessary drawings and test certificates as required by them shall be furnished by the vendor.

24.5 The erection work shall be supervised by competent supervisors holding relevant supervisory license from the Government.

24.6 Installation of Equipment

a. The equipment shall be installed in switchgear rooms, MCC rooms, control rooms and at shop floors.

b. The scope of work of The Bidder under installation shall be inclusive of but not limited to the following:

c. Physical inspection and handling

d. Assembly and interconnection of shipping sections, if any, as per manufacturer's instructions. Supply of materials, fabrication and installation of supporting frames/ brackets for proper support of equipment/ panels/ devices/ cable trays etc.

e. Installation on foundation/ supports/ brackets.

f. Alignment, levelling and clamping/ welding/ fixing/ grouting with supports/ foundation bolts as required.

g. Mounting loose supplies and connection of wiring.

h. Conducting pre-energisation tests/ checks to ensure that installation is carried out as per manufacturer's instructions/ direction of supervising engineer and is healthy/ fit for energisation.

24.7 Cable Installation shall be as per Chapter SUB-SECTION-B – 10 CABLING, EARTHING AND LIGHTNING PROTECTION for detailed specification

25.0 TESTING OF INSTALLATION AFTER ERECTION

25.1 The Bidder shall carryout tests/ checks after erection of equipment/ cables to check, ensure and demonstrate the conformity of equipment supplied and installation done with the specification and statutory requirement.

25.2 Prior to starting the test, the Bidder shall satisfy himself and ensure that

a. The installation is strictly in accordance with the specification, drawings and statutory requirement.

b. Any automatic controls that might vitiate the tests have been relaxed.

c. All instruments to be used for testing are suitable for the purpose and have been calibrated by a recognised laboratory within the last 12 months and copy of the calibration certificates have been submitted to the Owner/ Consultant.

d. The testing, commissioning, operation and maintenance manuals are available to the testing engineer and Owner/ Consultant.

e. Formats for recording test results have been finalised with the Owner/ Consultant and copies have been distributed to all concerned.

25.3 The skilled manpower to test all the equipment, cables, earthing etc deputed by The Bidder is well aware of and prepared to perform checks/ tests.

25.4 The tests shall be witnessed by the representatives of Owner/ Consultant.

25.5 The Bidder shall compile and tabulate all the test results in agreed formats and submit to Owner/ Consultant for approval prior to acceptance of installation.

25.6 Testing and checking shall be carried out to demonstrate and record prior to completion, that supply and installation meets the requirement/ performances specified. The installation shall be tested in presence of Owner/ Consultant.

25.7 The Bidder shall give at least 24 hours' notice to Owner/ Consultant to enable them to witness the test.

25.8 The Bidder shall submit to Owner/ Consultant test record sheets on daily basis.

25.9 Equipment or any part of the installation shall be energised only after all pre-energisation tests are completed and test results are approved by Owner/ Consultant.

25.10 Failure to submit test results as tests are completed may render the Bidder for carrying repeat tests.

25.11 The Bidder shall supply six (6) bound and indexed copies of all tests in agreed formats prior to preliminary acceptance and handing over of the equipment/ installation, duly signed by representatives of the Owner/ Consultant who have witnessed the tests.

25.12 It will be the responsibility of the Bidder to supply/ arrange at his own cost all necessary testing equipment and measuring equipment required for conducting the tests as per applicable standards.

25.13 Should any of the tests reveal any discrepancy or non-conformity, the same shall be attended to and retested before proceeding with any other tests.

25.14 All tests shall be conducted in accordance with this specification, standard specifications of Bureau of Indian Standards, recommendations of IEC and IE Rules.

25.15 Tests checks to done at site shall be inclusive of but not limited to the following:

a. Physical Check & Verification : All Equipment/Cables etc

b. Tightness of connections : All Equipment/Cables etc

c. Checking for cleanliness : All Equipment/Cables etc

d. Size & No. of Earth connection : All Equipment/Cables etc

e. Erection, alignment, mounting height: All Equipment/Cables etc and clearances

f. Insulation Resistance test : All Equipment/Cables etc

g. Earth continuity test : All Equipment/Cables etc

h. Earth Resistance test : All Equipment/Cables etc

i. Earth loop impedance test : All Equipment/Cables etc

j. No load & rated load current : All Motors/ Loads

k. No load & rated load P.F. : All Motors/ Loads

l. No load & rated load Power : All Motors/ Loads

m. Functional checks : All Equipment & Controls

n. Primary injection test : All switchgear

o. Secondary injection tests All protective relays/ devices

p. Ratio and polarity test CTs

q. Power frequency HV test Power & Control circuit

r. Phase sequence checks /C & bus couplers

s. Winding resistance test Motors & Transformers

t. Direction of rotation All motors

u. Free running for 2 Hrs All motors

v. Under voltage tests All U/V Devices

w. Calibration Checks All instruments

x. Load and Performance tests UPS, PLC, & Variable Frequency equipment, Battery Bank

y. Checking of Voltage, current UPS, PLC, & Variable Frequency equipment

z. Checking of specific gravity and acid level Battery

aa. Illumination levels All areas

25.16 It is anticipated that following equipment will be necessary to perform testing of the installation. The Bidder shall, therefore, arrange these as well as any other equipment for testing of the installation.

a. HV Testing Set

b. Primary Injection Set

c. Secondary Injection Set

d. IR Testers

e. Earth Continuity testers

f. Soil resistivity Testers

g. Earth resistance Testers

h. Phase to earth loop impedance testers

i. Milli volt drop testers

j. Micro-ohm meter

k. Phase sequence testers

l. Clip-on ammeters

m. Voltmeters

n. Power factor meter

o. Frequency meter

p. 3 Ph 4 wire unbalance load kWh meter

q. Cable fault location equipment

r. Digital multi-meter suitable for testing IC voltage and current levels

s. Analogue Multi-meters

t. Portable multi-range precision ammeters, voltmeters complete with CTs, PTs for AC/ DC circuits.

u. Protection relay test plugs

v. Portable earthing equipment

w. Dual beam oscilloscope with storage facility.

x. UV recorder

y. Illumination level meter

z. Thermometers

aa. Power Analyser / Portable Power Meter bb. Rpm meter cc. Noise meter

25.17 At least following tests shall be specifically conducted before commissioning in presence of owner's representative. All the test results shall be recorded and submitted to the owner. a) Insulation Test

b) Continuity Test

c) High Voltage Test

d) Simulation Test

e) Earth Resistance Test

26.0 QUALITY ASSURANCE

26.1 All equipment, components, materials proposed to be supplied by The Bidder shall be procured, manufactured, erected, commissioned and tested as per a comprehensive Quality Assurance Programme (QAP) to be approved by the Owner/ Consultant.

26.2 The Successful Bidder shall submit within 1 Month of from order; Quality Assurance Plan (QAP) for all the equipment/ panels/ cables/ motors/ devices etc. under their scope of supply.

26.3 All routine and acceptance tests shall be carried out as per relevant IS / IEC/ Other Standards during inspection at manufacturer's works in presence of Owner or his representative.

26.4 The Bidder shall submit type test certificates for similar equipment supplied by him elsewhere. In case type test certificates (not more than 5 years old and conducted at duly accredited laboratory) for similar equipment is not available, the type test shall be conducted in presence of Owner or his representative without any financial implications to Owner.

26.5 The inspection procedure shall be finalized and approved by Owner and/ or their consultant/ authorized representative.

26.6 Inspection will be carried out as per drawings and quality assurance plan approved by the Owner/ Consultant. Inspection shall be carried out either at manufacturer's shop/ works or any other place where facilities for conducting tests/ checks are available.

26.7 Owner reserves the right to witness any of the tests and verify the documents of the Bidder, his supplier/ vendor/ manufacturer.

26.8 Manufacture test certificate for bought out components shall be submitted during inspection.

26.9 No equipment or part items shall be dispatched without final acceptance certificate and dispatch instructions in writing issued by Owner and/or their authorized representatives.

26.10 The Bidder shall carry out an inspection and testing programme during manufacture in his works and/ or that of his vendor's works to ensure accuracy/ correctness/ completeness of components, compliance with drawings, conformance to functional and / or performance requirements, identify and acceptability of all materials, parts and equipment. The Bidder shall also carry out all tests/ inspections required to establish that the items/ equipment conform to requirements of the specification and the relevant codes/ standards specified in the specification in addition to carrying out tests as per the approved Quality Plan.

26.11 Quality audit/ surveillance/ approval of the results of the tests and inspection, approval of drawings will not, however, prejudice the right of the Owner to reject the equipment at any subsequent stage if it does not comply with the specification or does not give complete satisfaction in service and shall in no way limit the liabilities and responsibilities of the The Bidder of ensuring complete conformance of the materials/ equipment supplied to relevant specification, standard, data sheets, drawings etc.

26.12 The owner or their representative shall be allowed to visit the manufacturing works for stage inspection during manufacturing stage.

26.13 The Bidder shall intimate the owner 4 weeks in advance of the tests and submit the detailed schedule of tests.

26.14 The Bidder s shall supply reports of type tests, acceptance tests, all requisite factory tests and site tests in bound volumes.

26.15 All the equipment shall be tested at site to know their condition and to prove suitability for energisation and required performance.

27.0 COORDINATION WITH OTHER CONTRACTORS

27.1 The Bidder shall coordinate with Owner's other Contractors and shall freely exchange all technical information required for this purpose.

27.2 All civil works connected with electrical installation shall be under the Bidder's scope.

PART B
ELECTRICAL

ELECTRICAL

B – 00	GENERAL ELECTRICAL REQUIREMENTS
B – 01	DELETED
B – 02	MOTORS
B – 03	VFD
B – 04	TRANSFORMERS AND ASSOCIATED EQUIPMENTS
B – 05A	MV SWGR (SWITCHGEAR)
B – 05B	MV SWGR (PCM)
B – 06A	LT SWITCHGEARS AND LT BUSDUCTS
B – 06B	LT SWITCHGEARS-SCHEMATIC
B – 07	DELETED
B – 08	HT LT AND CONTROL CABLES
B – 09	DELETED
B – 10	CABLING, EARTHING AND LIGHTNING PROTECTION
B – 11	LIGHTING
B – 12	FIRE PROOF CABLE PENETRATION SEALING SYSTEM
B – 13	DELETED
B – 14	DELETED
B – 15	ELECTRICAL HOIST, CRANE AND ELEVATOR
B – 16	BATTERY CHARGER
B – 17	DELETED
B – 18	CONSTRUCTION POWER
B – 19	BATTERY
B – 20	HT LOAD BREAK SWITCH
B – 21	CONTROL PANELS FOR CHP & AHP
B – 22	BUSDUCTS
B - 23	DELETED

SUB-SECTION-B – 00

GENERAL ELECTRICAL REQUIREMENTS

	TECHNICAL REQUIREMENTS
1.00.00	**GENERAL REQUIREMENTS**
1.01.00	For the purpose of design of equipment/systems, an ambient temperature of 50 deg. Centigrade and relative humidity of 95% shall be considered. for equipment in air-conditioned areas, design ambient temperature shall be 35 deg.C,
1.02.00	All equipment's shall be suitable for rated frequency of 50Hz with a variation of +3% & -5%, and 10% combined variation of voltage and frequency
1.03.00	Contractor shall provide fully compatible electrical system, equipment's, accessories and services for the entire system in his scope as well as those specifically required by the Employer
1.04.00	All the equipment, material and systems shall, in general, conform to the latest edition of relevant National and International Codes & Standards,
1.05.00	The auxiliary AC voltage supply arrangement shall have, 11 kV, 3.3KV and 415V systems. It shall be designed to limit voltage variations as given below under worst operating condition: a) 11KV/3.3KV +/- 10% b) 415 V/240 V +/- 10% c) 220V/110V/48V DC +/-5%
1.06.00	The voltage level for motors shall be as follows: a) Up to 0.237 KW : Single phase 240V AC / 3 phase 415V AC b) Above 0.237 KW and up to 160 KW : 3 phase, 415V AC c) Above 160 KW and below 1500 KW : 3 phase, 3.3 kV AC d) Above 1500 KW including 1500 KW : 3 Phase, 11 kV AC Voltage rating for special purpose motors viz, VFD and screw compressors, shall be as per manufacturer's standard.
1.07.00	The preferred AC control supply voltage shall be 240V for all 415 V non-breaker-controlled feeders.
1.08.00	The designed fault level for various voltage levels shall have the following minimum values: 11 KV systems - 40 kA rms for 3 second 3.3 KV systems - 40 kA rms for 3 second 415 V systems - 50 kA rms for 1 second

	TECHNICAL REQUIREMENTS
1.09.00	The nominal voltage of main DC system shall be 220V. DC batteries shall be designed for continuous float operation with trickle charge, hence all the associated components like batteries, battery chargers, DC motors, relays, contactors, timers etc. shall be suitable for continuous operation at the maximum continuous battery float voltage including suitable temperature correction factors.
1.10.00	Design of civil foundation for High Mast and street light poles are in the scope of bidder. Also civil foundation of street light poles is in the scope of bidder.
1.11.00	Approach provision shall be provided for reaching all instruments/equipment for maintenance of the same.
1.12.00	In fire hazardous areas like Gasifier/gas/ liquid fuel storage/ handling areas, lighting fixtures, Motors, Panels, safety switches, panels, switchgears etc shall be flame proof.
1.13.00	Availability of OEM's representatives at site before commissioning of respective equipment like LT Switchgear, VFD, Belt Weigher, ILMS, MD etc
1.14.00	Provenness of the Equipment, system, being offered by the bidder should satisfy the criteria Indicated in the "Provenness criteria" indicated elsewhere in the specification. Refer Clause 14.00
2.00.00	Electrical Power Distribution scheme for the project as conceived by the Employer is indicated in tender SLD
3.00.00	**SIZING & DESIGN (shall be in line with EQP SPEC)** All Auxiliary transformers shall be sized so as to have 10% margin at design ambient conditions after considering final load requirements, at peak load conditions and the No Load Voltage Correction Factor. No Load Voltage Correction Factor (= Transformer No Load voltage/ rated bus Voltage) shall be used for sizing of all transformers i.e. The transformer size = the calculated size X no load voltage correction factor (11.5/11, 3.45/3.3, 0.433/0.415).
3.04.00	**Auxiliary Transformer (shall be in line with EQP SPEC)** Adequate number of auxiliary transformers shall be provided to meet the demand on 11KV, 6.6/3.3 KV and 415V systems under most onerous conditions, with the criteria that each 3.3KV /415 V switchgear / MCC / DB shall be fed by 2x100% transformers /feeders **or as per feeding arrangement as shown in tender SLD**, and these shall be rated to carry the maximum load including owner's load (if applicable) expected to be imposed. Individual Transformer for CHP systems shall be sized to cater to load of both streams running. LT Transformer rating shall be limited to 2000 KVA

3.05.00 **MV Switchgears**

b) 11kV and 6.6/3.3 kV incomers from transformers to switchgear and ties between switchgears shall be through bus ducts

3.06.00 **LV Switchgears**

All switchboards shall be of double front, draw out, complete closed-door operation, metal enclosed, indoor, floor-mounted, free-standing type of bolted design. Entire bus bar system shall be insulated with PVC sleeves (UL 224). Cable terminations located in cable alley shall be designed to meet the Form IV-B (as per IEC 60439) for safety purpose.

a) All ACDBs, DCDBs, Solenoid Valve DBs and MCCs located on Stacker Reclaimer, Paddle feeders and Travelling trippers shall be of Fixed Module type. All 415V Circuit breaker modules and other MCC modules shall be fully draw out type.

b) The Circuit Breakers / Contactors shall be of air break type & should conform to the requirements of IS / IEC 60947.

c) MPCB/MCCB shall be provided for supply feeders of current rating up to 16 Amps. MCCB shall be provided for all supply feeders of current rating above 16 Amp and including 400A. Air circuit breakers shall be provided for supply feeders above 400 Amps.

d) Bottom most operable handle should be at least 300mm above FFL. Shrouding of at least 3mm thickness to be provided below the hanging portion of vertical busbars. Half width module

e) Motors rated up to and including 75 kW are provided with MPCB and contactors. Motors rated above 75kW are provided with ACB & composite numerical protection relay. Motor starters are direct-on-line type. All moving and fixed contacts of each draw-out modules must be of rating more than 150% of MCCB/MPCB mounted inside the module. Each phase of vertical busbars shall be separated by phase barrier.

MOTOR FEEDERS BELOW AND INCLUDING 75KW SHALL BE CONTACTOR CONTROLLED. THE MOTOR FEEDERS ABOVE 75KW SHALL BE AIR CIRCUIT BREAKER CONTROLLED.

f) For 415V system, busduct assemblies shall be provided for incoming connection from transformers to the switchboard and interconnecting sections between switchboards wherever transformer rating is 630KVA or above.

g) The sizing of LV boards shall be dependent on conditions such as total load connected to a board, diversity factors for various loads connected, Fault Level and Voltage Regulation Considerations, etc.

h) As far as practicable the system shall provide segregated supplies to main and standby auxiliaries so that the failure of supply to main auxiliary shall in no way jeopardize the standby auxiliary feed. Automatic changeover at critical switchgear / MCC sections shall be provided as necessary to prevent the loss of a unit or to ensure the equipment safety.

i) All indoor floor mounted switchgear (PCCs/MCCs), ACDBs of busbar rating more than or equal to 100 A and DCDBs shall require to qualify the Sub-QR clause of LT switchgear.

h) Sizing of LT boards

i. Input kVA for a Drive = (Rating in kW X Load Factor) / (Efficiency X Power Factor) where values of load factor, power factor and efficiency are defined below:

Load (service) factor for 415 V loads is taken as 0.85 for continuous and 0.4 for intermittent loads.
Power factor 415 V Uni-Directional drives is taken as 0.8 and efficiency as 0.85
Power factor of 415 V bidirectional drive loads is taken as 0.65 and efficiency as 0.8 for motor rating less than 15 kW. For motor ratings of 15 kW and above the corresponding values are 0.75 and 0.8.

ii. The Finally selected Busbar ratings for Switchboards, MCCs, ACDBs and Busducts shall include a 10% margin over the transformer full load current/calculated values whichever is higher.

iii. Lighting load shall be considered with a service factor of 70% of the associated lighting transformer size, on each section of main switchgears with incomer from transformer. at least one number lighting DB and one number Welding DB in each switchgear building shall be provided. [fed from transformer] except Unit service switchgear (Boiler and Turbine)

iv. Welding sockets shall be connected from Welding DBs, which shall be fed through 1X100% Welding transformers. load of Welding DB's shall be considered in switchgear and transformer sizing.

v. The sizing of Unit Emergency boards shall be in according to the DG rating for catering unit loads in Blackout Conditions. The Emergency board shall have tie to both sections from Unit Service Switchgear.

vi. Each Lighting DB shall have 2X100% transformers.

vii. All the electrical equipment's shall be designed / sized considering motor input power (i.e. BKW divided by motor efficiency).

j) Layout Criteria

The switchboards can be split into two sections based on layout constraints in case of long switchboards to optimize Switchgear room layouts. The two sections of the split shall be connected by Busduct / Cable as per layout requirements.

k) Spare capacity

All switchgear, Motor Control Centers (MCCs) & AC/DC distribution boards, LCP etc. shall have at least 20% or minimum two (whichever is higher) fully equipped switch-fuse modules of each rating as spares, uniformly distributed over different vertical sections. In addition, all switchgears, MCCs, AC/DC boards, etc., shall have as spares at least twenty (20%) per cent of starter modules/MCCB module or at least one module (whichever is higher) of each physical size, equipped for the rating of the largest auxiliary fed from that size of module.

	m) Plant control cable Interconnections Control cable interconnections between switchgears and transformer marshalling boxes, switchgears and motor terminal boxes / push button stations, and between various switchgears shall be as follows: a) Standard control cable sizes shall preferably be 3CX1.5, 5CX1.5, 7CX1.5 & 10CX1.5 mm2 ,14CX1.5 mm2, 19Cx2.5 mm2 b) Min Cable size for motor space heater application shall be 2CX2.5 $mm^{2.}$ Actual cable shall be finalized based on voltage drop criteria. c) Interconnections for Current Transformer terminals shall use two cores of 2.5mm^2 size per phase d) Core identification shall be using core color for up to 5-core cable and core number for cable with more than 5 cores. e) Separate control cables shall be used for current transformers f) The spare cores shall be made available in each of the control cable as specified in the relevant specification.
3.07.00	**Numerical Relay Networking** The Numerical Relay Network system shall be an integrated system for protection, control (except motor feeders), measurement and monitoring of all MV & LV circuit breakers / vacuum contactors in the Auxiliary Power Supply network. The system shall have communicable numerical relays complying with IEC-61850 on all feeders which shall be networked on Ethernet to form a distributed dual ring architecture to be connected to DDCIMS for monitoring & data acquisition of all MV & LV circuit breakers/ MV vacuum contactors on IEC 61850 protocol. The circuit breaker will normally be controlled from remote control panels (DDCMIS) through closing and shunt trip coils. All the protective relays associated with the Circuit breaker modules shall be of Numerical communicable type for Protection, Control, Metering and Status monitoring. All the numerical relays shall have communications on three ports, local front port communication to laptop and dual ports on IEC 61850 to communicate with the DCS through LAN. **Control Philosophy** The Design Philosophy shall be as follows: (a) All the 11 KV/ 3.3 KV & LT Incomers, Bus Ties, Bus couplers, Transformer Breaker feeders shall be controlled from DDCMIS through hard-wired interlocks & Close/Trip commands. (b) All MV breaker/Vacuum contactor controlled, and LT Breaker controlled motor feeders shall be controlled from the DDCMIS through hard-wired interlocks & Close/Trip commands.
3.06.00	**Cables and Bus Ducts**

The minimum rating of cable and bus ducts shall meet the following criteria:

All the cables and bus ducts feeding switchboards from transformers shall be sized based on transformer rating. All the cables and bus ducts feeding transformers shall be sized based on current ratings of transformer at the minimum voltage tap of the transformer. All other cables and bus-ducts shall be sized based on the load demand under most onerous conditions.

Cables shall be selected so as to limit maximum voltage drop at equipment terminals during normal operation and starting conditions well within permissible values. Cables shall be derated for the site ambient and ground temperatures, grouping and soil resistivity and cable laying configuration. **All HT cables shall be of unearthed grade.**

3.07.00 Earthing & Lightning Protection System

The earthing system for plant shall be designed for a life expectancy of at least forty (40) years, for a system fault current of 63 kA for 1.0 sec. The minimum rate of corrosion of steel (over calculated diameter) for selection of earthing conductor shall be 0.12mm per year.

Grounding and lightning protection for the entire power plant, switchyard and other areas or buildings covered in the specification shall be provided in accordance with IS 3043, IEC 62305, IEEE 80 and IEEE 665.

3.08.00 D.C. Systems

Complete DC system, comprising of batteries, battery charges, relays, contactors, timers etc. shall be suitable for continuous operation at the maximum continuous float voltage including suitable temperature correction factors.

The battery sizing shall be done based on different types of continuous and intermittent loads including motor starting (wherever applicable) under complete blackout condition, for the duration specified so as to meet the system requirement. The total DC load shall include 20A continues load for BHEL use. All intermittent loads shall be considered with minimum 1-minute duration. Nameplate ratings of DC motors shall be used in sizing.

The battery shall be sized considering a minimum electrolyte temperature of 15 ^{O}C along with temperature correction factors as per relevant standard. An ageing factor of 1.25 shall be considered for Ni-Cd only. The no. of cells, end cell voltage shall be considered based on the minimum and maximum voltage window and cable drop etc. as per system requirement.

Each system shall comprise of two nos. of batteries and two nos. of float-cum-boost chargers each rated for 100% capacity. DC scheme shall ensure that each critical consumer is fed from two different bus sections. DCDBs shall provide adequate number of feeders on each section.

Boost/ fast charging time shall be as per worst operating condition and would satisfy technical requirements recommended by battery manufacturer. Each battery charger must be capable of supplying all the continuous D.C. loads (fed through both section of DCDB) plus the trickle charging current of both the batteries. In addition, each charger must have sufficient surplus capacity for running of the largest D.C auxiliary so that the battery is not drained during testing of the same. Battery charger should also be capable of boost/ fast charge the battery from completely discharged condition to fully charged condition without imposing any limitations under worse operating conditions.

The various DC Systems envisaged along with minimum battery bank ratings to be adopted are indicated in the following table. Bidder may supply additional DC systems at offsite load centers as per system requirement:

Area	DC Voltage	Load	Minimum Battery Bank Rating
CHP & AHP	220 V	Total DC load including DC Lighting at an acceptable voltage for at least 60 minutes. Load for MV switchgear (free issue) in CHP & AHP area to also be considered in 220V Battery/Charger sizing	90 AH for Ni-Cd High Discharge (KPH) type batteries Separate 220V DC system shall be considered for CHP and AHP

DC Health Monitoring Systems shall be provided to monitor the condition of each battery cell of 220V battery banks on-line on 24x7 basis. With DC Health Monitoring System, it shall be possible to measure & analyze the individual cell and battery parameters so that any damage to battery shall be prevented by pro-active maintenance. The location of cell monitoring systems shall be away from the battery bank. All the cards used for BHMS system shall have conformal coating.

6.00.00 LV Side of all LT Transformers (415V) shall be solidly earthed through bolted links.

7.04.00 220V DC system shall be kept ungrounded.

7.05.00 33kV System and 11kV miscellaneous supply system shall be Solidly Earthed. 11KV/3.3KV system earthing shall be low resistance earthed type to limit earth fault current to 400A. The resistor shall be rated to carry this current at least for 10 seconds.

7.06.00 Diesel generator shall also be kept ungrounded (earthing through PT).

9.00.00 **FAULT LEVEL**

Equipment through fault withstand capabilities under worst operating conditions duly taking into account negative tolerances on transformer, generator & maximum fault levels of source etc. shall be as follows:

ii)	Transformers	- 2 seconds
v)	11 & 3.3KV kV busduct	- 1 second
vi)	Switchgears	- 1 second
vii)	Cables to the feeders protected by breakers	Main protection fault clearing time with 0.12s min
viii)	Cables of all other feeders	as per MCCB operating time
ix)	11KV, 6.6KV & 3.3KV cable screen	- 2 seconds for the

adopted ground fault current

x) EHV systems - 1 second

(** Note) Thermal withstand design time duration. The indicated values of time durations are used in transformer design for ensuring thermal stability of the transformers and are to be proven through calculations.

10.00.00 **MOTORS**

The ratio of locked rotor KVA at rated voltage to rated KW shall not exceed the following (without any further tolerance) except for ID and MDBFP Motors:

(a) From 50KW & up to 110KW : 11.0
(b) From 110 KW & up to 200 KW : 9.0
(c) Above 200 KW & up to 1000KW : 10.0
(d) From 1001KW & up to 4000KW : 9.0
(e) Above 4000KW : 6 to 6.5

Starting voltage requirement: permissible starting voltage for motor shall be as follows:

(a) Up to 85% of rated voltage for ratings below 110 KW
(b) Up to 80% of rated voltage for ratings from 110 KW to 200 KW
(c) Up to 85% of rated voltage for ratings from 201 KW to 1000 KW

11.00.00 **All the plant and equipment's/systems supplied under the contract shall be designed following "Fail Safe" concept in case of failure of Power Supply like Electric Power, Hydraulic pressure, Pneumatic pressure, Vacuum etc the system shall be designed in such a way that the equipment shall always move/remains (as applicable) to safest position as per system requirement to ensure safety of Man and Machinery.**

12.00.00 **Latest Cybersecurity guidelines laid down by CEA/Government of India shall be followed.**

13.00.00 Dielectric epoxy-based coating covering entire finished floor and checkered plates shall be provided in all MV switchgear (11/3.3 KV) rooms and also in switchgear rooms having both MV and LV switchgears. The minimum dielectric strength for insulating floor (for all switchgear rooms up to and including 11 KV switchgear) shall be 45 KV ac rms (Class B as per Table-4 of IS-15652: 2006).. The minimum thickness of insulation coating shall be 2000 microns for switchgear rooms up to 11 KV

14.00.00	PROVENNESS The bidder/its sub-vendor(s) is required to meet the provenness criteria and/or qualification requirement for the items/services listed below as per the stipulated criteria indicated in the respective clauses. For the purpose of qualification of Bidders / Sub-vendor(s), experience shall be reckoned as on the techno-commercial bid opening date of EPC package unless otherwise specified in the respective clauses. The Bidder/its Sub vendor(s) shall be a company incorporated in India under the Companies Act of India for Collaborator(s) / Associate / Licensor / Technology provider route as specified in various clauses of the provenness requirement for equipment/systems.
14.00.01	ISOLATED PHASE BUSDUCT Bidder / Sub Vendor should have designed, manufactured, supplied, erected/ supervised erection and commissioned/supervised commissioning of Isolated Phase Busduct for a turbo-generator of at least 500MW, which should have been in successful operation for at least two (2) years.
14.00.02	BATTERY CHARGER Bidder/ Sub Vendor should have manufactured and supplied at least two (2) numbers of static automatic voltage regulator type Battery Chargers of highest offered rating or above, at least one (1) each at two (2) different industrial installations, which should have been in successful operation for at least two (2) years. NOTE: Two different installations mean two different project sites or two different contracts.
14.00.03	LT SWITCHGEAR ROUTE 1 1.1 Bidder/ Sub Vendor should have manufactured and supplied at least a total of four hundred & fifty (450) numbers of draw out type Air Circuit Breaker Panels and / or draw out type Motor Control Centre Panels with fault rating of at least 45kA for one (1) second and 105kA peak under a single order and these panels should have been in successful operation for at least two (2) years. And 1.2 Bidder/ Sub Vendor should have manufactured and supplied at least one hundred & fifty (150) numbers of Air Circuit Breakers having fault rating of at least 45kA rms BREAKING, 105kA peak MAKING and 45kA withstand for one (1) second, and their associated draw out type Air circuit breaker panels having fault rating of at least 45kA for one (1) second and 105kA peak, which should have been in successful operation for at least two (2) years. ROUTE 2 1.3 Bidder/ Sub Vendor should have manufactured and supplied at least a total of two hundred & twenty-five (225) numbers of draw out type Air Circuit Breaker Panels and / or draw out type

	Motor Control Centre Panels with fault rating of at least 45kA for one (1) second and 105kA peak under a single order and these panels should have been in successful operation for at least two (2) years. And 1.4 Bidder/ Sub Vendor should have manufactured and supplied at least seventy-five (75) numbers of draw out type Air Circuit Breaker panels having fault rating of at least 45kA for one (1) second and 105kA peak, which should have been in successful operation for at least two (2) years. And 1.5 Bidder/Sub Vendor shall be considered qualified provided its Associate or Collaborator or Technology Provider or Licensor meets the requirement stipulated in Route-1 for sourcing of Air Circuit Breakers. The Associate or Collaborator or Technology Provider or Licensor shall provide a letter of technical support for successful performance of the Air Circuit Breakers, as per the format, given in the bidding document. This letter of technical support should be submitted at the time of placement of order on the Sub Vendor. And 1.6 Bidder/ Sub Vendor should have established manufacturing facility for draw out type Air Circuit Breaker Panels and draw out type Motor Control Centre Panels in India. Further, all the panels for this project shall be manufactured and supplied from the Indian manufacturing facility. NOTE: 1. Each Single Front Panel shall be counted as one (1) Panel, Double Front Panel as one (1) Panel and Air Circuit Breaker Panel as one (1) Panel. 2. The provenness criteria shall be applicable for all draw out type and fixed type switchboards except Lighting DBs and Welding DBs
14.00.04	11 kV / 6.6 kV / 3.3 kV SWITCHGEARS 1.1 Bidder/ Sub Vendor should have manufactured and supplied at least one hundred (100) numbers of 6.6kV or above Switchgear panels with fault rating of at least 40kA for one (1) second and 100kA peak, which should have been in successful operation for at least two (2) years. 1.2 Bidder/ Sub Vendor should have manufactured and supplied at least one hundred (100) numbers of Vacuum Circuit breakers for 6.6kV or above panels with a rating of 40kA rms BREAKING, 100kA peak MAKING and 40kA withstand for one (1) second, which should have been in successful operation in 6.6kV or higher voltage application for at least two (2) years.
14.00.05	NUMERICAL RELAYS & NETWORKING 1.1 Bidder/ Sub Vendor should have manufactured and supplied and successfully configured at least one hundred (100) numbers of Numerical Relays with IEC 61850 used for application in Feeder Protections/Transformer Protections/Motor protections. These relays should have been in successful operation for at least two (2) years. 1.2 Bidder/ Sub Vendor should have manufactured/ integrated and successfully done Site Acceptance Test (SAT) for a network on IEC 61850 with at least one hundred (100) numbers of Communicable Numerical Relays.

14.00.06	DC BATTERIES Bidder/ Sub Vendor should have manufactured and supplied at least two (2) numbers of highest offered rating or above of high discharge type plante positive plate type battery (in case bidder offers Lead Acid plante type battery) or high discharge type Nickel Cadmium battery (in case bidder offers Nickel Cadmium battery), at least one (1) each at two (2) different industrial installations, which should have been in successful operation for at least two (2) years. NOTE: Two different installations mean two different project sites or two different contracts.
14.00.07	HT POWER CABLES The bidder/Sub-vendor should have manufactured and supplied following cables: (a) Atleast 50kms of XLPE insulated power cables of 6.35/11 KV or higher voltage grade, executed in one or more orders. (b) At least one (1) Km of flame-retardant low smoke cables of any voltage level.
14.00.08	DG SETS The bidder/Sub-vendor should have supplied at least two (2) numbers of DG sets of rating not less than 1500 kVA, at least one (1) each at two (2) different installations, which should be in successful operation for at least two (2) years. The offered make of the DG set (Alternator and Engine) shall be same as that of reference plant DG sets. NOTE: Two different installations mean two different project sites or two different contracts.
14.00.09	AUXILIARY OIL FILLED TRANSFORMERS AND HT TRANSFORMERS The Bidder/Sub-Vendor should have manufactured & supplied at least two numbers (one each at two different installations) of 16MVA, 11KV or higher rating oil filled transformers which should have been in successful operation for a period of at least two (2) years And Bidder/Sub-Vendor should have his own facilities for conducting all routine and type tests as per IS: 2026 (except short circuit test). And 16 MVA, 11 KV or higher rated oil filled transformer manufactured by Bidder/Sub-Vendor should have been successfully short circuit tested. NOTE: (i) Two different installations mean two different project sites or two different contracts. (ii)Equipment designed by the Bidder/Sub-vendor by itself or through its collaborator/associate/technology provider/licensor for reference plant, shall also be considered meeting the requirement of design.
14.00.10	AUXILIARY DRY TRANSFORMERS

	TECHNICAL REQUIREMENTS
	The Bidder/Sub-Vendor should have manufactured & supplied at least two numbers (one each at two different installations) of 2.5MVA, 11KV or higher rating Dry Type transformers which should have been in successful operation for a period of at least two (2) years And Bidder/Sub-Vendor should have his own facilities for conducting all routine and type tests as per IS: 2026 (except short circuit test). And 2.5 MVA, 11 KV or higher rated Dry Type transformer manufactured by Bidder/Sub-Vendor should have been successfully short circuit tested. NOTE: (i) Two different installations mean two different project sites or two different contracts. (ii)Equipment designed by the Bidder/Sub-vendor by itself or through its collaborator/associate/technology provider/licensor for reference plant, shall also be considered meeting the requirement of design.
15.00.00	1. All equipment to be supplied shall be of type tested design. During detail engineering, the contractor shall submit for Owner's approval the reports of all the type tests as listed in this specification and carried out within last five years from the date of bid opening. These reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client. 2. However if the contractor is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in the case of type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests under this contract at no additional cost to the owner either at third party lab or in presence of client/owners representative and submit the reports for approval. 3. All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price.

SUB-SECTION-B – 02

MOTORS

MOTORS

1.00.00 GENERAL REQUIREMENTS

1.01.00 This chapter has to be read in conjunction with other related documents:

Degree of Protection

Degree of protection for various enclosures as per IEC60034-05 shall be as follows: -

i)	Indoor motors	-	IP 55
ii)	Outdoor motors	-	IP 55 (Additional Canopy to be provided)
iii)	Cable box-indoor area	-	IP 55
iv)	Cable Box-Outdoor area	-	IP 55

2.00.00 CODES AND STANDARDS

1)	Three phase induction motors	:	IS15999/IEC:60034
2)	Single phase AC motors	:	IS 996/ IEC:60034
3)	Crane duty motors	:	IS:3177, IS/IEC:60034
4)	DC motors/generators	:	IS:4722, IS/IEC:60034
5)	Energy Efficient motors	:	IS 12615, IEC:60034-30

3.00.00 TYPE

3.01.00 **AC Motors:**

a) Squirrel cage induction motor suitable for direct-on-line starting.

b) Continuous duty LT motors (at 50 deg.C ambient temperature), shall be **Premium Efficiency class – IE3**, conforming to IS 12615, or IEC:60034-30. HT motors shall have minimum design efficiency of 95 %. However, tolerance on this efficiency value shall be applicable as per IEC 60034.

c) Motor operating through variable frequency drives shall be suitable for inverter duty with VPI insulation. Also these motors shall comply the requirements stipulated in IEC: 60034-18-41 and IEC: 60034-18-42 as applicable.

3.02.00 DC Motors Shunt wound.

4.00.00 RATING

(a) Continuously rated (S1). However, crane motors shall be rated for S4 duty, 40% cyclic duration factor.

(b) Whenever the basis for motor or driven equipment ratings are not specified in the corresponding mechanical specification sub-sections, maximum continuous motor ratings shall be at least 10% above the maximum load demand of the driven equipment under entire operating range including voltage and frequency variations.

5.00.00	**TEMPERATURE RISE**
	Air cooled motors (AC &DC)
	70 deg. C by resistance method for thermal class 155(F) insulation.
	Water cooled
	80 deg. C over inlet cooling water temperature mentioned elsewhere, by resistance method for thermal class 155(F) insulation.
6.00.00	**OPERATIONAL REQUIREMENTS**
6.01.00	**Starting Time**
6.01.01	For motors with starting time upto 20 secs. at minimum permissible voltage during starting, the locked rotor withstand time under hot condition at highest voltage limit shall be at least 2.5 secs. more than starting time.
6.01.02	For motors with starting time more than 20 secs. and upto 45 secs. at minimum permissible voltage during starting, the locked rotor withstand time under hot condition at highest voltage limit shall be at least 5 secs. more than starting time.
6.01.03	For motors with starting time more than 45 secs. at minimum permissible voltage during starting, the locked rotor withstand time under hot condition at highest voltage limit shall be more than starting time by at least 10% of the starting time.
6.01.04	Speed switches mounted on the motor shaft shall be provided in cases where above requirements are not met.
6.02.00	**Torque Requirements**
6.02.01	Accelerating torque at any speed with the lowest permissible starting voltage shall be at least 10% motor rated torque.
6.02.02	Pull out torque at rated voltage shall not be less than 205% of rated torque. It shall be 275% for crane duty motors.
6.03.00	NOT USED
7.00.00	**DESIGN AND CONSTRUCTIONAL FEATURES**
7.01.00	Suitable single-phase space heaters shall be provided on motors rated 55 kW and above to maintain windings in dry condition when motor is standstill. Separate terminal box for space heaters & RTDs shall be provided. However, for flame proof motors, space heater terminals inside the main terminal box may be acceptable.
7.02.00	All motors shall be either Totally enclosed fan cooled (TEFC) or totally enclosed tube ventilated (TETV) or Closed air circuit air cooled (CACA) type. However, motors rated 3000KW or above can be Closed air circuit water cooled (CACW). The method of movement of primary and secondary coolant shall be self-circulated by fan or pump directly mounted on the rotor of the main motor as per IEC 60034-6. However, VFD driven motors can be offered with forced cooling type with machine mounted fan or pump driven by separate electric motor. Motors and EPB located in hazardous areas shall have flame proof enclosures conforming to IS:2148 as detailed below (a) Fuel oil area : Group – IIB (b) Hydrogen generation / Gassifier : Group - IIC or (Group-I, Div-II as per plant area NEC) or (Class-1, Group-B, Div-II as per NEMA /IEC60034)
7.03.00	Winding and Insulation (a) Type : Electrolytic grade Copper conductor, non-hygroscopic, oil resistant, flame resistant Insulation. (b) Starting duty : Two hot starts in succession, with motor initially at normal running temperature. However, conveyor motors shall be suitable for 3 consecutive hot starts

	(c)	11kV, 6.6 KV & 3.3 kV AC motors	:	Thermal class 155 (F) insulation. The winding insulation process shall be total Vacuum Pressure Impregnated i.e. resin poor method. The lightning Impulse & interturn insulation surge withstand level shall be as per IEC-60034 part-15.
	(d)	240VAC, 415V AC & 220V DC motors	:	Thermal Class (F) or better

7.04.00	Motors rated above 1000KW shall have insulated bearings/housing to prevent flow of shaft currents.
7.05.00	Motors with heat exchangers shall have dial type thermometer with adjustable alarm contacts to indicate inlet and outlet primary air temperature.
7.06.00	Noise level for all the motors shall be limited to 85 dB(A) except for BFP motor for which the maximum limit shall be 90dB(A) (Tolerance limits as per IS/IEC shall be applicable on specified values). Vibration shall be limited within the limits prescribed in IS:12075 / IEC 60034-14. Motors shall withstand vibrations produced by driven equipment. HT motor bearing housings shall have flat surfaces, in both X and Y directions, suitable for mounting vibration pads. Contractor shall ensure the adequate size of vibration pads for mounting of suitable vibration sensors.
7.07.00	In HT motors, at least four numbers simplex / two numbers duplex platinum resistance type temperature detectors shall be provided in each phase stator winding. Each bearing of HT motor shall be provided with 3 numbers duplex RTDs.
7.08.00	Motor body shall have two earthing points on diagonally opposite sides.
7.09.00	11 KV motors shall be offered with: i) Separable Insulated Connector (SIC) as per IEEE 386. The offered SIC terminations shall be provided with protective cover. SIC termination kit shall be suitable for fault level of 25 KA for 0.17 seconds. OR ii) Dust tight phase segregated double walled (metallic as well as insulated barrier) Terminal box--PSTB shall be suitable for fault level of 50KA/40KA for 0.12 seconds (Fault level shall be as per system fault level for 11 KV system defined elsewhere in the specification). Removable gland plates of thickness 3 mm (hot/cold rolled sheet steel) or 4 mm (non-magnetic material for single core cables) shall be provided.
7.10.00	3.3/6.6 KV motors shall be offered with dust tight phase segregated double walled (metallic as well as insulated barrier) Terminal box. Alternately Elastimold type Terminal box should also be accepted as per OEM standard proven practice. Contractor shall provide termination kit for the offered Terminal box. The offered Terminal Box shall be suitable for fault level of 250 MVA/500MVA for 0.12 sec for3.3/6.6KV respectively. Removable gland plates of thickness 3 mm (hot/cold rolled sheet steel) or 4 mm (nonmagnetic material for single core cables) shall be provided.
7.11.00	The spacing between gland plate & center of bottom terminal stud shall be as per Table-I.
7.12.00	All motors shall be so designed that maximum inrush currents and locked rotor and pullout torque developed by them at extreme voltage and frequency variations do not endanger the motor and driven equipment.
7.13.00	The motors shall be suitable for bus transfer schemes provided on the 11kV, 6.6 KV, 3.3 kV /415V systems without any injurious effect on its life.
7.14.00	For motors rated 2000 KW & above, neutral current transformers of PS class shall be provided on each phase in a separate neutral terminal box.
7.15.00	NOT USED.
8.00.00	NOT USED.
9.00.00	NOT USED.
10.00.00	**TYPE TEST**
10.01.00	**HT MOTORS**
	LIST OF TYPE TESTS TO BE CONDUCTED

	The following type tests shall be conducted on each type and rating of HT motor (a) No load saturation and loss curves up to approximately 115% of rated voltage (b) Measurement of noise at no load. (c) Momentary excess torque test (subject to test bed constraint). (d) Full load test (subject to test bed constraint) (e) Temperature rise test at rated conditions. During heat run test, bearing temp., winding temp., coolant flow and its temp. shall also be measured. In case the temperature rise test is carried at load other than rated load, specific approval for the test method and procedure is required to be obtained. Wherever ETD's are provided, the temperature shall be measured by ETD's also for the record purpose. **LIST OF TESTS FOR WHICH REPORTS HAVE TO BE SUBMITTED** The following type test reports shall be submitted for each type and rating of HT motor (a) Degree of protection test for the enclosure followed by HV and no load run test. (b) Terminal box-fault level withstand test for each type of terminal box (phase side only) of HT motors only. (c) Lightning Impulse withstand test on the sample coil shall be as per clause no. 4.3 IEC-60034, part-15 (d) Surge-withstand test on inter-turn insulation shall be as per clause no. 4.2 of IEC 60034, part-15
10.02.00	**LT Motors** **LIST OF TESTS FOR WHICH REPORTS HAVE TO BE SUBMITTED** **The following type test reports shall be submitted for each type and rating of LT motor of above 100 KW only** 1. Measurement of resistance of windings of stator and wound rotor. 2. No load test at rated voltage to determine input current power and speed 3. Open circuit voltage ratio of wound rotor motors (in case of Slip ring motors) 4. Full load test to determine efficiency power factor and slip 5. Temperature rise test 6. Momentary excess torque test. 7. High voltage test 8. Test for vibration severity of motor. 9. Test for noise levels of motor (Shall be limited as per clause no 7.06.00 of this section) 10. Test for degree of protection and 11. Overspeed test. 12. Type test reports for motors located in fuel oil area having flame proof enclosures as per IS 2148 / IEC 60079-1
10.03.00	All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price.
10.04.00	Deleted

TABLE - I

DIMENSIONS OF TERMINAL BOXES FOR LV MOTORS

Motor MCR in KW	Minimum distance between centre of bottom terminal stud and gland plate in mm
UP to 3 KW	**As per manufacturer's practice.**
Above 3 KW - upto 7 KW	85
Above 7 KW - upto 13 KW	115
Above 13 KW - upto 24 KW	167
Above 24 KW - upto 37 KW	196
Above 37 KW - upto 55 KW	249
Above 55 KW - upto 90 KW	277
Above 90 KW - upto 125 KW	331
Above 125 KW-upto 200 KW	385/203 (For Single core cables only)

For HT motors the distance between gland plate and the terminal studs shall not be less than 500 mm.

PHASE TO PHASE/ PHASE TO EARTH AIR CLEARANCE:

NOTE: Minimum inter-phase and phase-earth air clearances for LT motors with lugs installed shall be as follows:

Motor MCR in KW	Clearance
UP -to 110 KW	10mm
Above 110 KW and up to 150 KW	12.5mm
Above 150 KW	19mm

SUB-SECTION-B – 03

VFD

VFD

1.00.00 **GENERAL:** 2.00.00 **CODES AND STANDARDS**

HT breaker	IEC:60056
DC reactor	IEC 60289
Transformers	IS:2026, IEC:60076, IEC 61378
Bushing	IS: 2099, IEC 60137
Adjustable Speed Electrical Power Drive Systems	IEC 61800
Semiconductor converters–General requirements	IEC 60146
IEEE Recommended practices and requirements for harmonic control in electrical power systems - IEEE 519	
Degrees of protection provided by enclosures (IP Code) IEC 60529	
Electrostatic immunity test	IEC1000-4-2
Fast transient immunity test	IEC1000-4-4
Surge immunity test	IEC1000-4-5
High-voltage switchgear and control gear; Pt.102: Alternating current disconnectors and earthing switches	IEC 62271-102
High-voltage switchgear and control gear; Pt.200: AC metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 KV IS/IEC: 62271-200	
AC electricity meters	IS: 722

Metal oxide surge arrestor without gap for AC system	IEC: 60099-4
Terminal blocks for copper conductors	IEC: 60947-7-1
Dry transformer	IS: 11171
Motor	IS:15999, IEC-60034, IEC60034 / NEMA 30 & 31
Contactor/Switches/Fuses etc.	IEC:60947, IS: 13947
Harmonics & EM compatibility	IEEE:519/IEC: 61000
VFD	IEC: 60034/ IEC: 61800

3.00.00 **OPERATING CONDITIONS**

3.01.00 For the purpose of design of equipment/systems, an ambient temperature of 50 deg. Centigrade and also relative humidity of 95% at 40 deg. Celsius shall be considered.

3.02.00 All equipment shall be suitable for rated frequency of 50 Hz with a variation of +3% & -5%, and 10% combined variation of voltage and frequency unless specifically brought out in the specification.

3.03.00 The voltage level for the VFD output to be fed to motor shall be as follows: -

1. Upto 400 kW : 415V/690V, Low Voltage, Three Phase AC
2. Above 400kW and upto 700 KW : 690V, Low Voltage, Three Phase AC
3. Above 700KW : Medium Voltage

From here onwards in the specifications all the VFD Systems consisting of either 415 V or 690 V may be termed as LV VFD while the higher rated VFD System shall be termed as MV VFD. If nothing is mentioned than the Clause is applicable for both the LV and the MV VFD until deliberated otherwise.

4.00.00 **SYSTEM DESCRIPTION**

Type of drive	3-Phase Diode / Thyristor / Multi Stage IGBT / IGCT / SGCT/ IEGT
Type of Cooling of VFD	Naturally air cooled/forced air cooled/Liquid cooled
Converter Type	Full wave diode rectifier/active front end type

Inverter Type	Thyristor/IGBT/IGCT/SGCT/IEGT

5.00.00 **GENERAL REQUIREMENTS**

5.01.00 **Medium Voltage VFD**: The Variable frequency drive (VFD) system shall be of a modern proven design for similar applications in power plants/industry. The system shall be either Current Source Inverter (CSI) or Voltage Source Inverter (VSI) type with minimum eighteen (18) pulse design / active front end VFD.

5.02.00 **415 V/690 V LV VFD:** The Variable frequency drive (VFD) system shall be of a modern proven design for similar applications in power plants/industry. The system shall be either Current Source Inverter (CSI) or Voltage Source Inverter (VSI) type & type of the VFD shall be selected as mentioned below.

1. Upto 100 kW : minimum Six (6) pulse / active front end VFD
2. Above 100kW : minimum Twelve (12) pulse / active front end VFD

5.04.00 The offered equipment shall be with state of art technology and proven field track record. No prototype equipment shall be offered.

5.05.00 The VFD manufacturer shall ensure the proper coordination of their VFD with the Driven Motor and the supply system. The VFD operation shall have no inherent detrimental impact on the Motors/ cables & supply system.

6.00.00 **TECHNICAL AND OPERATIONAL REQUIREMENTS**

6.01.00 The system shall be designed to deliver the motor input current and torque for the complete speed torque characteristics of the driven equipment, with worst input supply voltage and frequency variation. The system shall be suitable for the load characteristics and the operational duty of the driven equipment.

6.02.00 The overload capacity of the controller shall be 150% of the rated current of the motor for one minute for constant torque applications and 110% of rated current for one minute for variable torque applications at rated voltage. If the motor load exceeds the limit, the drive shall automatically reduce the frequency and voltage to the motor to guard against overload.

6.03.00 The drive system shall be designed to operate in one or more of the following operating modes as to suit characteristics of the driven equipment or specified by the load:

a. Variable torque changing as a function of speed.

b. Constant torque over a specific speed range.

c. Constant power over a specific speed range.

d. Any other as specified in data-sheet

6.04.00 VFDs shall comply with the latest edition of IEEE 519 & IEC 61000 for both individual as well as total harmonic voltage and current distortion limits. The Voltage and Current limits shall be applicable at the Point of Common Coupling (PCC), which shall be the MCC/ Switchgear/ from which the VFD system is fed.

6.05.00	The above compliance shall be verified by the field measurements of harmonics at the PCC with and without VFDs operation.
6.06.00	VFD shall be capable of withstanding the thermal and dynamic stresses and the transient mechanical torque, resulting from short circuit. Any damage resulting from such a short circuit or internal fault shall be limited to the component concerned.
6.07.00	The system shall be suitable to maintain speed variation within range 10-110% or as per the requirement of driven equipment with speed set accuracy of +1% of rated maximum speed and steady state regulation of +0.5% of rated speed as per system requirement.
6.08.00	The VFD System shall maintain a power factor of 0.95 (minimum) (for LV VFD system) and 0.9 (minimum) (for MV VFD system) in the entire operating range.
6.09.00	Maximum allowable audible noise from the VFD system will be 85 dB (A) at a distance of one meter under rated loaded with all cooling fan operating conditions.
6.10.00	All the circuit components shall be suitably protected against over voltages, surges, lightning etc.
6.11.00	The panels shall be designed to provide easy access to hardware, to facilitate replacement of cards in case of any failure.
6.12.00	All the VFDs for particular application shall be of same design so as to ensure 100 % interchangeability of components.
6.13.00	For each programmed warning and fault protection function, the VFD shall display a message in complete English words or Standard English abbreviations. Time tagged fault messages shall be stored in the drive for fault diagnosis.
6.14.00	The VFD cubicles shall be placed in air-conditioned environment. However, installation of VFDs less than 100 kW in non-air condition and non-dusty environment such as MCC room etc., shall also be acceptable.
6.15.00	The 3-Phase Thyristor/IGCT/SGCT/ multistage IGBT/IEGT based VFD system shall have minimum number of components to ensure very high reliability. The input side converter shall have 3-Phase Diode/Thyristor bridge configuration modular type and inverter shall be of 3-Phase Thyristor/IGCT/SGCT/multi stage IGBT/IEGT type, using Pulse Width Modulation or better technique for generating near sine wave output to motor.
6.16.00	Fiber optic cable connection shall be provided preferably to ensure high network reliability.
7.00.00	**VFD COMPATIBILITY WITH THE MOTOR**
7.01.00	MV VFD output current waveform, as measured at the motor, shall be inherently sinusoidal at nominal loads, with a total harmonic current and voltage distortion within acceptable/standard limits. VFD with transformers on output side are not acceptable.
7.02.00	The system design shall not have any inherent output harmonic resonance in the operating speed range.
7.03.00	VFD shall provide stable operation of motor from high-voltage dv/dt stress, regardless of cable length to motor. The vendor shall clearly state the limitations in the motor cable distance in his proposal. However, due to system requirements & constraints if the cable length becomes critical, filters/ chokes etc. shall be provided by the VFD manufacturers as an integral part of the VFD to mitigate the reflected wave effect of harmonics.
8.00.00	**BYPASS ARRANGEMENT**
8.01.00	The bypass arrangement shall be provided unless otherwise specified in relevant mechanical chapters. The VFD System shall have an optional feature to run the motor under bypass arrangement for operation of Motor with VFD bypassed. During starting (under rated conditions) the motor will be switched on in

	VFD Mode to limit the starting current and after gaining speed, the load would be switched over to bypass mode.
8.02.00	Comprehensive motor protection scheme for protection and control for operation VFD during bypass mode shall be finalized during detailed engineering.
9.00.00	**STANDBY VFD ARRANGEMENT (if specified, as per system requirement)**
9.01.00	A Common standby arrangement with auto/manual switchover shall be provided in case of failure of any VFD in a group of drives. Complete protection, interlocks & control required shall be provided in the changeover module.
10.00.00	**EFFICIENCY**
10.01.00	Efficiency (Drive only) shall be minimum 98% for both MV VFD and LV VFD. Overall efficiency (Includes the transformer if applicable) shall be minimum 96.5% for LV VFD and minimum 95 % for MV VFD at rated load and speed. Overall Efficiency evaluation shall include input transformer, harmonic filters and power factor correction (if applicable), VFD converters, cooling fans and output filter, as applicable in the system. Auxiliary controls, such as internal VFD control boards, cooling fans/pumps.
10.02.00	In absence of valid test report, a factory test shall be performed at the VFD manufacturer's facility verifying the efficiencies. Manufactures who are supplying Drive and transformer from different locations, efficiency test will be conducted separately for Drive and transformer.
11.00.00	**COOLING SYSTEM**
11.01.00	VFD manufacturer to primarily offer Air cooled Design. However, in case of large ratings, liquid cooled drives may be accepted subject to employer's approval. In case of liquid cooled system, there shall be no necessity of continuous water supply system (Closed Loop System).
11.2.00	In case of Air-cooled design, the VFD Cooling system shall be such that it puts minimum heat load inside the room and preferably throw the hot air outside the room with ventilation ducts. The Cooling system shall be designed in such a way that the Air Conditioning & Ventilation Air requirements are kept to minimum. The VFD Manufacturer shall furnish the data regarding heat load, air flow requirements during the detailed engineering.
11.03.00	Forced Air cooled VFDs shall be provided with cooling fans mounted integral to the VFD/ enclosure/cubicle. The VFD shall include suitable instrumentation such as air-flow pressure switches / temperature detectors etc., to monitor proper operation of the air cooling system. If the fan fails, the system must generate the alarm/trip for the fan failure.
12.00.00	**TRANSFORMER:**
12.01.00	Type: Outdoor Mineral oil filled ONAN type or Indoor air-cooled Dry type, Three phase unit, rectifier/converter duty type transformer.
12.02.00	All other components, technical parameters shall be as per applicable IEC/IS.
12.03.00	Enclosure for Dry Type Transformer (as applicable) Enclosure shall be of a tested quality sheet steel of minimum thickness 2 mm & shall also accommodate cable terminations. The housing door shall be interlocked such that it should be possible to open the door only when transformer is off. The enclosure shall be provided with lifting lugs and other hardware for floor mounting.
12.04.00	Core — Shall be High grade non-ageing cold rolled grain-oriented silicon steel Laminations.

12.05.00	Winding conductor	Shall be electrolytic grade copper. Windings shall be of class F insulation or better.
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12.06.00	Winding temperature Indicator (WTI)	Shall be Platinum resistance type temperature detector in each limb.
12.07.00	Thermistors	Shall be embedded in each limb with alarm and trip contacts for remote annunciation.
12.08.00	Temperature rise:	For dry type transformer the winding temperature rise shall be class-F (90 deg) for Class-H insulation and class-B (70 deg rise) for Class-F Insulation winding over an ambient of 50 deg.
13.00.00	**POWER CONVERTER:**	
13.01.00	The static power converter shall consist of a line side converter for operation as a rectifier and a load side power converter for operation as a fully controller inverter. Power converter shall be fast switching, most efficient and low loss type.	
13.02.00	The converter shall be coordinated with the transformers. The converter shall be able to withstand a three-phase short circuit current until interrupted by normal breaker operation.	
13.03.00	Adequate short circuit and over voltage protection shall be provided for the converter and inverter system.	
13.04.00	All power converter devices shall include protective devices, snubber networks and dv/dt networks as required.	
13.05.00	The current rating of the converter's semi-conductor components shall not be less than 120% of the nominal current flowing through the elements at full load of the VFD through the whole speed range. If the parallel connection of semiconductor is applied, the above current rating shall not be less than 140% of the above values.	
13.06.00	All power diodes shall be of silicon type with minimum VBO rating at 2.5 times the rated operating voltage.	
13.07.00	The power converter circuit shall be designed so that motor can be powered at its full nameplate rating continuously without exceeding its rated temperature rise nor reducing its service factor due to harmonic currents generated by the inverter operation. The conversion devices and associated heat sinks shall be assembled such that individual devices can be replaced without requiring the use of any special precautions / tools.	
13.08.00	The cooling system of the electronic components, if provided, shall be monitored and necessary alarms shall be provided to prevent any consequential damage to the power control devices.	
14.00.00	**OUTPUT FILTER (AS APPLICABLE):**	
14.01.00	Output/ dv/dt filter shall be provided, if required. It shall be an integral part of the VFD system and included within the VFD enclosure. It shall inherently protect motor from high voltage dv/dt stress.	
15.00.00	**DC LINK CAPACITOR (AS APPLICABLE):**	

CLAUSE NO.	TECHNICAL REQUIREMENTS
15.01.00	Capacitor shall be of self-healing film or electrolytic type having high life time. The capacitor shall be an integral part of VFD system. DC link Capacitors shall have discharge resistors which shall be capable of reducing the residual charges to zero just after the capacitor is disconnected from the supply source. The capacitor shall be suitable for high ripple currents.
16.00.00	AC/**DC Reactor (As applicable)** 1) Type: Dry type, air cored, self-cooled, indoor type. Suitable for withstanding earth fault continuously. 2) Insulation: Thermal Class 155(F), temperature rise is limited to thermal class 130 (B). 3) Noise level shall not exceed value specified in NEMA TR-1.
17.00.00	**VFD PANEL REQUIREMENTS**
17.01.00	Enclosure frames and load bearing members shall be as per MV/LV switchgear chapters (as applicable).
17.02.00	The cable entry shall be from the bottom of the panel and a removable bolted un-drilled gland plate.
17.03.00	All Panels shall be of dust-proof and vermin-proof construction and shall be provided with a degree of protection of IP: 3X or better for MV VFD and IP: 4X or better for LV VFD as per IS/IEC 60947
17.04.00	Enclosures must be designed to avoid harmonic and inductive heating effects and to shield any outside equipment from interference, enclosing and shielding the complete to eliminate any radio frequency interference. The construction of the panel shall provide effective protection against electromagnetic emissions.
17.05.00	Each panel shall be provided with illuminating lamp, space heater with switch fuse and variable setting thermostat.
17.06.00	Proper ventilation using air filters and fans/pumps shall be provided in the panels to ensure that maximum temperature inside the cubicle is within permissible limits for reliable and continuous operation of the system.
18.00.00	NOT USED.
19.00.00	**HT SWITCHGEAR**
19.01.00	VOID
20.00.00	**MOTORS**
20.01.00	VFD shall be used to drive three (3) phase squirrel cage inverter duty Induction motor with VPI insulation (Resin poor) suitable for VFD application. These motors shall be provided with insulated bearing on at least one side for motor frame size above 250 frame. However, contractor's proven practice with respect to use of insulated bearing in VFD driven motor may be accepted subject to Employer's approval.
20.02.00	Motors shall also meet the requirements mentioned in subsection for motors, relevant portions of the specifications for driven equipment and relevant IS/IEC.
20.03.00	Motor shall be suitable for operation with a solid-state power supply consisting of an adjustable frequency inverter for speed control & shall be suitable for the current waveforms produced by the power supply including the harmonics generated by the drive.
20.04.00	Motor insulation shall be designed to accept the applied voltage waveform, within the Vpeak and dv/dt limits as per IEC-61800.

CLAUSE NO.	TECHNICAL REQUIREMENTS
20.05.00	Drive manufacturer shall coordinate with the motor manufacturer for proper selection of the motor for the given load application and the output characteristics of the drive.
20.06.00	Other requirements of motor shall be as stipulated in technical chapter of Motors and driven equipment in Part-B of technical specifications.
21.00.00 .	**LT & HT CABLES**
21.01.00	Contractor's scope shall also include LT and HT cables suitable for VFD system and Motors.
22.00.00	**CONTROL AND PERFORMANCE REQUIREMENTS**
22.01.00	The VFD to provide an automatic current limiting feature to control motor currents during startup and provide a "soft start" torque profile for the motor load combination. Current and torque limit adjustments shall be provided to limit the maximum VFD output current and the maximum torque produced by the motor.
22.02.00	It shall be possible to vary the speed of the drive and control it in either Local or Remote mode. Local / Remote selection shall be done from VFD panel unless otherwise specified.
22.03.00	Provision shall be kept for exchange of information between different VFD control system parameters thru PLC/DDCMIS. Man machine interface for (MV) VFD shall have LED type or better monitor with keyboard (password protected) in the VFD room and provision for printing SOE/alarm in PLC/DCS in control room Parameter Monitoring: -Input and output voltage of Drive - Input and output current of Drive - Motor speed - Input and output power frequency of Drive - Torque -Input and Output power of Drive system (covering transformer if applicable) - Output kWhr of Drive - Transformer (if applicable) temperature for alarm & trip. - Ambient temperature - Run/stop and local/remote status displayed
22.04.00	Drive shall be equipped with a front mounted operator console panel consisting of a backlit alphanumeric display and a keypad with keys for parameterization and adjusting parameter. Control panel shall be operable with password for changing the protection setting, safety interlock etc.
22.05.00	Operator console/Main Control Card shall have facility / port to connect external hardware such as Lap-Top etc. Console shall have facility for upload and download of all parameter settings from one drive to another drive for start up and operation.
22.06.00	User-friendly licensed software (for entire plant life) for operation and fault diagnostic shall be loaded in the drive system panel before commissioning.
23.00.00	**PROTECTION FEATURES**
23.01.00	The system offered shall incorporate adequate protection features as per IEC 61800-4: 2002 Table-8, properly coordinated for the drive control and for motor including following: i) Converter transformer: short circuit, over current, earth fault & winding temperature high protection. ii) Incoming and outgoing line surge protection. iii) Under / over voltage protection iv) Phase loss, phase reversal, overload, negative phase sequence, locked rotor protection. v) Instantaneous Over current & Earth fault protection

vi) Converter/Inverter module failure indication.
vii) Over frequency/speed protection.
viii) Ventilation failure indication & alarm.
ix) Over temperature of VFD
x) Bearing temperature protection.
xi) System earth fault protection.
xii) Speed reference loss protection.

23.02.00 Under VFD Bypass Mode (if applicable) all the electrical protections related to the Motor shall remain applicable.

24.00.00 **CONTROL FEATURES**

24.01.00 Following controls shall be provided as a part of the Operator Control Panel or through separate switches on the front panel door.

i) Start / stop (in local/remote mode)
ii) Speed control (Raise / lower)
iii) Acknowledge/Accept/ Test Push Button for annunciation
iv) Auto / Manual / Test Mode select
v) Emergency stop
vi) Trip-Remote Breaker

25.00.00 **DIAGNOSTIC FEATURES**

25.01.00 The VFD shall include a microprocessor/PLC based digital diagnostic system which monitors its own control functions and displays faults and operating conditions.

25.02.00 Fault diagnostic shall be built into the system to supervise the operation and failure of the system. The information regarding failure of any of the system including shut down of the system shall be available. It shall be possible to retrieve the record of events prior to tripping of the system or de-energization. Auxiliary supply to the system components or to the electronics (firmware) for the diagnostics / display shall be taken care of by the manufacturer for this purpose.

26.00.00 **SERVICEABILITY / MAINTAINABILITY**

26.01.00 Power Component Accessibility: All power components in the converter sections shall be designed for rack-out accessibility for ease of maintenance and to minimize repair downtime.

26.02.00 Marking / Labeling: Sleeve type wire marker tags or other acceptable means of permanent identification shall be applied to power and control wiring. Individual labels shall be provided for all major components of the VFD system.

27.00.00 NOT USED.

28.00.00 **TESTS**

28.01.00 **ROUTINE TESTS**

All acceptance and routine tests as envisaged in QA section shall be carried out. Charges for these shall be deemed to be included in the equipment price.

28.02.00 **TYPE TESTS**

LIST OF TYPE TESTS TO BE CONDUCTED

The following type tests shall be conducted under this contract for MV VFD

i) Overall efficiency determination of VFD system including transformer/ Harmonic filters etc at motor full load
ii) Temperature rise test
iii) Noise level
iv) Harmonics of No-load current. (Input/Output)

LIST OF TESTS FOR WHICH REPORTS HAVE TO BE SUBMITTED

The following type test reports shall be submitted for VFD Panels'

1) VFD panels (For LV VFD used with load >= 50 KW)

i. Rated Current/ Output
ii. Temperature rise test
iii. Noise level test
iv. Power Loss Determination Test
v. Power factor measurement.
vi. Degree of Protection Test
vii. EMC Test
viii. The Fast transient SWC tests as per ANSI / IEEE C37.901-2002 / IEC 60255-22-04-2008 / IEC 61800

2) VFD panels (For MV VFD)

i. Rated Current/ Output
ii. Current Sharing
iii. Voltage Division
iv. Power Loss Determination Test
v. Power factor measurement.
vi. Degree of Protection Test
vii. The Fast transient SWC tests as per ANSI / IEEE C37.901-2002 / IEC 60255-22-04-2008 / IEC 61800

3) AC/DC Reactor

i. Lightning impulse test (If applicable)
ii. Heat run test
iii. Short time current test (If applicable)
iv. Noise level test

4) Transformers

i. As per requirements mentioned in subsection for Transformer chapter in technical specifications.

SUB-SECTION-B – 04

TRANSFORMERS & ASSOCIATED EQUIPMENTS

1.0.0 INTENT OF SPECIFICATION

This section covers the requirements of dry type LV service transformers.

2.0.0 SCOPE OF WORK

The scope of work shall include supply, installation, testing and commissioning of the following:

a) 6.6 & 11 / 0.433 kV rated dry type transformers for CHP, AHP, LHP System
b) Static excitation transformer
c) Commissioning spares and consumables
d) Mandatory spares
e) Tools & tackles
f) Any other equipment required for the system

3.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the following Indian Standards, IEC publications and any other standards of latest edition including amendments, except where modified and /or supplemented by this specification.

a) IS 2099 : Specification for bushings for alternating voltages above 1000V
b) IS 3347 : Dimension for porcelain transformer bushings
c) IS 3639 : Specification for fittings and accessories for power transformers
d) IS 4257 : Porcelain bushings for transformers
e) IS 10028 : Code of practice for selection, installation and maintenance of transformers.
f) IS 2705 : Specification for current transformers
g) IS 10561 : Application guide for power transformers.
h) IS 11171 : Specification for dry-type power transformers
i) CBIP Manual on transformers

4.0.0 DESIGN REQUIREMENTS

4.1.0 Transformers shall be designed with maximum temperature rise of 90°C over design ambient of 50°C. The core and other associated parts shall also be limited to the same value of temperature rise as for the windings.

4.2.0 Required numbers of service transformers for supplying 415 V loads of entire plant shall be provided. For each switchgear, 2X100% rated transformers shall be considered. Each transformer shall be rated to meet the loads connected on both the bus sections of switchgear with 10% design margin. The rating of transformers shall be between 630 kVA and 2500 kVA.

4.3.0 For each mechanical system, separate set of service transformers shall be provided. Loads of two systems shall not be fed from the same transformer.

4.4.0 The transformers shall be capable of delivering the rated output at any particular tap continuously without exceeding the specified temperature limits under the following operating conditions.

- Voltage variation of ± 10% of rated voltage of that particular tap.
- Frequency variation of +3% -5% of rated frequency.
- Combined voltage and frequency variation of 10% (absolute sum).

- Minimum ambient temperature specified in the specification

4.5.0 The maximum flux density in any part of the core and yoke at the rated MVA, voltage and frequency shall be such that under 10 per cent continuous over-voltage condition it does not exceed 1.67 Tesla.

4.6.0 Transformers shall withstand, without injurious heating 125% over fluxing for a period of one (1) minute and 140% over fluxing for a period of five (5) seconds. (Over fluxing caused by combined voltage and frequency fluctuations).

4.7.0 Transformers shall be capable of operating at 125% rated voltage for a period of one (1) minute and 140% rated voltage for a period of ten (10) seconds due to sudden load throw off.

4.8.0 The transformers shall be free from annoying hum and vibration when it is in operation, even at 110% rated voltage.

4.9.0 The transformers shall be designed with particular attention to the suppression of maximum harmonic voltage, especially the third and fifth so as to minimize interference with communication circuit.

4.10.0 The transformers shall be capable of withstanding without injury, the thermal & magnetic stresses caused by faults on any of the winding /through faults with full voltage maintained on other winding for a period of 2 seconds. Bushing CT shall be rated for the same fault current for a duration of 1 second.

4.11.0 The transformers shall be capable of being loaded in accordance with IS: 6600/IEC-600354. There shall be no limitation imposed by bushings, tap changers etc. or any other associated equipment.

4.12.0 The noise level of transformer, when energized at normal voltage and frequency with fans running shall not exceed, when measured under standard conditions, the values specified in NEMA standard publication TR-1.

4.13.0 Efficiency of the transformers shall be in the range of 98.25 to 98.75% at 0.8 PF at full load for various ratings between 500 kVA and 2500 kVA.

5.0.0 CONSTRUCTIONAL FEATURES

5.1.0 Dry type transformers shall be Vacuum pressure impregnated type (VPI) or encapsulated type.

5.2.0 Core & Windings

Windings shall be fully uniformly insulated. The high voltage and the low voltage coils shall be wound with high conductivity copper conductors and the insulation shall be done by Vacuum pressure impregnation process. Coils shall be separated by a uniform air space that permits free circulation of cooling air between the coils. Windings shall be properly sized, insulated and supported for the voltages and currents to be encountered in operation, including short circuits. Insulation shall be class –H and temperature rise shall be limited to class F.

5.3.0 Core

The transformer core shall consist of thin, individually insulated sheets of high permeability, cold rolled grain-oriented, non-aging silicone steel. They shall be miter-corner-cut without burs, to provide a cross section most nearly resembling the circular cross-section. Laminations shall be

cut and stacked utilizing step-lap construction to reduce losses and sound. Designed flux density shall be kept well below saturation.

The assembled core shall be braced with heavy structural steel angle or channel to apply uniform clamping forces across the entire width, top and bottom. The core shall be protected from corrosion with high temperature rated rust-resistant coating.

5.4.0 Core and Coil Assembly

Construction shall consist of separate high and low voltage coils for each phase, mounted coaxially, with high/low air space between coils adequate for the rated voltage potentials. Coils shall be mounted concentrically and supported in place on the transformer core so as to restrain movement in shipping and in service. Each coil shall be supported on epoxy blocks, top and bottom, with resilient pads to retain the coils while permitting thermal expansion under loading. The core-and-coil assembly shall be designed and manufactured to withstand without damage the short circuit testing. All leads from the windings to the terminal board and bushings shall be rigidly supported to prevent injury from vibration or short circuit stresses.

5.5.0 Bus

All bus work shall be designed to withstand maximum short circuit stresses when connected to a supply system having a specified fault capacity, and to meet all test voltage requirements, without audible or visible corona.

Low voltage bus shall be high conductivity copper. Connections of coil windings to bus shall be brazed or welded using shielded arc techniques. Connection and terminal bolting surfaces shall be tin or silver-plated. Bolted connections shall include spring washers to maintain bolted surface pressure. All bus shall be sized to for the amperes involved and maximum specified ambient temperatures.

High voltage bus shall be high conductivity copper. It shall be supported by glazed porcelain insulators for surge strength. It shall have bolt-connected joint and terminal surfaces tin or silver-plated. High voltage leads shall be bus or flexible, insulated cable with suitable terminations. Taps shall have flexible cable or solid copper links or jumpers.

Ground bus shall be copper bus or aluminium extending the full length of the enclosure. It shall have provisions to mount appropriate terminal connections for external grounding.

5.6.0 Enclosure

The enclosure shall be a ventilated enclosure for indoor use and be designed to provide adequate ventilation for the transformer. Protection of enclosure shall be atleast IP 33. Screens shall be perforated sheet steel type. Mesh size shall be such that lizard, rats etc. cannot enter inside the enclosure.

Double leaf access shall be provided with concealed hinge and neoprene gaskets for easy access to HV links and also for withdrawal of core and coil assembly if required. The enclosure shall be of CRCA sheet steel with a minimum thickness of 2 mm while the roof and vertical supports shall be formed from minimum 3 mm thick sheet steel. The enclosure shall be adequately reinforced to ensure rigidity so as to permit transportation of transformer within enclosure.

The core of the transformer shall be visibly grounded to the enclosure by means of a flexible grounding conductor sized adequately. Each transformer shall be provided with one set of bi directional rollers for rolling the transformer parallel to either centre line.

5.7.0 Base

The transformer base shall be a separate rigid steel construction capable of supporting the core and coil assembly and enclosure. Construction shall include provisions for lifting as well as for jacking and skidding or rolling in both directions. Lifting provisions shall be designed for lifting the transformer and the core-and-coil assembly, separately or together.

5.8.0 Temperature Indicators

For measuring temperature in the winding PT-100 Resistance temperature detectors shall be embedded in all three phases in LV windings. Potential free alarm and trip contacts shall be provided in to operate alarm and trip circuits. Four channel temperature scanner & local winding temperature indicator for winding temperature measurement shall be provided in the marshaling box. The same shall be hooked up to DCS/EMS.

5.9.0 Off Circuit Tap Changer

a) Off circuit taps as specified shall be provided on the high voltage winding.

b) The transformer shall be capable of operation at its rated kVA on any tap provided the voltage does not vary by more than 10% of the rated voltage corresponding to the tap.

c) The winding including the tapping arrangement shall be designed to maintain electromagnetic balance between HV and LV windings at all voltage ratios.

d) The tap change switch shall be three phase, hand operated for simultaneous switching of similar taps on the three phases by operating on external hand wheel.

e) The tap changing shall be possible without disturbing the transformer in any way except de-energizing.

f) Arrangement shall be made for securing and locking the tap changer in any of the working positions, and it shall not be possible for setting or locking it in any intermediate position. An indicating device shall be provided to show the tap in use.

g) Cranking device for manual operation of the off circuit tap changing gear shall be removable and suitable for operation by a man standing on ground level. The mechanism shall be complete with the following:-

- Mechanical tap position indicator which shall be clearly visible from near the transformer.
- Mechanical stops to prevent over cranking of the mechanism beyond the extreme tap positions.
- Manual operating mechanism shall be labeled to show direction of operation for raising the secondary voltage and vice versa.
- A warning plate indicating “The switch shall be operated only when the transformer has been de-energised” shall be fitted.

5.10.0 Safety Interlock

For all dry type transformers following safety interlocks shall be provided:

a) A safety interlock to ensure that the enclosure door can be opened only when transformer is de energized.

b) Safety limit switches operated by door handle for tripping HV breaker.

5.11.0 Limit Switches

Minimum 4 Nos. limit switches shall be provided for transformer enclosure door interlock. Each Limit switch shall have 1 NO & 1 NC contact. All NO contacts of limit switch shall be connected series and NC contacts shall be connected parallel. Limit switch shall be used for HT Circuit breaker tripping and HT Circuit breaker closing permissive.

5.12.0 Bushings

a) All bushings shall be homogenous, non-porous porcelain type, uniformly glazed and free from blisters, burns and other defects complete with suitable terminal connectors of adequate capacity..

b) Bushings located indoor can be epoxy-molded types.

c) Clamps and fittings of steel or malleable cast iron shall be galvanised.

d) Bushing location shall provide adequate phase and ground clearances.

e) For indoor bushing, creepage distance shall be 20 mm/KV.

5.13.0 Cable Box

a) A dust tight air insulated type cable box with IP: 55 protection shall be provided for terminating the cables with termination kit.

b) Inspection cover for fixed portion of cable box shall be provided. Handles for lifting cable box shall be provided.

c) Gland plate for single core cable termination shall be of Aluminium.

d) The cable box shall have Pressure Relief Diaphragm (PRD).

5.14.0 Busduct Termination

For busduct termination a flanged throat or equivalent connection shall be provided with IP 55 degree of protection to suit the busduct. The busduct shall be non-phase segregated type. Busduct terminals and flange shall be coordinated with bus duct size. The arrangement shall be such as to permit removal of the transformer and core / coil assembly without dismantling the bus duct installation. Necessary flexible shall be provided to connect the bushing terminals to the busbar.

5.15.0 Neutral Terminals

a) Two Nos. neutral terminals shall be provided on LV side. One neutral terminal shall be part of phase connection arrangement busduct throat/ LV cable-box (as applicable). Other neutral terminal shall be brought to the transformer bottom for connection to station earth by means of earthing bar of copper / Aluminium, supported on insulators mounted on transformer body.

b) Neutral bushing CT shall be provided for protection. CTs shall be cast resin type. CT shall be located as per protection requirement.

5.16.0 Marshalling Box

a) The marshalling box shall be fabricated using sheet steel of at least 2 mm thickness.

b) Marshalling box shall be complete with all internal wiring and identification ferrules, cables, conduits required for wiring between marshalling box and instruments on transformer.

c) The marshalling box shall be provided with thermostatically controlled space heaters and shall have IP: 54 degree of protection.

d) CT terminals shall be with shorting and disconnecting facility.

e) Cable gland plate shall be of removable type.

f) The marshaling box shall have MCB for incoming power supply.

g) Marshaling box shall have seven channel temperature scanner & local winding temperature indicator for winding temperature measurement. Terminal block shall be provided in the marshaling box to connect cabling between RTD's and Temperature scanner. The temperature scanner unit shall continuously monitor the winding temperature and shall be provided with auxiliary relays with potential free contacts for alarm and trip.

5.17.0 Wiring

- All control, alarm and indication devices provided with the transformer shall be wired up to the terminal blocks.

- Wiring shall be done with 1100 V grade XLPE insulated FRLS wires in conduit or XLPE insulated armoured FRLS cable. Minimum wire size shall be 2.5 sq.mm. stranded copper for control & 4 sq.mm. stranded copper for CTs. Not more than two wires shall be connected to a terminal. 20% spare terminals shall be provided.

- All devices and terminal blocks within the marshaling box shall be identified by symbols corresponding to those used in applicable schematic or wiring diagrams. Each wire shall be ferruled by plastic tube with indelible ink print at both end having terminal block no. terminal no. as per approved schematic or wiring diagrams.

5.18.0 Name plate

Each transformer shall be provided with a rating name plate. Plates shall be stainless steel material fitted in a visible position . Name plates shall be of white non-hygroscopic material with engraved black lettering.

6.0.0 PAINTING

All the fabricated surfaces shall be pre-treated by degreasing, de-rusting and chemically cleaned prior to application of epoxy resin red oxide primer to give a dry film thickness of 50 microns. The finishing paint shall be half gloss based on an epoxy based. The paint shall be applied in two coats to give a minimum dry film thickness of not less than 50 microns. The final paint shade of external surface of shall be RAL 7035.

7.0.0 TESTS

7.1.0 Offered rating and type of transformer should have type tested.

7.2.0 Type tests/ Routine tests / Special tests / Acceptance tests shall be conducted as per standards and test reports shall be submitted for review.

7.3.0 The following type tests shall be conducted one on each rating of transformer

- Measurement of winding resistance
- Measurement of voltage ratio and check of phase displacement
- Measurement of impedance voltage, short circuit impedance (principal tapping) and load loss.
- Measurement of no-load loss and current.
- Separate source voltage withstand test
- Induced overvoltage withstand test
- Lightning impulse test
- Temperature rise Test.

7.4.0 Following routine tests shall be conducted on each transformer

- Measurement of voltage ratio and check of phase displacement
- Measurement of impedance voltage / short circuit impedance (principal tapping) and load loss.
- Measurement of no load loss and current.
- Separate source voltage withstand test
- Induced overvoltage withstand test

7.5.0 Following Special tests shall be conducted on each rating of transformer

- Short circuit withstand test
- Partial discharge measurement • Measurement of Acoustic noise level
- Degree of protection test.

7.6.0 The following tests/ checks shall be conducted at site. Any other tests/checks as per the manufacturer's recommendation shall also be carried out

- Resistance measurement of windings
- Ratio test
- Vector group test
- Tap changer test
- Temperature indicator test
- Marshaling kiosk test
- Magnetizing current test
- Earthing connections continuity test
- CT polarity check

8.0.0 TECHNICAL PARAMETERS OF DRY TYPE TRANSFORMERS

Sl. No.	Description	Unit	Data
1.	Service		Indoor
2.	Type		Dry type, two winding
3.	No. of Phase		Three
4.	Frequency	Hz	50
5.	No. of windings		Two
6.	Nominal system voltage (HV / LV)	kV	11/0.433 6.6/0.433
Sl. No.	**Description**	**Unit**	**Data**
7.	Vector group		Dyn1
8.	Type of cooling		AN
9.	Impulse withstand level		
a)	HV side	kV	75
10.	One minute Power frequency withstand voltage		
a)	11 side	kV	28
a)	6.6 side	kV	20
b)	LV side	kV	3
11.	Connections		
a)	HV side		Delta
b)	LV side		Star
12.	Neutral Earthing		
a)	HV side		
b)	LV side		Solidly grounded
13.	Terminal arrangement		
a)	HV side		Cable Box

b)	LV side		Busduct
a)	LV Neutral side		Ground conductor
14.	Bushings		
a)	Indoor Bushings Creepage distance		20 mm /kV
15.	Tap Changer		
a)	Type		OCTC
b)	Tap provided on		HV side
c)	Range of taps	%	+5% to –5% in steps of 2.5%
16.	Short circuit withstand duration	Sec	2

9.0.0 DRAWINGS & DOCUMENTS

The following drawings and documents shall be submitted for approval during detail engineering stage.

- Transformer sizing calculation
- Technical data sheet
- Dimensional General Arrangement drawing of transformer.
- Parts list
- Bushing / Terminal arrangement
- Cable box details
- Busduct termination arrangement
- Catalogues/drawings for bought out items.
- Transport /Shipping dimension drawing
- Foundation Plan & loading details
- Name plate details
- Design calculations for short circuit withstand capability.
- Erection and commissioning procedures
- Operation and maintenance manual
- Test reports
- Sub-vendor list
- Manufacturing quality plan
- Field quality plan

SUB-SECTION-B – 05A

MV SWITCHGEAR

SUB-SECTION-B – 05B

MV SWGR (PROTECTIONS, CONTROL AND METERING)

PROTECTIONS, CONTROL AND METERING

1.00.00 SYSTEM DESCRIPTION

1.01.00 **SWITCHGEAR NUMERICAL RELAY NETWORKING**

Switchgear Numerical Relay network Architecture

(a) The typical configuration of such a proposed system is as per the enclosed drawing no. 0000-205-POE-A-001 (Overall Architecture of Switchgear Relay Network). The numerical relay network shall include relays on all MV & LV switchgears being supplied under this package. Each ring network shall consist of switchgear level Ethernet switches connected through Fibre Optic cable and subsequently connected to Network Level Ethernet Switches placed in main plant control equipment room (CER).

(b) The point-to-point testing of all signals of Numerical Relays for the Switchgear network at the DDCMIS and protection equipment (Switchgear) end shall be the responsibility of the contractor.

2.00.00 SYSTEM PERFORMANCE REQUIREMENTS

2.01.00 **Latency:** The system shall be so designed and implemented as to provide data transfer speeds prescribed by *IEC 61850-5*.

2.02.00 **Reliability:** All components shall be designed and configured to make the system highly reliable. Failure of any component shall be immediately announced and wherever possible, the system shall be made self-healing.

2.03.00 **Diagnostic tools:** The system shall have necessary diagnostic tools to continuously monitor the system performance and provide feedback to the operator / engineer. Necessary software tools to track changes in the system shall be provided.

3.00.00 NUMERICAL RELAYS

3.01.00 **General requirements**

3.01.01 All Numerical relays shall be of types, proven for the application satisfying requirements specified elsewhere and shall be subject to Employer's approval. Numerical Relays shall have appropriate setting ranges, accuracy, resetting ratio, transient overreach and other characteristics to provide required sensitivity for the intended application.

3.01.02 All numerical relays shall be rated for control supply voltage as mentioned elsewhere under system parameters and shall be capable of satisfactory continuous operation between 80-120% of the rated voltage. Making, carrying and breaking current ratings of their contacts shall be adequate for the circuits in which they are used. Threshold voltage for binary inputs shall be suitably selected to ensure avoidance of mal operation due to stray voltages and preferably shall be more than 70% of the rated control supply voltage.

3.01.03 One minute power frequency withstand test voltage for all numerical relays shall at least be 2kV (rms).

3.01.04 All IEDs shall have freely programmable optically isolated binary inputs (BI) and potential free binary output (BO) contacts, the quantity of which shall be adequate to realize the associated interlocks / feedbacks. At least 2 binary inputs (BI) & 2 binary outputs (BO) shall be kept as Spares for Employer's future use.

In case the offered IED does not have the required number of I/Os, the same can be achieved through external I/O device of same make complying with the requirement.

CLAUSE NO.	TECHNICAL REQUIREMENT
3.01.05	Failure of a control supply and de-energization of a relay shall not initiate any circuit breaker / vacuum contactor operation.
3.01.06	Disturbance Record waveforms, event records & alarms shall be stored in Non-volatile memory and failure of control supply shall not result in deletion of any of these data.
3.01.07	All the numerical relays shall have communications on three ports, one local front port communication to laptop and two rear port on IEC 61850 to communicate with the DDCMIS through LAN.
3.01.08	All Numerical relays shall have features for electrical measurements including voltage, current, power (active & reactive), frequency, power-factor and energy parameters.
3.01.09	All numerical relays shall have provision of both current (CT) and voltage (VT) inputs. Relays shall be suitable for both residually connected neutral CT input as well as CBCT input. Relays shall be suitable for CT secondary current of 1A. Following minimum no. of CT inputs to be provided in numerical relays used for different type of feeders as mentioned below including phase and neutral CT inputs.

1	DB(MV transformer feeders without differential)	4CT
2	DBF(MV transformer feeders with differential)	7CT
3)	DA(MV motor without Diff)	4CT
4)	DAF(MV motor with Diff)	7CT
5)	DC(MV incomer)	5CT
6)	DD/DE-OG/DE-IC(MV Tie, buscoupler)	4CT
7)	DAET(LT incomer)	4CT
8)	DAE(Buscoupler,Tie)	4CT
9)	DM(ACB Controlled Motor)	4CT
10)	DG I/C	7CT

3.01.10	Relays used in incomers, ties and bus couplers shall have provision of two sets of voltage inputs (3Nos for bus voltage & 1No. for line voltage) for the purpose of synchronization.
3.01.11	All CT terminals on the relays shall be of fixed type suitable for connection of ring-type lugs to avoid any hazard due to loose connection leading to CT open-circuit. In no circumstances Plug In type connectors shall be used for CT / VT connections.
3.01.12	All numerical relays shall have keypad / keys to allow relay setting from relay front. Pre-programmed or programmable key for Master trip (86) reset shall be provided on the relay front.
3.01.13	Relays shall have suitable output contact for circuit breaker failure protection (CBFP).
3.01.14	Relays shall have self-diagnostic feature with continuous self-check for power failure, program routines, memory and main CPU failures and a separate output contact for indication of any failure.
3.01.15	Relays shall have at least two sets or groups of two different sets of adaptable settings. Relays shall have multiple IEC / ANSI / user-programmable characteristics.
3.01.16	Design of the relay must be immune to any kind of electromagnetic interference.
3.01.17	All cards/ hardware of numerical relays shall be suitable for operation in Harsh environmental conditions with respect to high temperature, humidity & dust.
3.01.18	Relays of each type/model shall be supplied with same Firmware/Software version for the complete package.

CLAUSE NO.	TECHNICAL REQUIREMENT
3.02.00	**Protections: Relay Types & Protections**
3.02.01	**Motor Feeder Protections (Module Type DA/DAF/CC/DM)** The Motor protection relay shall be suitable for providing the following protections **a) Thermal Overload Protection (49),** **b) Short Circuit Protection (50)** **c) Earth Fault Protection (50N)** **d) Negative Phase Sequence Protection (46)** **e) Locked Rotor Protection (50LR)** **f) Motor start monitoring & Restart inhibit feature** **g) Number of starts limitation (66)** **h) Under Voltage protection with time delay (27M)** **i) Motor Differential protection (87M)** **j) VT Fuse-fail protection (60)**
3.02.02	**Transformer Feeder Protections (Module Type DB/DBF/CCT)** The Transformer protection relay shall be suitable for providing the following protections. **a) Three Phase Over current and Earth Fault protection (50 & 50N)** **b) Transformer Differential protection (87T)** **c) Transformer trouble trips** **d) Inrush protection function**
3.02.03	**Protections for Incomers, Bus-couplers and Tie feeders (Module Type DC/DE/DD/DAET/DAE)** The Incomer, Bus Coupler & Tie feeder protection relay shall be suitable for providing the following protections **a) Three Phase Over current and Earth Fault protection (50 & 50N)** **b) Restricted Earth Fault protection (64R) [Applicable only for DC/DAET]** **c) Stand by earth fault protection (51N) [Applicable only for DC]** **d) Inrush protection function** **e) Synchronizing Check (25)** **f) Bus No-volt**
3.03.00	**Other Protections and Control features**
~~3.03.01~~	Control of breakers / vacuum contactors shall be carried out from DDCMIS through hardwired control commands in the form of 24V DC signal. All close and trip commands from DDCMIS shall be hardwired through separate coupling relays ~~to BI of numerical relays in form of 220 V DC signal.~~
3.03.02	Deleted
3.03.03	Deleted
3.03.04	Trip circuit supervision shall be provided for all feeders to monitor the circuit breaker / contactor trip circuit both in pre-trip and post-trip conditions.

CLAUSE NO.	TECHNICAL REQUIREMENT
3.03.05	Schematics requiring auxiliary relays / timers for protection function shall be a part of numerical relay. The number of auxiliary relay and timer functions shall be as required for the application. Timer functions shall be configurable for on & off delays as per requirement.
3.03.06	The numerical relay shall be able to provide supervisory functions such as trip circuit monitoring, circuit breaker status monitoring, VT and CT supervision.
3.03.07	The numerical processor shall be capable of measuring and storing values of a wide range of quantities, all events, faults and disturbance recordings with a time stamping using the internal real time clock. Battery backup for real time clock in the event of power supply failure shall be provided.
3.03.08	At least 200-time tagged events / records shall be stored with time stamping. Details of at least 5 previous faults including the type of protection operated, operating time, all currents & voltages and time of fault.
3.03.09	Diagnostics Automatic testing, power on diagnostics with continuous monitoring to ensure high degree of reliability shall be provided. The results of the self-reset functions shall be stored in battery back memory. Test features such as examination of input quantities, status of digital inputs and relay outputs shall be available on the user interface.
3.03.10	20 Signals (both Analog & Digital) from each relay shall be communicated to DDCMIS on IEC 61850 protocol. Exact signals shall be finalised during detailed engineering.
3.03.11	Sequence of events shall have 1ms resolution at device level.
3.03.12	Measurement accuracy shall be 2 % for rated RMS Current and voltage
3.03.13	It shall be possible to carryout open / close operation of breakers from a laptop by interfacing from the relay front port during initial commissioning.
3.03.14	All motor feeders(>30KW) shall have min one no. of 4-20mA analog output (current signal) for use in control logics in DDCMIS or for information in DDCMIS.
3.03.15	GOOSE Controls shall be configured in the Numerical Relays for following functions. The response time of GOOSE interlocks shall be 10ms. (GOOSE Performance Class P1, Message Type 1A) (a) Inter tripping (b) Reverse Blocking including Hard Wiring (c) Earthing Interlocks
4.00.00	**ETHERNET SWITCH**
4.01.00	**Ethernet Switch at Switchgear Level/Network Level:** Ethernet switches shall be 'substation hardened ',19" rack mounted and shall comply with IEC61850 for communications and environment requirements. The Ethernet switches shall be of Layer 2 & managed type with four (4) Nos of Fibre Optic ports fully populated with SFP modules and Sixteen (16) / Eight(8) Copper ports to achieve the LAN configuration indicated in the drawing. These switches shall be mounted inside the switchgear panels and shall be suitable for accepting dual redundant power supplies. The FO ports shall be Single mode 1000Mbps ports. Copper ports shall be 10/100Mbps ports. The switch shall support RSTP/MSTP. The Ethernet Switch shall have feature of MAC binding per port and IEEE 801.1X radius Authentication for Port Security. Switch shall have feature to monitor the Port status over Modbus/SNMP Protocol & Port Configuration through Web Interface.
4.02.00	Necessary software for configuration and real-time network monitoring shall be provided along with the Ethernet switches. Network monitoring feature shall be integrated with the HMI (Switchgear EWS) to provide complete network status.
5.00.00	**LAN CABLE & CONNECTOR**
5.01.00	Cat5e/Cat6 Ethernet cable shall be used for connecting the numerical relays to Ethernet switches. In case FO ports are proposed on the numerical relays, Ethernet switches shall also

	have suitable FO ports as per the quantity mentioned above. Further, additional FO patch cords of maximum length (quantity – 10% of total quantity of IEDs) shall be supplied to facilitate maintenance.
6.00.00	**FO CABLE & CONNECTOR**
6.01.00	The Fibre Optic cable shall be armoured, Single-mode, graded index OMI (ISO/IEC 11801) of Diameter 125µm core / cladding with max attenuation of 1.52 dB/km at 1310nm wavelength & 1.0 dB/km at 1550nm wavelength. The cable should be suitable for operation at 1310/1550nm. The outer Sheath / Jacket of the FO Cable shall be Fire retardant.
7.00.00	**Ethernet Switch Box**
7.01.00	Ethernet Switch Box shall consist of the following: (a) Two nos. Ethernet switches (layer-3) at network level for Ring formation and taking data from Numerical relay network (IEC-61850) and providing to DDCMIS(IEC-61850) (b) At least 2 Nos (1 working + 1 standby) ventilation fans with monitoring (c) Arrangement for receiving and distributing auxiliary power supply to various equipment / circuits along with monitoring devices for incoming power supply (d) 1 LED light +1 Power Socket with Switch (e) Any other equipment / device necessary for completeness of the system
7.02.00	The Network level Ethernet Switches shall be provided to network the various switchgears at different locations through LAN system. They shall also provide gateway between Numerical relays, HMI (Switchgear EWS) and DDCMIS.
8.00.00	**HMI (Switchgear Engineering Workstation) and Laptop**
8.01.00	HMI (Switchgear Engineering Workstation) shall consist of industrial grade PC with Laser printer connected to the relay network through Network level switches for online configuration/setting change of relays & ethernet switches. Automatic downloading and saving of the disturbance records & event files from relays through automatic DR download software tools provided by the relay vendors shall also happen in this HMI. All the HMI PCs being offered in the system shall be as per the latest available configurations as on the date of bid opening. The minimum storage capacity shall be 1 TB, minimum RAM shall be 16GB and processor shall be I7/ equivalent or higher. Screen size shall be minimum 24 inches.
8.02.00	Operating system of the HMI shall be 64-bit Windows Professional/Enterprise version and necessary application software such as relays configuration & setting software, Disturbance record analysis software, Relays IEC 61850 configuration software, Ethernet Switches configuration software, Anti-virus software, etc shall be installed in the HMI.
8.03.00	Licensed software for automatic downloading & saving of Disturbance records and Event records from Numerical relay to Switchgear Engineering works stations (EWS) shall also be provided & installed in HMI (Switchgear EWS).
8.04.00	Laptops shall have same hardware configuration and software as for HMI PC except screen size which shall be 14 inches.
8.05.00	HMI console (furniture i.e. Table with drawer & chair) shall be provided for each HMI. The console shall have space for keeping an additional PC (to be supplied as part of main plant & switchyard DC health monitoring system) also.
9.00.00	**SYSTEM SOFTWARE REQUIREMENTS AND DOCUMENTATION**
9.01.00	The Contractor shall provide all licensed software packages required by the system for meeting the intent, functional and parametric and performance requirements of the specification. All licenses (except anti-virus which shall be valid for 3 years) shall be valid for the continuous service life of the plant.
10.00.00	**SYSTEM SECURITY**

CLAUSE NO.	TECHNICAL REQUIREMENT
10.01.00	Security features shall be provided for Identification and authentication control at each level for safeguarding against unauthorized access.
10.02.00	The contractor shall provide software locks / passwords to the Employer's engineers at site for all operating and application software at all levels.
10.03.00	Security Audit for Switchgear Relay Network shall be done as mentioned in Section- VI, Part-B Sub-Section – IIIC-02 DDCMIS Annexure IIIC-02J. Suitable actions based on the findings of the security audit shall be carried out by the relay/ Ethernet switch supplier.
10.04.00	**STANDARDS AND COMPLIANCE**
	The system shall comply with the latest versions of the following Standards and Specifications as a minimum:
10.04.01	IEEE 1686-2013: IEEE Standard for Intelligent Electronic Devices Cyber Security Capabilities.
10.04.02	IEC-62443-4-2: Security for industrial automation and control systems - Part 4-2: Technical security requirements for IACS components.
10.04.03	IEC TS 62351-6: Power systems management and associated information exchange - Data and communications security - Part 6: Security for IEC 61850.
11.00.00	**FAST BUS TRANSFER SYSTEM**
	Deleted
12.00.00	**ENGINEERING**
12.01.00	Complete engineering including the following: (a) Development of Module Type-wise Schemes with hardwired & soft logics. (b) Configuration of Feeder IED including Protection and Control logics (c) Configuration of Fast Bus Transfer Systems (d) Relay Network Design based on reliability & speed (e) Configuration and application development of Switchgear relay network as required for real time monitoring & data acquisition (f) Preparation & Submission of mimic document for Relay Network architecture for helping DDCMIS supplier to create the dynamic/static mimic in DDCMIS for Network monitoring (g) Preparation of I/O lists for each module type for integration with DDCMIS on IEC-61850 protocol (h) The integration of Switchgear Relay Network with Switchgear DDCMIS shall be finalized in consultation with the Switchgear DDCMIS supplier in Technical Co-ordination meetings (TCMs) and the same shall be tested as a part of Major Design Feature testing with a prototype system of the offered Switchgear relay Network system, at the works of the DDCMIS supplier or any other place approved by Employer. (i) The required. ICD / .CID files of the Numerical relays under MV Switchgears for the integration with the DDCMIS shall be provided by the Numerical relay vendor along with necessary engineering support as and when required during detail engineering. (j) During the Factory Acceptance Test (FAT) of the DDCMIS, Relay & Ethernet Switch supplier will arrange a prototype ring with at least three ethernet switches (L2) with one numerical relay of each type and L3 Switches network, at the works of the DDCMIS supplier along with the necessary engineering support. Exact test setup shall be finalized during detailed engineering.

CLAUSE NO.	TECHNICAL REQUIREMENT
12.02.00	Numerical relay configuration for all relays being supplied under the package shall be carried out in line with the approved schematics and shall be submitted for Employer's approval. Setting calculations and relay settings configured in relay software for all relays shall be submitted for Employer's approval. Approved relay configuration / settings files shall be loaded in all the relays prior to dispatch to site.
13.00.00	**TRAINING**
13.01.00	The vendor shall arrange for training on system design, engineering, operation and maintenance of Numerical relays & Numerical relay Network system at the principal's facility and at site as follows:
13.02.00	Training at principals works (Relay Manufacturer) in the following areas: a) Basics of Feeder, Transformer and Motor Protection for IEC 61850 Numerical relay and detail discussion on functions available in the relays. b) Relay configurations and hands on practice of preparation of logic & settings, .CID files through relay software tools and relay GOOSE Logics. c) Interfacing / communication of relay with software: uploading / downloading of logic. d) Secondary injection testing of provided function blocks and guidelines for relay settings. DR downloading and analysis for Fault diagnostics e) Common problems faced and trouble shooting The Scope shall include providing training in the areas stated above for five (5) No Executives from Engineering, Site Erection, and O & M for a duration of five (5) days. The cost of training including boarding & lodging and local transportation shall be in the vendor's scope. **Training Workshop at Site** Workshop Training at site shall aim for familiarization of Site Engineers for commissioning and day to day O & M of Numerical Relays and Numerical Relay Network and trouble shooting. The scope shall include Two No's of Numerical Relay and Numerical Relay Network workshops and Training for a batch of 20 Engineers at Project Site. One such Workshop shall be organized before the commissioning of First MV Switchboard and the Second workshop shall be conducted before Unit Commissioning. Employer shall provide the required Infrastructure such as Training Conference room, Projection systems etc.
14.00.00	**AUXILIARY POWER SUPPLY**
14.01.00	The numerical relays & Ethernet switches being installed at switchboard shall be suitable for auxiliary power supply 240V DC/110V DC with tolerance of 80% to 120 % of rated voltage & shall be finalized during detailed engineering. Ethernet switches shall have provision to receive dual redundant power supplies. However, other network components such as Network level switches, HMI,etc. shall be suitable for 240V AC & redundant 240V AC UPS supply for these components shall be provided.
15.00.00	**INPUT / OUTPUT INTERFACE, FILTERS AND OPTICAL ISOLATION**
15.01.00	Relay shall be immune to capacitance effect due to long length of connected control cables. Any external hardware, if required for avoiding mal operation of the relay due to cable capacitance shall be included as a standard feature.
15.02.00	All I/Os shall have optical isolation. Analog inputs shall be protected against switching surges, harmonics etc.
15.03.00	No separate earth bus shall be required for the relays. It shall be possible to connect the relay earth to the common earth bus in the switchgear panel which shall be connected to the plant earth mat.

16.00.00 **TIME SYNCHRONIZATION**

16.01.00 Time clock synchronization equipment provided for the DDCMIS shall have SNTP port and all the clocks of the numerical relays, Ethernet Switches, HMI, etc., shall be time synchronized on SNTP with the same. The resolution of time synchronization shall be +/- 1.0 millisecond or better throughout the entire system. Necessary cable (with protective conduit, if required) for connecting the GPS receiver / clock to the Network level switches shall also be in bidder's scope.

16.02.00 One Digital display of time shall be provided in the Network level Ethernet switch box.

17.00.00 **TYPE TESTS AND FACTORY ACCEPTANCE TESTS**

17.01.00 Type test reports for the following tests on the model of the relays & Ethernet switches being offered shall be submitted for Employer's review. Type Tests of Ethernet Switches shall have been conducted at NABL accredited Lab.

S. No.	TEST ITEMS	Standard
1	Dimensions of structure and visual inspection	IEC 60297-3-101
2	Functional requirements:	Relevant IEC 60255-100 series
	– Steady-state simulation	
	– Dynamic simulation	
3	Product safety requirements	IEC 60255-27
	(including the dielectric tests and thermal short time rating)	
4	EMC requirements:	IEC 60255-26
	– Emission	
	– Immunity	
5	Energizing quantities:	
	– Burden	N/A
	– Change of auxiliary energizing quantity	IEC 60255-11
6	Contact performance	N/A
7	Communication requirements	Relevant IEC protocol standards
8	Climatic environmental requirements:	IEC 60068-2-14, IEC 60068-2-1, IEC 60068-2-2,
	– Cold	
	– Dry heat	

	– Change of temperature	IEC 60068-2-78, IEC 60068-2-30, IEC 60255-27
	– Damp heat	
9	Mechanical requirements: – Shock	IEC 60255-21-1, IEC 60255-21-2, IEC 60255-21-3
	– Vibration	
	– Bump	
	– Seismic	
10	Enclosure protection	IEC 60529, IEC 60255-27

18.00.00 **ERECTION AND COMMISSIONING AND SAT FOR NUMERICAL RELAYS & RELAY NETWORK SYSTEMS**

18.01.00 The contractor shall prepare an erection guideline and commissioning Procedure, SAT procedure for the Relay Network system and submit to Employer for review and approvals.

19.00.00 **RELAY TEST EQUIPMENT**

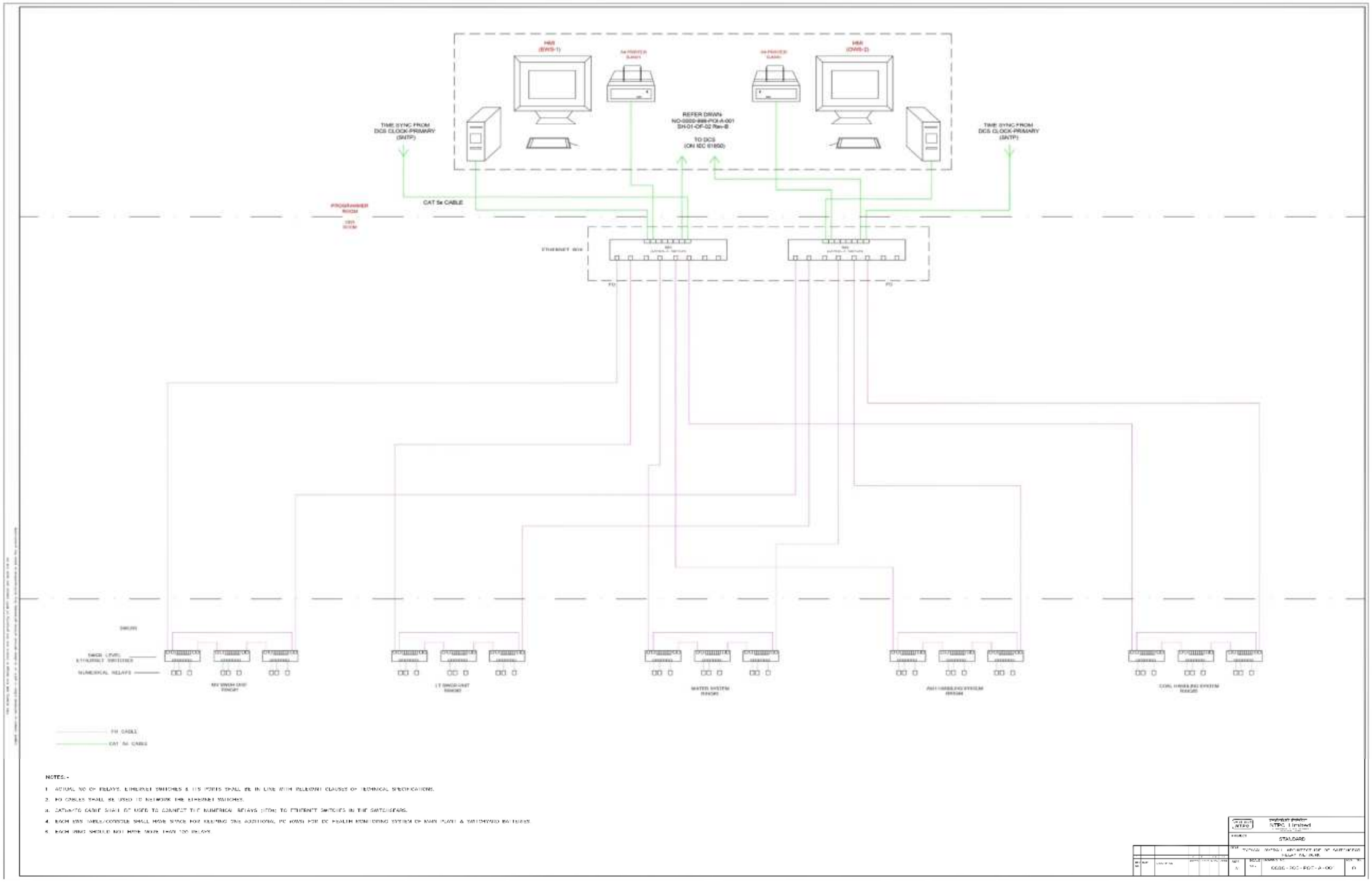
19.01.00 The required relay test equipment shall comprise the following:

(a) One 3 phase (4 Voltage and 6 current sources) dynamic portable relay test system for allowing dynamic and steady state testing.

(b) Any other auxiliary items required for comprehensive protection testing all types of the protection relays supplied under this contract.

19.02.00 It shall have the capability to replay the Disturbance / Fault records acquired by the numerical relays in IEEE / COMTRADE format or EMTP simulations, to facilitate dynamic testing of all the numerical relays supplied under this contract. The required software for steady state/dynamic testing of all the numerical protection relays along with a laptop dedicated for the testing shall also be supplied. The relay test set shall be suitable for IEC 61850 compliance testing with required no. of RJ45, FO and USB Ports. The test set shall have min 8 nos. (GI) binary inputs and 4 nos. (GI) binary outputs. The associated software for automated relay testing and IEC61850 GOOSE/GSSE Configuration shall also be supplied.

CLAUSE NO.	TECHNICAL REQUIREMENT



NOTES:-

1. ACTUAL NO OF RELAYS, ETHERNET SWITCHES & ITS PORTS SHALL BE IN LINE WITH RELEVANT CLAUSES OF TECHNICAL SPECIFICATIONS.
2. NO CABLES SHALL BE USED TO NETWORK THE ETHERNET SWITCHES.
3. CAT6A/7G CABLE SHALL BE USED TO CONNECT THE NUMERICAL RELAYS (IEDs) TO ETHERNET SWITCHES IN THE SWITCHGEARS.
4. EACH EWS TABLE/CONSOLE SHALL HAVE SPACE FOR KEEPING ONE ADDITIONAL PC (EWS) FOR DC HEALTH MONITORING SYSTEM OF MAIN PLANT & SWITCHYARD BATTERIES.
5. EACH RING SHOULD NOT HAVE MORE THAN 100 RELAYS.

SUB–SECTION – B-06

LT SWITCHGEARS & LT BUSDUCTS

1.00.00 DESIGN PHILOSOPHY / PRACTICE FOR LV BOARD SIZING

The sizing of LV boards shall be dependent on conditions such as total load connected to a board, diversity factors for various loads connected, Fault Level and Voltage Regulation Considerations, etc.

As far as practicable the system shall provide segregated supplies to main and standby auxiliaries so that the failure of supply to main auxiliary shall in no way jeopardize the standby auxiliary feed. Automatic changeover at critical switchgear / MCC sections shall be provided as necessary to prevent the loss of a unit or to ensure the equipment safety.

1.01.00 **Design Considerations:**

1.1.1 Sizing of LT boards

a) Input kVA for a Drive = (Rating in kW X Load Factor) / (Efficiency X Power Factor) where values of load factor , power factor and efficiency are defined below:

Load (service) factor for 415 V loads is taken as 0.85

Power factor 415 V Uni-Directional drives is taken as 0.8 and efficiency as 0.85

Power factor of 415 V bidirectional drive loads is taken as 0.65 and efficiency as 0.8 for motor rating less than 15 kW. For motor ratings of 15 kW and above the corresponding values are 0.75 and 0.8.

b) The Finally selected Busbar ratings for Switchboards, MCCs, ACDBs and Busducts shall include a 10% margin over the calculated values.

c) Lighting load shall be considered with a service factor of 70% of the associated lighting transformer size, on each section of main switchgears with incomer from transformer. at least one number lighting DB and one number Welding DB in each switchgear building shall be provided.

d) A spare capacity of about 10 % shall be kept for addition of loads during detail engineering as many of the LT loads cannot be predicted during the Rating selection of the Board.

e) Busbar Ratings of Valve / Damper ACDBs shall be derived by addition of 5% of the total kVA load connected and the rating of the largest Valve / Damper connected.

f) Welding sockets shall be connected from Welding DBs, which shall be fed through 1X100% Welding transformers. No load of Welding DB's shall be considered in switchgear and transformer sizing.

h) Each Lighting DB shall have 2X100% transformers.

1.1.2 Sizing of Offsite Boards

a) The loads for mechanical auxiliary systems shall be met by auxiliary transformers based on the criteria that each switchgear/MCC/Distribution board shall be fed by 2x100% transformers/feeders and, these shall be rated to carry the maximum load expected to be imposed. Each of the above boards shall be sectionalized.

1.02.00 **Layout Criteria**

The switchboards can be split into two sections based on layout constraints in case of long switchboards to optimize Switchgear room layouts. The two sections of the split shall be connected by Busduct / Cable as per layout requirements.

1.03.00 **Spare capacity and Future Requirements**

Each of the LV switchboards shall be designed for 1.1 times the required rating as a spare capacity. Further all LV Switchboard shall be provided with spare feeders / modules considering 20% or min.1 no of each type and rating in each section of the board. Spare feeders shall be provided for all Panels, boards etc.

1.04.00 **Standardization**

It shall be preferred to have all LV Switchboards for the entire plant from One / Two manufacturer(s) from maintainability and spares management point of view.

It shall be preferred to follow a standardization of Terminal Numbers across all LV Modules for ease of Interconnection and maintenance.

1.5.1 **Plant control cable Interconnections**

Control cable interconnections between switchgears and transformer marshalling boxes, switchgears and motor terminal boxes / push button stations, and between various switchgears shall be in the contractor's scope.

(a) Standard control cable sizes shall preferably be 3CX1.5, 5CX1.5, 7CX1.5 & 10/14CX1.5. Howeevr 2.5 Sqmm cable to be provided as per requirement as per the cable sizing.

(b) Cable size for motor space heater application shall be 2CX2.5 mm^2

(c) Interconnections for Current Transformer terminals shall use two cores of 2.5mm^2 size per phase

(d) Core identification shall be using core colour for up to 5-core cable and core number for cable with more cores

(e) Separate control cables shall be used for current transformers

(f) At least one spare core shall be made available in each of the control cable if no. cores are more than 2

2.00.00 CODES AND STANDARDS

2.01.00 All equipment shall, generally, comply with the updated issues of

(a.) Applicable Indian Standards

(b.) Indian Electricity Act.

(c.) Indian electricity rules

2.02.00 Equipment complying with any other authoritative / internationally recognized standards such as IEC, British, U.S.A., German, etc. will also be considered if it ensures performance equivalent or superior to Indian Standards. In such cases the contractor shall clearly indicate the standard adopted and furnish the copy of latest English version of the same along with the bid and bring out the salient features for comparison.

2.03.00 All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as published one month prior to the date of opening of bids. In case of conflict between this specification and those (IS codes, Standards etc.) referred to herein, the former shall prevail. All work shall be carried out as per the following codes and standards.

IS: 5	Colours for ready-mixed paints and enamels.
IS: 694	PVC insulated cables for working voltages up to and including 1100V.
IS: 722	A.C. Electricity Meters
IS: 1248	Electrical Indicating instruments
IS/IEC: 60947–1	Degree of protection provided by enclosures for low voltage Switchgear and Control gear
IS/IEC: 60947-2	A.C. circuit Breakers
IS: 2551	Danger Notice Plates
IS: 2629	Hot dip galvanising
IS: 2705	Current Transformers
IS/IEC: IEC-60947-4-1	Contactors and motors starter for voltages not exceeding 1000 V AC or 1200 V DC
IS: 3043	Code of practice for earthing.
IS: 3072	Code of practice for installation and maintenance of Switchgear
IS: 3156	Voltage Transformers
IS: 3202	Code of practice for climate proofing of electrical equipment.
IS: 3231	Electrical relays for power system protection.
IS/IEC 60947	Air-Break Switches, air break disconnectors, air break disconnector and fuse combination units for voltages not exceeding 1000V AC or 1200 V DC.
IS/IEC 60947-1 / IEC-60947-1	General Requirements for Switchgear and Control gear for voltages not exceeding 1000 V.
IS: 5082	Wrought Aluminium and Aluminium alloys for electrical purposes.
IS: 6005	Code of practice of phosphating of iron and steel.
IS/IEC 60947-5-1 / IEC-60947-5-1	LV switchgear and Control gear Control current devices and switching element.
IS: 8623 (3 parts) / IEC: 60439	Specification for factory built assemblies of Switchgear & Control gear for voltages up to and including 1000 V AC & 1200 V DC.
IS: 8686	Static Relays

IS: 13703 / IEC: 60269	HRC Cartridge fuses
IS: 10118 (4 parts)	Code of practice for selection, installation and maintenance of switchgear and control gear.
IS: 11171	Specification for dry type transformers.
IEC: 60255	Electrical Relays
IEC: 61850	Communication networks and systems in substations
IS: 11353	Guide for uniform system of marking and identification of conductors and apparatus terminals
IS: 12021	Specification of control transformers for switchgear and Control gear for voltage not exceeding 1000V AC.
IEC: 60947-7-1	Terminal blocks for Copper conductors
IS :513 (2008)	Cold Rolled Low Carbon Steel Sheets and Strips

3.00.00 TECHNICAL PARAMETERS

Power Supply

AC SYSTEM

1)	Voltage	415 V $\pm$ 10%,3 Phase, 4 wire, solidly earthed
2)	Frequency	50 Hz +/- 5%
3)	Combined variation (in volts & frequency)	10% absolute sum
4)	Fault Level	50 kA(RMS)

DC SYSTEM

1)	System Voltage	220 V DC 2-Wire, Unearthed
2)	Fault Level	20 kA

CONTROL SUPPLY VOLTAGE

1)	(i) Closing coil of circuit breaker	220 V DC/110 V DC
2)	Spring charging motor	220 V DC/110 V DC
3)	MCC control supply	110 V AC Neutral solidly earthed
4)	Space heater & lighting	240 AC Neutral solidly earthed

CUBICLE DATA

Busbar Rating

1)	Continuous Current rating	As per requirement /Sizing Calculation
2)	Short time rating where	
	a) CB is used as incomer	50 kA(RMS) for one sec (Ph-Ph & Ph-N)
	b)MCCB is used as incomer	Prospective current of 50 kA(RMS) for the MCCB clearing time , (Ph-Ph & Ph-N)
3)	Dynamic Rating where	
	a) CB is used as incomer	105 kA(PEAK) , (Ph-Ph & Ph-N)
	b)MCCB is used as incomer	Prospective current of 105 kA (PEAK) as limited by MCCB (Ph-Ph & Ph-N)
4)	Busbar insulation	
	a) For switchgear /MCC/ACDB/DCDB /MCCB Box	PVC Sleeve insulated(UL224) CE/UL certified
5)	Horizontal Busbar & Jumper Connection	High Conductivity Aluminium Alloy/Copper
6)	Vertical Busbar	Copper Only
7)	Hardware for busbars(Bolts/Nuts/Spring Washer)	High Tensile steels

Enclosure Details

1)	Material	CRCA 2mm: Load bearing Structure and Frame 1.6mm: Doors, covers etc 3mm for Gland Plates (CRCA/HR) 4mm for Gland plates (Non-Magnetic) –Single Core Cable Entry
2)	Type	Metal enclosed, indoor, floor-mounted, Free Standing Type

3)	Degree of Protection	IP:52 (below 1600 Amp.) (IP:42 for Busbar chamber, 1600 Amp & above, Gasketing arrangement shall be as per type tested design for IP 5X) As per IS/IEC:60947 IP65: Paddle Feeder and Travelling Tripper MCC IP55: Outdoor Panels enclosed in Stainless Steel Mounted on 500 mm Pedestal
4	Design	Complete Closed Door Design
5	Internal Arc Classification	50KA, 0.5 sec
6	Cable Alley Compartment	Form-4B as per IEC-61439
7	Gasket	Steel Reinforced EPDM /PU Foam/Neoprene gaskets
8)	Height	2450mm max
9)	Clearances	25 mm: (Ph-Ph)/(Ph-earth) Insulation Sleeves/Barriers shall be provided for clearance less than 25 mm Incomer Rear Door and Busbar-400mm

CIRCUIT BREAKER

1)	Type	Air break spring charged stored energy type
2)	Operating duty	O-3 min-CO-3 min-CO
3)	Symmetrical interrupting	50 kA(RMS)
4)	Short circuit rating	105 kA(PEAK)
5)	Short Circuit Breaking current	
	a) AC Component	50 kA(RMS)
	b) DC Component	As per IS/IEC 60947
6)	Short time withstand	50 kA(RMS) for 1 s
7)	No of aux. contacts	4 NO + 4 NC for DDCMIS interface 6NO+6NC Auxillary Contact(directly operated from breaker operated Mechanism)
8)	Antipumping Feature	Both Mechanical and Electrical

METERS

1)	Accuracy Class	2.0
2)	One min. power frequency withstand test voltage	2.0 kV(RMS)

Current Transformers

1)	Type	Cast Resin Bar Primary / Nylon Casing
2)	Voltage class and frequency	650 V, 50 HZ
3)	Class of insulation	E or better
4)	Rated Secondary Current	1 A
5)	Accuracy class & burden	
	a) For protection	5P20, 5VA PS Class for REF
	b) For metering	class 1.0, 5VA (min) class 0.2s, 5VA (min) for feeders indicated in SLD ,if any
6)	Instrument Security Factor (ISF) for metering CT	5
7)	Short time withstand	
	a) For CT Associated with circuit breaker	50 kA(RMS) for 1 sec
	b) For CT Associated with MCCB protected feeders	Prospective current of 50 kA(RMS) for the MCCB clearing time
8)	Dynamic withstand	
	a) For CTs Associated with circuit breaker	105 kA(PEAK)
	b) For CT Associated with MCCB protected feeders	Prospective current of 105 kA(PEAK) as Limited by MCCB

BUSDUCT (NON-SEGREGATED, AIR INSULATED TYPE)

1)	Rating	As per requirement /Sizing Calculation
1)	Type	Non-Segregated

2)	One minute power frequency withstand voltage	2.5 kV
3)	One second short ckt withstand current	50 kA(RMS)
4)	Momentary dynamic current withstand	105 kA(PEAK)
5)	Enclosure	3mm Al Alloy Rectangular(IP:55) Al sheet flange protection hood for outdoor
8)	Gasket	Steel Reinforced EPDM /PU Foam /Neoprene gaskets
9)	Conductor	Material: Alumunium Clearance:25 mm(Min)
10)	Steel Structure	Hot Dipped Galvanised
11)	Earthing	GI of Adequate Size along full length

VOLTAGE TRANSFORMERS

1)	Type	Cast Resin
2)	Voltage Ratio	415 / 110 V for line PT 415/√3 / 110/√3 V for Bus PT
3)	Method of Construction	V-V
4)	Accuracy Class	0.5 0.2 for feeders indicated in SLD ,if any
5)	Rated Voltage factor	1.1continuous, 1.5 for 30 sec.
6)	Class of insulation	E or better
7)	One minute power frequency withstand voltage	2.5 KV

HRC FUSES

1)	Voltage Class	650 Volts
2)	Rupturing capacity	80 kA (rms) for AC ckt., 20 kA for DC ckt.

CONTACTORS

1)	Type	Air break electro magnetic
2)	Utilising Category	AC3 of IS/IEC 60947 for non reversible AC4 of IS/IEC 60947 for reversible drives DC3 for DC contactor
3)	Operating Coil Voltage	(i)110V AC(-15%-+10%) Drop out voltage-less than 70% Guaranteed Drop out at 20% of rated voltage (ii)220V DC((-15%-+10%)

Relays

1)	Power frequency withstand voltage	2.5 kV for 1 sec. or 2.0 kV for 1 min.

CONTROL TRANSFORMERS

1)	Type	Dry / Cast Resin
2)	Voltage Ratio	415 / 110 V with taps $\pm$ 5% in steps of 2.5%
3)	Class of insulation	Class-B or better
4)	One minute power frequency withstand voltage	2.5 kV
5)	Rating	1.5 X Adequate for application.

LIGHTING TRANSFORMER / WELDING TRANSFORMER

1)	Type & Rating	Dry type / 100 KVA(Welding TRF), 50KVA(Minimum)(Lighting TRF)
2)	Voltage Ratio	415/415V, +/- 5% taps in steps of 2.5%
3)	Class of insulation	B or better
4)	One minute power frequency withstand voltage	2.5 KV
5)	Enclosure protection	IP-42
6)	Type Test	As per IS 2026

7)	Fault level	3-5 KA secondary side

TRANSDUCERS

1)	Current transducers	
	a) Input	0-1 A (CT secondary)
	b) Rated frequency	50 Hz
	c) Output	4-20 mA (2 Nos. decoupled)
	d) Over current	Transducer for motor current ammeters shall be capable of withstanding min. 6 times CT sec. current of 1A for a min period of 30 seconds
	e) Accuracy	1.0
2)	Voltage Transducers	
	a) Input	500 V, 50 Hz (for AC) / 250 V / 125 V DC (for DC)
	b) Output	4-20 mA (2 Nos. decoupled)
	c) Accuracy	1.0

MCCB & MPCB

1)	Type	Thermal Magnetic based(in built front adjustable releases
2)	Rated insulation level	690V
3)	Rated ultimate & Service S.C. breaking capacity	50 kA
4)	Rated making capacity	105 kA
5)	Utilization category	A

MCB

1)	Rated voltage	415V/240V/110V AC 240V DC
2)	Current breaking Capacity	10 KA
3)	Characteristic Curve	C or above

AC & DC MCCB Box

1)	Construction	(i)Metal Enclosed Fixed Type CRCA:2mm structure :1.6mm enclosure Or (ii)Poly Corbonate (a) Halogen Free,flame Retardant(UL-94,V0) (b) Thickness:4mm (iii) UL224 sleeved Busbars
2)	Degree of Protection	Indoor: IP52 Outdoor: IP54
3)	Characteristic Curve	C or above

Earth Bus and Earthing

Material	GS/Cu/Al of Sufficient cross section Separate Copper Earth bus for Electronic Earthing of IMCs

Internal Wiring and Control Terminal Blocks

Control Terminal Blocks		
1)	Rating	650V grade, 10 A ,6.6 polyamide UL 94Separate Copper Earth bus for Electronic Earthing of IMCs
2)	Type	Screw less, push in technology (IEC 60947-7-1 and UL certified)
3) Spare		20%
Internal Wiring		
1)	Rating	650 V grade, FRLS, single core 2.5 sq. mm cu for CT connection 1.5 sq. mm cu for others

LOCAL/EMERGENCY PUSH BOTTON

1)	Construction	CRCA/Die Cast Al:1.6mm enclosure Or (ii)Poly Corbonate (a) Halogen Free,flame Retardant(UL-94,V0) (b) Thickness:4mm (iii) UL224 sleeved Busbars
2)	Degree of Protection	IP55, IP65(Dusty Area)
3)	Characteristic Curve	C or above
4)	Contacts	Latched Type EPB 2NO+2NC

4.00.00 CONSTRUCTIONAL DETAILS OF SWITCHBOARDS

4.01.00 All Switchboards i.e., 415 V Switchgears, Motor Control Centres (MCCs), AC Distribution Boards (ACDBs), 220 V DC Distribution Boards (DCDBs) and Solenoid Valve Distribution Boards, shall be of metal enclosed, indoor, floor-mounted, free-standing type.

4.02.00 All switchboard frames and load bearing members shall be fabricated using suitable mild steel structural sections or pressed and shaped cold-rolled sheet steel of thickness 2.0 mm. Frames shall be enclosed in cold-rolled sheet steel of thickness 1.6 mm. Doors and covers shall also be of cold rolled sheet steel of thickness 1.6 mm. Stiffeners shall be provided wherever necessary. The gland plate thickness shall be 3.0 mm for hot / cold-rolled sheet steel and 4.0 mm for non-magnetic material.

4.03.00 All panel edges and cover / door edges shall be reinforced against distortion by rolling, bending or by the addition of welded reinforcement members. The top covers of the panels should be designed such that they do not permanently bulge/ bend by the weight of maintenance personnel working on it.

4.04.00 The switchboards shall be of bolted design. The complete structures shall be rigid, self-supporting, and free from flaws, twists and bends. All cut-outs shall be true in shape and devoid of sharp edges.

4.05.00 All switchboards shall be of dust-proof and vermin-proof construction and shall be provided with a degree of protection of IP: 5X as per IS/IEC 60947. However, the busbar chambers having a degree of protection of IP: 42 are also acceptable where continuous busbar rating is 1600A and above. Provision shall be made in all compartments for providing IP: 5X degree of protection, when circuit - breaker or module trolley has been removed. All cut-outs shall be provided with EPDM / Neoprene gaskets.

4.06.00 Provision of louvers on switchboards would not be preferred. However, louvers backed with metal screen are acceptable on the busbar chambers where continuous busbar rating is 1600 A and above.

4.07.00 The enclosure for outdoor oil filtration panels shall be constructed of stainless steel sheets in order to have protection against corrosion. The Degree of protection for outdoor panels shall be IP: 55. The panels shall be mounted on a pedestal at a height of 500mm from ground level.

4.08.00 All switchboards shall be of uniform height not exceeding 2450 mm.

4.09.00 Switchboards shall be easily extendable on both sides by the addition of vertical sections after removing the end covers.

4.10.00 Switchboards shall be supplied with base frames made of structural steel sections, along with all necessary mounting hardware required for welding down the base frame to the foundation / steel insert plates. The base frame height shall be such that floor finishing (50 mm thick) to be done by Contractor after erection of the switchboards does not obstruct the movement of doors, covers, withdrawable modules etc.

4.11.00 All switchboards shall be divided into distinct vertical sections (panels), each comprising of the following compartments:

(a.) BUSBAR COMPARTMENT

A completely enclosed bus bar compartment shall be provided for the horizontal and vertical bus bars. Bolted covers shall be provided for access to horizontal and vertical busbars and all joints for repair and maintenance, which shall be feasible without disturbing any feeder compartment. Auxiliary and power bus bars shall be in separate compartments.

(b.) SWITCHGEAR / FEEDER COMPARTMENT

All equipment associated with an incomer or outgoing feeder shall be housed in a separate compartment of the vertical section. Two-tier breaker arrangement in a vertical section shall be offered for outgoing breaker feeders of rating up to 1600A. The design of the vertical

section for such an arrangement shall ensure ease of termination of power cables of size & quantity appropriate to respective feeder rating. The compartment shall be sheet steel enclosed on all sides with the withdrawable units in position or removed. Insulating sheet at rear of the compartment is also acceptable. The front of the compartment shall be provided with the hinged single leaf door with captive screws for positive closure.

(c.) CABLE COMPARTMENT OR CABLE ALLEY

A full-height vertical cable alley of minimum 250 mm width shall be provided for power and control cables. Cable alley shall have no exposed live parts and shall have no communication with busbar compartment. Cable terminations located in cable alley shall be designed to meet the Form 4b as per IEC 61439 for safety purpose. Necessary grommets shall be provided at the cable entry of individual modules. Wherever cable alleys are not provided for distribution boards, segregated cable boxes for individual feeders shall be provided at the rear for direct termination of cables. For circuit breaker external cable connections, a separately enclosed cable compartment shall also be acceptable. The contractor shall furnish suitable plugs to cover the cable openings in the partition between feeder compartment and cable alley. Cable alley door shall be hinged.

(d.) CONTROL COMPARTMENT

A separate compartment shall be provided for relays and other control devices associated with a circuit breaker.

4.12.00 Sheet steel barriers shall be provided between two adjacent vertical panels running to the full height of the switchboard, except for the horizontal busbar compartment. EPDM / Neoprene gasket shall be provided between the panel sections to avoid ingress of dust into panels.

4.13.00 After isolation of power and control circuit connections it shall be possible to safely carryout maintenance in a compartment with the busbar and adjacent circuit live. Necessary shrouding arrangement shall be provided for this purpose. Wherever two breaker compartments are provided in the same vertical section insulating barriers and shrouds shall be provided in the rear cable compartment to avoid accidental touch with the live parts of one circuit when working on the other circuit.

4.14.00 All 415V switchgear (circuit-breaker) panels shall be of single-front type. MCCs and DBs shall be of single-front / double-front construction as per the requirements. All single-front switch boards shall be provided with single-leaf, hinged or bolted covers at the rear. The bolts shall be of captive type. The covers shall be provided with "DANGER" labels. All panel doors shall open by 90 deg or more. In case of double-front MCCs, if this cannot be achieved for panels adjacent to a breaker panel, suitable dummy panel shall be provided by the Contractor wherever necessary.

4.15.00 All ACDBs, DCDBs and Solenoid Valve DBs shall be of fixed module type. All 415V circuit-breaker modules and contactor controlled motor modules shall be of fully draw-out type having distinct 'Service' and 'Test' positions. The equipment pertaining to a draw-out type incomer or feeder module shall be mounted on a fully withdrawable chassis which can be drawn out without having to unscrew any wire or cable connection. Suitable arrangement with cradle/ rollers, guides along with tool/lever operated racking in/out mechanism shall be provided for smooth and effortless movement of the chassis. For modules of size more than half the panel height, double guides shall be provided for smooth removal or insertion of module. All identical module chassis of same size shall be fully interchangeable without having to carry out any modifications. Suitable interlock shall be provided in DCDB for prevention of opening of Isolator (Incomer) when the bus coupler is open and vice-versa.

4.16.00 All draw-out modules shall be provided with “Closed door operation” feature wherein movement of the module from “Isolated” position to “Service” position & vice-versa and power ON / OFF operation of the module shall be possible only with the module door closed condition.

4.17.00 All disconnecting contacts for power and control circuits of draw-out modules shall be of robust and proven design, fully self-aligning and spring-loaded. Both fixed and moving contacts shall be silver-plated and replaceable. The spring-loaded power and control draw- out

contacts shall be on withdrawable chassis and the same on fixed portion shall not be accepted.

4.18.00 Individual opening in the vertical bus enclosure shall permit the entry of moving contacts from the draw-out modules into vertical droppers.

4.19.00 As indicated in schematic drawings of DDCMIS controlled modules, contractor shall supply & mount two (2) coupling relays in the corresponding modules.

4.20.00 All equipment and components shall be neatly arranged and shall be easily accessible for operation and maintenance. The internal layout of all modules shall be subject to Employer's approval. The Contractor shall submit dimensional drawings showing complete internal details of busbars and module components, for each type and rating for approval of Employer.

4.21.00 Employer reserves the right to alter the cable entries, if required during detailed engineering, without any additional commercial implication.

4.22.00 Each switchboard shall be provided with undrilled, removable type gland plate, which shall cover the entire cable alley. Contractor shall ensure that sufficient cable glanding space is available for all the cables coming in a particular section through gland plate. For all single core cables, gland plate shall be of non-magnetic material. The gland plate shall preferably be provided in two distinct parts for the easy of terminating addition cables in future. The gland plate shall be provided with gasket to ensure enclosure protection. Recommended drilling chart of gland plates for all power and control cables in the vertical panels shall be indicated by the Contractor in the respective G.A. drawings of the boards.

4.23.00 The Contractor shall consider layout of panels in a switchboard consisting of various feeder modules in a straight line, unless specified otherwise. The actual composition and disposition of various modules in a switchboard shall be finalised during detailed engineering. The Contractor shall provide adopter panel / dummy panel required to meet various configuration / arrangement of busbars adopted by the Contractor. The Switchboards fed from indoor transformer will be flange connected to the same and the same shall be located as close as desirable to the transformer. The details of transformer flanges for those transformers not being supplied under this package shall be given to the contractor for matching the connections. The switchboards fed from outdoor transformers of rating 1000kVA and above shall be connected through busducts. For transformers of 1000kVA rating, cable connection may also be acceptable in case of layout constraints. For lower rated transformers, the connection shall be through cables. Busduct connections wherever applicable shall be preferably in a straight line alignment. Adopter panels and dummy panels shall be provided wherever required.

4.24.00 Adequate space in a separate compartment shall be identified for mounting of Ethernet Switch (19” rack mounting), in all switchgears having numerical relays. Further, mounting of Ethernet switch in the above compartment at site and provision of inter-panel wiring (Cat5e Ethernet / Fibre Optic) for connection of numerical relays to Ethernet switch shall be in the contractor’s scope. Arrangement to provide required control supply (110 V / 220 V DC) to Ethernet switch shall be made in the switchgear.

4.25.00 CLEARANCES

The minimum clearance in air between phases and between phases and earth for the entire run of horizontal and vertical busbars and bus-link connections at circuit-breaker shall be 25 mm. For all other components, the clearance between "two live parts", "a live part and an earthed part", shall be at least ten (10) mm throughout. Wherever it is not possible to maintain these clearances, insulation shall be provided by sleeving or barriers. However, for horizontal and vertical busbars the clearances specified above should be maintained even when the busbars are sleeved or insulated. All connections from the busbars up to MCB shall be fully shrouded / insulated and securely bolted to minimize the risk of phase to phase and phase to earth short circuits.

5.00.00 PROTOTYPE PANELS

In order to establish the compliance with the requirements of this technical specification, prototype panels shall be made and offered for the Employer’s inspection and approval

before the start of manufacturing of panels for this project. The exact configuration of such prototype panels shall be finalized during detailed engineering.

6.00.00 CONSTRUCTIONAL DETAILS OF AC & DC BOARDS

6.01.00 All distribution boards shall be metal enclosed, fixed type, non-compartmentalized construction, suitable for indoor/ outdoor mounting on wall or steel structure.

6.02.00 The board frame shall be fabricated using suitable mild steel structures or pressed and shaped cold rolled sheet steel of thickness not less than 2.0 mm. The frames shall be enclosed by cold rolled sheet steel of thickness not less than 1.6 mm.

6.03.00 The boards shall be provided with doors on the front. The doors shall preferably be in two halves with hinges at the extreme ends and locking facility at the centre.

6.04.00 Suitable EPDM/Neoprene gaskets shall be provided to make distribution boards completely dust and vermin-proof with a degree of protection of IP-55 for indoor and IP-65 for outdoor application, as per IS/IEC 60947.

6.05.00 Each DC MCCB Box shall comprise of the following :

(a.) 1 no. 63 A DP MCCB as incomer

(b.) 100 A fully insulated (PVC sleeved, UL224) busbars.

(c.) 8 nos. 16A outgoing DP MCB feeders.

(d.) 1 no. auxiliary contactor for supply monitoring.

(e.) 1 no. Blue LED indicating lamp.

Each AC MCCB Box shall comprise of the following :

(a.) 1 no. 63A TPN MCCB as incomer.

(b.) 100 A, 3-phase, 4-wire, fully insulated (PVC sleeved, UL224) busbars.

(c.) 9 nos. 16 A DP MCB and 3 nos. 16 A TPN MCB units as outgoing feeders.

(d.) 3 nos. LED indicating lamps (R, Y, B) for incoming supply monitoring.

6.07.00 Deleted

6.08.00 Cable entry facilities shall be provided at top / bottom with removable gland plates of suitable thickness. All incoming and outgoing cables shall be terminated on suitable terminal blocks.

7.00.00 POWER BUSBARS AND INSULATORS

7.01.00 All 415 V Switchboards, MCCs and ACDBs shall be provided with three phase and neutral busbars. Two separate sets of vertical busbars shall be provided in each panel of double front MCCs / DBs. Interleaving arrangement for busbars shall be adopted for switchboards with a rating of more than 1600A. DCDBs shall be provided with two (2) busbars. Entire busbar system shall be insulated with PVC sleeves. Busbar sleeves shall be compliant to UL224 (Extruded insulating tubing), CE/UL certified, having fire retardant properties and working temperature of 105^0C.

7.02.00 Vertical busbars of non-breaker panels shall be completely phase segregated by suitable insulating supports / walls made of fire-retardant, non-hygroscopic, track-resistant material to minimise the occurrence of arc faults.

7.03.00 All busbars and jumper connections shall be of high conductivity Aluminium alloy / Copper of adequate size.

7.04.00 The cross-section of the busbars shall be uniform throughout the length of switchboard section and shall be adequately supported and braced to withstand the stresses due to the specified short circuit currents. Neutral busbar short circuit strength shall be same as main busbars.

7.05.00 All busbars shall be adequately supported by non-hygroscopic, non-combustible, track-resistant and high strength sheet moulded compound or equivalent type polyester fibre glass moulded insulator. Separate supports shall be provided for each phase and neutral busbar. If a common support is provided, anti-tracking barriers shall be provided between the supports. Insulator and barriers of inflammable material such as Hylam shall not be accepted. The busbar insulators shall be supported on the main structure.

7.06.00 All busbar joints shall be provided with high tensile steel bolts, belleville / spring washers and nuts, so as to ensure good contacts at the joints. Non-silver plated busbar joints shall be thoroughly cleaned at the jointed locations and suitable contact grease shall be applied just before making a joint. All bolts shall be tightened by torque spanner to the recommended value. The overlap of the busbars at each joint surface shall be such that the length of overlap shall be equal to or greater than the width of the busbar. All Copper to Aluminium joints shall be provided with suitable bimetallic washers.

7.07.00 All busbars shall be colour coded as per IS: 375.

7.08.00 Wherever the busbars are painted with black Matt paint, the same should be suitable for temperature encountered in the switchboard under normal operating conditions.

7.09.00 The Contractor shall furnish calculations establishing the adequacy of bus bar sizes for specified current ratings.

8.00.00 AUXILIARY BUSBARS AND CONTROL TRANSFORMERS

8.01.00 **AC CONTROL SUPPLY BUSBAR**

Each bus-section of all Switchgears and MCCs shall be provided with two (2) nos. 415V / 110V control transformers. The 110V AC control supply from the control transformers shall be run through the MCC by means of two sets of control supply busbars of electrolytic Copper. In case of one transformer failure, whole bus section can be fed through single transformer. The control supply to different modules shall be tapped individually from the control supply busbars.

8.02.00 **DC CONTROL SUPPLY BUSBARS**

Electrically controlled circuit breaker boards shall be provided with DC control supply busbars. The manually controlled breakers shall also be provided with such busbars in case relays are provided. Each section of the switchboard shall be provided with a DC supply by the Contractor. The Contractor shall provide suitable terminals to receive the DC supply and distribute the same through above mentioned control busbars to the required modules of the respective section. The DC control supply bus of one section shall be coupled to the control supply of other section through a switch located in the bus-coupler breaker panel. The DC supply to the bus-coupler breaker may be given from any of the control buses. For Emergency Switchgear, two DC supplies shall be provided along with suitable diodes for deriving the control supply through diode auctioneering. Power Supply to Numerical Relay and Ethernet switch shall be an independent circuit with MCB tapped from the panel DC supply. Exact scheme for segregation of switchgear & numerical relay DC supplies shall be finalized during detailed engineering.

8.03.00 **SPACE HEATER BUSBARS**

Panel and motor space heaters shall be fed from separate AC auxiliary busbars running throughout the switchboard. The supply for these busbars shall be tapped from incomer, before the isolating switch/ circuit breaker. Incoming circuit to space-heater bus shall have MCB of suitable rating. Suitable terminals shall also be provided to facilitate energisation of space-heater bus from outside during long shutdowns of unit / switch-board.

8.04.00 **CONTROL TRANSFORMERS**

The control transformers shall be 415 V / 110 V with neutral point-earthed, of insulation class 'B' or better. The sizing of Control transformers shall be carried out by Contractor considering

the actual load of power contactors, auxiliary contactors, indicating lamps and other equipment in the module circuit. An additional load of 15 watts should also be considered for each module, for remote auxiliary relays and lamps to be connected in the control circuit of modules. Contractor shall also ensure that control transformers are adequately designed for meeting the momentary loading requirements & the voltage drop during this condition shall not be more than 5%.

9.00.00 EARTH BUS AND EARTHING

9.01.00 A galvanized steel / Copper / Aluminium earth bus shall be provided at the bottom of each panel and shall extend throughout the length of each switchboard. It shall be welded / bolted to the framework of each panel and breaker earthing contact bar. Vertical earth bus shall be provided in each vertical section which shall in turn be bolted / welded to main horizontal earth bus.

9.02.00 The earth bus shall have sufficient cross section to carry the momentary short circuit and short time fault current to earth, as indicated in "Technical Parameters", without exceeding the allowable temperature rise.

9.03.00 Suitable arrangements shall be provided at each end of the horizontal earth bus for bolting to Contractor's earthing conductors. The horizontal earth bus shall project out of the switchboard ends and shall have predrilled holes for this connection. All joint splices to earth bus shall be made through at least two bolts, and taps by proper lug and bolt connection.

9.04.00 All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus. Electrical conductivity of the whole switchgear enclosure framework and truck shall be maintained even after painting.

9.05.00 The carriage and breaker frame shall get earthed while being inserted in the panel and positive earthing of the breaker frame shall be maintained in all positions, i.e. SERVICE & ISOLATED, as well as throughout the intermediate travel.

9.06.00 Each module frame shall get engaged to the vertical earth bus before the disconnecting contacts on the module are engaged to the vertical busbars.

9.07.00 All metallic cases of relays, instruments and other panel-mounted equipment shall be connected to earth by independent stranded Copper wires of size not less than 2.5 sq. mm. All the equipment mounted on the door shall be earthed through flexible wire/braids. Insulation colour code of earthing wires shall be green. Earthing wires shall be connected to terminals with suitable clamp connectors, soldering is not acceptable. Looping of earth connections, which would result in loss of earth connections to other devices, when a device is removed, is not acceptable. However, looping of earth connections between equipment to provide alternative paths to earth bus is acceptable.

9.08.00 VT and CT secondary neutral point earthing shall be at one place only, i.e. on the terminal block. Such earthing shall be made through links so that earthing of one secondary circuit shall be removed without disturbing the earthing of other circuit.

9.09.00 All hinged doors having potential carrying equipment mounted on it shall be earthed by flexible wire/ braid. For doors not having potential carrying equipment mounted on it, earth continuity through scraping hinges/ hinge pins of proven design may also acceptable. The Contractor shall establish earth continuity at site also.

10.00.00 Circuit Breakers

10.01.00 Circuit breakers shall be three pole, air break, horizontal draw out type, and shall have fault making and breaking capacities as specified in "Technical Parameters". The circuit breakers which meet specified parameters of continuous current rating and fault making / breaking capacity only after provision of cooling fans or special device shall not be acceptable.

10.02.00 Circuit breakers along with its operating mechanism shall be provided with suitable arrangement for easy withdrawal. Suitable guides shall be provided to minimize misalignment of the breaker.

10.03.00 There shall be "SERVICE", "TEST" and "FULLY WITHDRAWN" positions for the breakers. In "Test" position the circuit breaker shall be capable of being tested for operation without energizing the power circuits i.e. the power contacts shall be disconnected, while the control circuits shall remain undisturbed. Locking facilities shall be provided so as to prevent movement of the circuit breaker from the "SERVICE", "TEST" or "FULLLY WITHDRAWN" position. It shall be possible to close the door in "Test" position. The circuit breaker rack in and rack out from Service to Test, Test to Isolated position or vice-versa shall be possible only in the door closed position.

10.04.00 All circuit breakers shall be provided with "6 NO" and "6NC" potential free auxiliary contacts. These contacts shall be in addition to those required, for internal mechanism of the breaker and should be directly operated from breaker operating mechanism. In case the manufacturer does not have a proven arrangement for providing the required number of circuit breaker auxiliary contacts on the fixed portion of the cubicle, necessary electrically reset latched relays shall be provided complete with all wiring in series with service position limit switch contacts, for multiplying the circuit breaker mounted auxiliary contacts and provide 4 NO and 4 NC contacts. Separate limit switches, each having required numbers of contacts shall be provided in both "SERVICE" and "TEST" position of the breaker. All contacts shall be rated for making, continuously carrying and breaking 10 Amp at 240 V AC and 1 Amp (Inductive) at 240 V DC respectively.

10.05.00 Suitable mechanical indications shall be provided on all circuit breakers to show "OPEN", "CLOSE", "SERVICE ", "TEST" AND "SPRING CHARGED" positions.

10.06.00 Main poles of the circuit breakers shall operate simultaneously in such a way that the maximum difference between the instants of contacts touching during closing shall not exceed half a cycle of rated frequency.

10.7.1 All circuit breakers shall be provided with the following interlocks :

10.7.2 Movement of a circuit breaker between "SERVICE" and "TEST" position shall not be possible unless it is in open position. Attempted withdrawal of a closed circuit breaker shall preferably not trip the circuit breaker. In case the offered circuit breaker trips on attempted withdrawal as a standard interlock, it shall be ensured that sufficient contact exists between the fixed and draw out contact at the time of breaker trip so that no arcing takes place even with the breaker carrying its full rated current.

10.7.3 Closing of a circuit breaker shall not be possible unless it is in "SERVICE" position, "TEST" position or in "FULLY WITHDRAWN" position.

10.7.4 Circuit-breaker cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker carriage, to cover the stationary isolated contacts when the breaker is withdrawn. It shall however be possible to open the shutters intentionally against pressure for testing purposes.

10.7.5 A breaker of particular rating shall be prevented from insertion in a cubicle of a different rating.

10.7.6 Circuit breakers shall be provided with coded key / electrical interlocking devices, as per requirements.

10.08.00 Circuit breaker shall be provided with anti-pumping relay and trip free feature, even if mechanical anti-pumping feature is provided.

10.09.00 Mechanical tripping shall be possible by means of front mounted Red "trip" push-button. In case of electrically operated breakers these push buttons shall be shrouded to prevent accidental operation.

10.10.00 Complete shrouding / segregation shall be provided between incoming and outgoing bus links of breakers. In case of bus coupler breaker panels the busbar connection to and from the breaker terminals shall be segregated such that each connection can be approached and maintained independently with the other bus section live. Dummy panels if required to achieve the above feature shall be included in the Contractor's scope of supply.

10.11.00 Circuit breaker shall be provided with Power operated mechanism as follows.

1.	Power operated mechanism shall be provided with a universal motor suitable for operation on 240 V DC / 240 AC Control supply, with voltage variation from 198 V to DC to 242 V DC . Motor insulation shall be class "E" or better.
2.	The motor shall be such that it requires not more than 30 seconds for fully charging the closing spring at minimum available control voltage.
3.	Once the closing springs are discharged, after one closing operation of circuit breaker, it shall automatically initiate recharging of the spring.
4.	The mechanism shall be such that as long as power is available to the motor, a continuous sequence of closing and opening operations shall be possible. After failure of power supply at least one open-close-open operation shall be possible.
5.	Provision shall be made for emergency manual charging and as soon as this manual charging handle is coupled, the motor shall automatically get mechanically decoupled.
6.	All circuit breakers shall be provided with closing and trip coils. The closing coil shall operate correctly at all values of voltage from 187-242 V DC. The trip coil shall operate satisfactorily at all values of voltage from 154-242V DC /77 V-121 V DC
7.	Provision for mechanical closing of the breaker only in "Test" and "WITHDRAWN" positions shall be made. Alternately, the mechanical closing facility shall be normally made inaccessible; accessibility being rendered only after deliberate removal of shrouds.
8.	It shall not be possible to open the ACB panel door in breaker closed condition. Further, the racking mechanism shall be accessible only after opening the breaker panel door.

Note: The circuit breakers for DC applications shall have manually operated mechanism of spring charged, stored energy type. The closing operation of the circuit breaker shall charge the tripping spring. Necessary interlocks shall be provided to inhibit closing of the circuit breaker unless the closing spring is fully charged.

11.00.00 TELESCOPIC TROLLEY

Telescopic trolley or suitable arrangement shall be provided for maintenance of circuit-breaker module in a cubicle. The trolley shall be such that the top most breaker module can be withdrawn on the trolley and can be lowered for maintenance purpose. The telescopic

trolley shall be such that all type, size and rating of breaker can be withdrawn /inserted of particular switchgear. The quantity of telescopic trolleys to be supplied shall be adequate for the number of switchgears / switchgear rooms.

12.00.00 Deleted

13.00.00 **MCCB**

13.01.00 MCCB shall be fixed type / part of withdrawable feeder module as per specification, three pole, air break type having trip free mechanism with quick make and quick break type contacts. MCCB shall have current limiting feature. MCCB of identical ratings shall be physically and electrically interchangeable. MCCB shall be provided with 1 NO and 1NC auxiliary contacts.

13.02.00 MCCB shall be provided with Microprocessor based inbuilt front adjustable releases (Overload & Short-circuit) and shall have adjustable Earth Fault protection unit also. The protection settings shall have suitable range to achieve the required time & current settings. LED indications shall also be provided for faults, MCCB status (on/off etc.).

13.03.00 MCCB terminals shall be shrouded and designed to receive cable lugs for cable sizes relevant to circuit rating. Extended cable terminal arrangement for higher size cable may also be offered. ON and OFF position of the operating handle of MCCB shall be displayed and the rotary operating handle shall be mounted on the door of the compartment housing MCCB. The compartment door shall be interlocked mechanically with the MCCB to prevent opening of the door unless the MCCB is in OFF position. MCCB shall be provided with padlocking facility to enable the operating mechanism to be padlocked. The MCCBs being offered shall have common / interchangeable accessories for all ratings like aux. switch, shunt trip, alarm switch etc. The MCCBs shall have the current discrimination up to full short circuit capacity and shall be selected as per manufacturer's discrimination table.

13.04.00 Auxiliary contacts of the MCCBs pertaining to critical feeders, to be decided during detailed engineering, shall be connected to the digital inputs available in the numerical relays of

Incomer / Bus-coupler / Outgoing circuit breaker feeders, for integration into the numerical relay network.

14.00.00 CONTROL AND SELECTOR SWITCHES

14.01.00 Control and selector switches shall be of heavy duty, rotary type with escutcheon plates clearly marked to show the positions. The control & selector switches should be as per IS/IEC 60947 Part V section 1. The switches shall be of sturdy construction suitable for mounting on panel front. Switches with shrouding of live parts and sealing of contacts against dust ingress shall be preferred.

14.02.00 Ammeter and voltmeter selector switches shall have four stay put positions with adequate number of contacts for 3-phase 4-wire system. These shall have oval handles. Ammeter selector switches shall have make before break type contacts to prevent open circuiting of CT secondary.

14.03.00 Contacts of the switches shall be spring assisted and shall be of suitable material to give a long trouble free service.

14.04.00 The contact ratings shall be at least the following :

1.	Make and carry, continuously, 10 A at 240 V DC and 110 V AC
2.	Breaking current at 240 V DC, 1 A (inductive)
3.	Breaking current at 110 V AC and 0.3 lagging p.f., 5A

15.00.00 CONTACTORS

15.01.00 Motor starter contactors shall be of air break, electromagnetic type rated for uninterrupted duty as per IS/IEC 60947 Part-4 Section- 1.

15.02.00 Contactors shall be double-break, non-gravity type and their main contacts shall be silver faced.

15.03.00 Direct-on-line contactors shall be of utilization category AC3. Reversing starters shall comprise of Forward and Reverse contactors mechanically and electrically interlocked with each other. These contactors shall be of utilization category AC4. DC contactors shall be of DC3 utilization category. For conveyor motors, minimum rating of power contactors shall be 240% of full load current of the motors. For other drives, minimum rating of power contactors shall be 200% of full load current of motor and for fan application it shall be 250%.

15.04.00 The number of normally open (NO) and normally closed (NC) auxiliary contacts of a contactor shall be as per requirement shown in the respective module drawings. It shall, however, be not less than 2NO+2NC.

15.05.00 Operating coil of contactors shall be of 110 V AC unless otherwise specified elsewhere. The contactor shall operate satisfactorily between 85% and 110% of the rated voltage. The contactor shall not drop out at 70% of the rated voltage but shall definitely drop out at 20% of the rated voltage.

15.06.00 Contactors for DC drives shall have a coil voltage of 240 V DC. DC operated contactor coil shall have an economy resistor and shall be suitable for satisfactory continuous operation at 187-242 V DC/ 93.5-121 V

16.00.00 Deleted

17.00.00 Instrument Transformers

17.01.00 All current and voltage transformers shall be of cast resin insulated type suitable for continuous operation at the temperature prevailing inside the switchgear enclosure, when the switchboard is operating at its rated condition and the specified ambient temperature. The class of insulation shall be 'E' or better.

17.02.00 Alternatively, current transformers with unbreakable, flame retardant, self-extinguishing Nylon casing of UL94 grade are also acceptable.

17.03.00 All instrument transformers shall be able to withstand the thermal and mechanical stresses resulting from the maximum RMS short circuit breaking and peak making current ratings of the associated switchgear.

17.04.00 All instrument transformers shall have clear indelible polarity markings. All secondary terminals shall be wired to separate terminals on an accessible terminal block where star point formation and earthing shall be done.

17.05.00 Current transformers may be multi or single-core type. All voltage transformers shall be single phase type.

17.06.00 The bus VTs shall be housed in a separate compartment. All VTs shall have readily accessible MCB on both primary and secondary sides.

17.07.00 All CTs shall be provided with supports independent of busbar / busbar supports.

17.08.00 The CTs shall be located in such a way that they can be easily approached for maintenance without necessitating shut down of adjacent feeders.

18.00.00 Numerical relays & networking

18.01.00 All circuit breaker feeders shall be provided with communicable numerical relays complying with IEC-61850, having protection, control, measurement and monitoring features. These relays shall be connected to the Switchgear SCADA System, through Ethernet switches. The relays shall be flush mounted on panel front with connections from the inside. These numerical relays shall be of types as proven for the application and shall be subject to Employer's approval. Numerical relays shall have appropriate setting ranges, accuracy, resetting ratio and other characteristics to provide required sensitivity. All equipment shall have necessary protections as detailed in the standard scheme drawings / module type descriptions.

18.02.00 Control of circuit breakers shall be carried out from DDCMIS through hardwired control commands in the form of 24V DC signal. Preferably, binary input of all relays shall be configurable to accept 24V DC signals directly from DDCMIS and no separate coupling relays shall be provided. The Local control console of the relay flush mounted on the switchgear would normally be used only for testing of circuit breaker in isolated position, and for tripping it in an emergency. Provision for closing & tripping of the circuit breaker locally from laptop through serial port shall be possible to facilitate commissioning activities. The basic control scheme of breaker feeders shall be developed using the programmable (soft) logics in the relay.

18.03.00 Each numerical relay shall be connected to the Ethernet switch provided in the Switchgear through Cat5e Ethernet /FO cable. Ethernet Switches shall be connected through Fibre Optic cable to form a ring network. A typical architecture of Switchgear SCADA is explained in chapter on MV Switchgear Protection, Control & Measurements.

18.04.00 The numerical relay shall be capable of measuring and storing values of a wide range of quantities, events, faults and disturbance recordings. The alarm / status of each of protection function and trip operation shall be communicated to Switchgear SCADA / DDCMIS. The numerical relays shall have built in feature / hardware interface to provide such inputs to Switchgear SCADA / DDCMIS for analog / digital values.

18.05.00 The required .ICD / .CID files of the Numerical relays under the scope of this package for the integration with the SCADA shall be provided by the Numerical relay vendor along with necessary engineering support. At least one no. of each type of Numerical Relay shall be made available during the Factory Acceptance Test (FAT) of the Switchgear SCADA system along with the necessary engineering support from the Numerical Relay vendor.

18.06.00 All relays shall be rated for control supply voltage as mentioned elsewhere under parameters and shall be capable of satisfactory continuous operation between 80-120% of the rated voltage. Making, carrying and breaking current ratings of their contacts shall be adequate for the circuits in which they are used. Contacts for breaker close and trip commands shall be so rated as to be used directly used in the closing and tripping circuits of breaker without the need of any interposing / master trip relays. Threshold voltage for binary inputs shall be suitably selected to ensure avoidance of mal operation due to stray voltages and typically shall be more than 70% of the rated control supply voltage.

18.07.00 One minute power frequency withstand test voltage for all numerical relays shall at least be 2kV (rms).

18.08.00 Failure of a control supply and de-energization of a relay shall not initiate any circuit breaker operation.

18.09.00 Disturbance Record waveforms, event records & alarms shall be stored in Non-volatile memory and failure of control supply shall not result in deletion of any of these data.

18.10.00 All IEDs shall have freely programmable optically isolated binary inputs (BI) and potential free binary output (BO) contacts, the quantity of which shall be adequate to realize the associated interlocks / feedbacks.

In case the offered IED does not have the required number of I/Os, the same can be

achieved through external I/O device of same make complying with the requirement stated elsewhere in this specification.

18.11.00 All the numerical relays shall have communications on three ports, local front port for communication with laptop and dual ports on IEC 61850 to communicate with the Switchgear SCADA System.

18.12.00 All the numerical relays shall have adequate processor memory for implementing the programmable scheme logic required for the realization of the protection / control schemes, in addition to the built in protection algorithms.

18.13.00 All Numerical relays shall have features for electrical measurements including voltage, current, power (active & reactive), frequency, power-factor and energy parameters.

18.14.00 Relays shall have event recording feature, recording of abnormalities and operating parameters with time stamping.

18.15.00 Master trip (86) and non-86 trips shall be software configurable to output contacts and no separate master trip relay shall be used.

18.16.00 All numerical relays shall have provision of both current (CT) and voltage (VT) inputs. Relays shall be suitable for both residually connected neutral CT input as well as CBCT input. Relays shall be suitable for CT secondary current of 1A. Motor relays shall have 4 CT inputs. Relays for Incomers, Bus-couplers & Ties shall have 4 CT inputs. All relays except incomers, ties and bus-couplers shall have 3Nos of VT inputs. Relays used in incomers, ties and bus couplers shall have provision of two sets of voltage inputs (3Nos for bus voltage & 1No. for line voltage) for the purpose of synchronization.

18.17.00 All CT terminals on the relays shall be of fixed type suitable for connection of ring-type lugs to avoid any hazard due to loose connection leading to CT open-circuit. In no circumstances Plug-in type connectors shall be used for CT / VT connections.

18.18.00 All numerical relay shall have key pad / keys to allow relay settings from relay front. All hand reset relays shall have reset button on the relay front. Relay to be self or hand reset shall be software selectable. Manual resetting shall be possible from remote.

18.19.00 Relays shall have self-diagnostic feature with self-check for power failure, programmable routines, memory and main CPU failures and a separate output contact for indication of any failure.

18.20.00 Relays shall have at least two sets or groups of two different sets of adaptable settings. Relays shall have multiple IEC / ANSI programmable characteristics.

18.21.00 Design of the relay must be immune to any kind of electromagnetic interference. Vendor shall submit all related type test reports for the offered model along with the offer.

18.22.00 All cards / hardware of numerical relays shall be suitable for operation in Harsh Environmental conditions with respect to high temperature, humidity & dust.

18.23.00 Relay shall be immune to capacitance effect due to long length of connected control cables. Any external hardware, if required for avoiding mal operation of the relay due to cable capacitance shall be included as a standard feature.

18.24.00 All I/Os shall have galvanic isolation. Analog inputs shall be protected against switching

surges, harmonics etc.

18.25.00 Numerical relays shall have two level password protections, one for read only and other for authorization for modifying the setting etc.

18.26.00 Numerical relays shall have feature for Time synchronization through the Switchgear SCADA System. The resolution of time synchronization shall be +/- 1.0 millisecond or better throughout the entire system.

18.27.00 Relays & Ethernet switches shall be suitable to accept both AC & DC supplies with range 110V or 220V with tolerance of 70 % to 120 % of rated voltage & shall be finalized during detailed engineering.

19.00.00 Other Protections and Control functions in the Relays

19.01.00 Trip circuit supervision shall be provided for all feeders to monitor the circuit breaker trip circuit both in pre-trip and post-trip conditions.

19.02.00 Schematics requiring auxiliary relays / timers for protection function shall be a part of numerical relay. The number of auxiliary relay and timer function for protection function shall be as required. Timer functions shall be programmable for on/off delays.

19.03.00 Bus no volt condition shall be configured to an output contact of the relay of incomers for suitably interfacing with DDCMIS wherever required.

19.04.00 The numerical relay shall be able to provide supervisory functions such as trip circuit monitoring, circuit breaker state monitoring, VT and CT supervisions and recording facilities with post fault analysis.

19.05.00 The numerical processor shall be capable of measuring and storing values of a wide range of quantities, all events, faults and disturbance recordings with a time stamping using the internal real time clock. Battery backup for real time clock in the event of power supply failure shall be provided.

19.06.00 At least 200 time tagged events / records shall be stored with time stamping. Details of at least 5 previous faults including the type of protection operated, operating time, all currents & voltages and time of fault.

19.07.00 Diagnostics Automatic testing, power on diagnostics with continuous monitoring to ensure high degree of reliability shall be shall be provided. The results of the self-reset functions shall be stored in battery back memory. Test features such as examination of input quantities, status of digital inputs and relay outputs shall be shall be available on the user interface.

19.08.00 The alarm/status of each individual protection function and trip operation shall be communicated to Switchgear SCADA / DDCMIS.

19.09.00 Sequence of events shall have 1ms resolution at device level.

19.10.00 Measurement accuracy shall be 1 % for RMS Current and voltage.

19.11.00 It shall be possible to carryout open / close operation of breakers from a laptop by interfacing from the relay front port during initial commissioning.

19.12.00 Required No. of extra binary inputs shall be provided in the numerical relay for digital inputs from critical outgoing MCCB feeders on that switchgear section.

19.13.00 Circuit-breaker status, protection status, etc. required for control logics shall be hardwired to DDCMIS. In addition, any other requirement of digital & analog signals for process controls shall be taken care of.

19.14.1 **TRAINING**

19.14.2 The contractor shall arrange for training on system design, engineering, operation and maintenance of Numerical relays and Switchgear networking system for a duration of two (2) man-months.

19.14.3 Workshop Training at site shall aim for familiarization of Site Engineers for commissioning and day to day O & M of Numerical Relays and trouble shooting.

20.00.00 INDICATING INSTRUMENTS

20.01.00 All indicating and integrating meters shall be flush mounted on panel front. The instruments shall be of at least 96mm square size with 90 degree linear scale and shall have an accuracy class of 1.0 or better. The covers and cases of instruments and meters shall provide a dust and vermin proof construction.

20.02.00 All instruments shall be compensated for temperature errors and factory calibrated to directly read the primary quantities. Means shall be provided for zero adjustment without removing or dismantling the instruments.

20.03.00 All instruments shall have white dials with black numerals & lettering. Black knife edge pointer shall be provided for meters.

20.04.00 Ammeters provided for motor feeders (for motors of rating ≥ 30kW & < 55 kW) shall have a compressed scale at the upper current region to cover the starting current up to 6.0 times the CT primary current.

20.5.1 All motor feeders of rating ≥ 30 kW and < 55 kW shall be provided with Multifunction Digital Energy Meter with communication facility to display the current, voltage, power factor, power energy related data locally as well as communicate these for remote metering/audit/analysis purposes. These meters shall meet the technical specification for Digital indicating energy meter shall be as follows:

a) Input Voltage:110VAC / 240VDC
b) Input Current:1A
c) Size:96X96 SQ.MM
d) Power & Energy Accuracy: 1.0
e) Mounting: Flush mounting
f) Type: True RMS 3-PHASE V,I, kW,PF & kWH indication
g) 4 Digit, seven segment LED display/LCD display, with floating decimal
h) Communication: In built RS 485 bus port
i) Operating Frequency: 45 HZ-65HZ
j) Dielectric Test: 2KV RMS for 1 minute
k) Over Current: 10 times for 3 sec.
l) Aux supply: 90V-300V AC/DC
m) Compliance: EMC/EMI
n) Field programmable CT ratio

o) Analog Current Output (4-20 mA)

21.00.00 PUSH BUTTONS

21.01.00 Push-buttons shall be of spring return, push-to-actuate type. Their contacts shall be rated to make, continuously carry and break 10 A at 110 V AC and 1 A (inductive) at 240 V DC.

21.02.00 All push buttons shall have two (2) normally open and two (2) normally closed contact, unless specified otherwise. The contact faces shall be of silver alloy.

21.03.00 All push-buttons shall be provided with integral escutcheon plates marked with its function.

21.04.00 The colour of the button shall as follows :

Green	for motor START, breaker CLOSE , valve/ damper OPEN commands.
Red	for motor trip, breaker open, valve / damper close commands.
Black	for all annunciation functions, overload reset and miscellaneous commands including reverse for clinker grinder etc.

21.05.00 All push buttons on panels shall be located in such a way that Red push button shall always be to the left of Green push button. In case of clinker grinder etc. the push buttons would be black - red-green from lift to right.

21.06.00 All emergency push buttons shall have mushroom knobs.

22.00.00 Indicating Lamps

22.01.00 Indicating lamps shall be of CLUSTER LED type. The lamps shall have escutcheon plates marked with its function, wherever necessary.

22.02.00 Lamps shall have translucent lamp-covers of the following colours, as warranted by the application :

Red	for motor ON, valve / damper OPEN, breaker CLOSE.
Green	for motor OFF , valve / damper CLOSE, breaker OPEN.
White	for motor AUTO TRIP.
Blue	for all healthy conditions (e.g. control supply, and also for SPRING CHARGED").
Amber	for all Alarm Conditions (e.g. overload). Also for "SERVICE" and "TEST" position indications.

22.03.00 Bulbs and lamp covers shall be easily replaceable from the front of the cubicle. The method of mounting indicating lamp fittings on panels shall prevent their rotation under the action of lamp removal or replacements, reliance upon the tightness of ring nut for the purpose is not sufficient.

22.04.00 Indicating lamps should be located just above the associated push-button / control switches. Red lamps shall invariably be located to the right of green lamps. In case a white lamp is also provided, it shall be placed between the red and green lamps along the centre line of control switch / push button pair. Blue and Amber should normally be located above the Red and

Green lamps.

22.05.00 When associated with push-buttons, red lamps shall be directly above the green push-button and green lamp shall be directly above the red push button.

22.06.00 All indicating lamps shall be suitable for continuous operation at 90% to 110% of their rated voltage.

23.00.00 Space Heater

23.01.00 Space heaters shall be provided in the switchboards wherever the manufacturer considers them necessary and recommends their provision for preventing harmful moisture condensation.

23.02.00 The space heaters shall be suitable for continuous operation on 240 V AC, 50 Hz, single phase supply, and shall be automatically controlled by thermostats. Necessary MCBs shall be provided.

23.03.00 The circuit for each panel and motor space heater should have an isolating MCB. In addition, the space heater circuit of each panel shall also have a thermostat of suitable rating.

24.00.00 INTERNAL WIRING

24.01.00 All switchboards shall be supplied completely wired internally upto the terminals, ready to receive external cables.

24.02.00 All inter-cubicle and inter-panel wiring and connections between panels of same switchboard including all bus wiring for AC and DC supplies shall be provided by the Contractor.

24.03.00 All auxiliary wiring shall be carried out with 650V grade, single core stranded Copper conductor, colour coded, PVC insulated wires. Conductor size shall be 1.5 mm^2 (min.) for control circuit wiring and 2.5 mm^2 (min) for CT and space heater circuits.

24.04.00 Extra flexible wires shall be used for wiring to devices mounted on moving parts such as hinged doors. The wire bunches from the panel inside to the doors shall be properly sleeved or taped.

24.05.00 All wiring shall be properly supported, neatly arranged, readily accessible and securely connected to equipment terminals and terminal blocks.

24.06.00 All internal wiring terminations shall be made with solderless crimping type tinned Copper lugs which shall firmly grip the conductor or an equally secure method. Similar lugs shall also be provided at both ends of component to component wiring. Insulating sleeves shall be provided over the exposed parts of lugs to the extent possible. Screw-less (spring loaded) / cage clamp type terminal shall also be provided with lugs.

24.07.00 Printed single tube ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. The wire identification marking shall be in accordance with IS: 375. Red Ferrules should be provided on trip circuit wiring.

24.08.00 Wiring for equipment, which are to be supplied by the Contractor and for which the Contractor has to provide mounting arrangement in his panels, shall also be provided by the Contractor, up to the terminal blocks.

24.09.00 All connections from vertical busbars for individual modules above 100 A shall be by Copper / Aluminium links only. The cable connections for modules less than 100 A shall be selected in such a way that there will not be any melting / shorting in case of a short circuit inside the

module. The insulation of the cable and its cross section shall be decided considering the high ambient temperature within the module. For all modules where use of cable is envisaged by the Contractor specific approval from the Employer regarding cable details are to be taken. For power wiring colour coded wire insulation / tapes shall be provided.

25.00.00 CONTROL TERMINAL BLOCKS

25.01.00 Terminal blocks shall be 650V grade, 10Amps rated, made up of unbreakable polyamide 6.6 grade. The terminals shall be either screw type or screw-less (spring loaded) / cage clamp type with lugs. Marking on terminal strips shall correspond to the terminal numbering in wiring diagrams. All metal parts shall be of non-ferrous material. In case of screw type terminals the screw shall be captive, preferably with screw locking design.

25.02.00 Terminal blocks for CT and VT secondary leads shall be of stud type, made up of unbreakable polyamide 6.6 grade. They shall be provided with links to facilitate testing, isolation star / delta formation and earthing. Terminal blocks for CT secondary shall have the short circuiting facility. The terminals for remote ammeter connection etc. shall also be disconnecting type only. All metal parts shall be of non-ferrous material. Screws shall be captive.

25.03.00 In all circuit breaker panels MCC modules at least 10% spare terminals for external connections shall be provided and these spare terminals shall be uniformly distributed on all terminal blocks.

25.04.00 All terminal blocks shall be suitable for terminating on each side two (2) nos. stranded Copper conductors of size up to 2.5 sq. mm each, or alternatively, the terminal blocks shall have the possibility of double shorting space to facilitate looping.

25.05.00 All terminals shall be numbered for identification and grouped according to the function. Engraved white-in-black labels shall be provided on the terminal blocks.

25.06.00 Wherever duplication of a terminal block is necessary it shall be achieved by solid bonding links.

25.07.00 Terminal blocks shall be arranged with at least 100mm clearance between two sets of terminal blocks. The minimum clearance between the first row of terminal blocks and the associated cable gland plate shall be 250 mm.

26.00.00 Power Cable Termination

26.01.00 Cable termination compartment and arrangement for power cables shall be suitable for heavy duty, 1.1 kV grade, stranded Aluminium conductor, PVC/ XLPE insulated, armored / unarmored and PVC sheathed cables. The size and type of cable for individual modules shall, preferably, be as indicated in the 'Module Selection Tables'. All necessary cable terminating accessories such as supporting clamps and brackets, hardware etc. for cables shall be provided by the contractor to suit the final cable sizes.

26.02.00 All power cable terminals shall be of stud type and the power cable lugs shall be of tinned Copper solderless crimping ring type conforming to IS: 8309. All lugs shall be insulated/ sleeved.

27.00.00 LOCAL PUSH BUTTON STATIONS

27.01.00 The enclosure shall be provided with a hinged guard at the front, covering full length, to avoid inadvertent operation of push buttons Support structure for mounting the LPBS shall also be

supplied by Contractor. The local push button stations shall be dust and vermin proof and shall have a degree of protection of IP -55 as per IS/IEC 60947. The DOP shall be IP-65 in case the same are located in dusty areas.

27.02.00 The local push button stations shall be metal enclosed, suitable for outdoor / indoor mounting on wall or steel structures. The enclosure shall be die-cast Aluminium or cold-rolled sheet steel of at least 1.6 mm thickness. LPBS shall be painted to shade no. RAL: 9002.

27.03.00 Local push button stations enclosure made of FRP (Fiberglass Reinforced Polymer) may also be offered. The FRP enclosure shall be of SMC Hot press Moulded, Halogen free and flame retardant as per UL94, V-0. The thickness of the FRP enclosure shall be at least 4mm. The colour of the FRP type LPBS shall be of RAL 7035 and the hinges, nuts & bolts shall be of Polyamide / Stainless Steel material.

27.04.00 The push button stations shall be suitable for bottom cable entry and shall be provided with removable undrilled gland plates or knockouts to facilitate termination of two numbers of control cables. Adequate space shall be available inside the push button station enclosure for terminating external cables directly on pushbutton terminals. Overall size of push button stations shall be subject to Employer's approval.

27.05.00 The push button station shall comprise of a latched type EMERGENCY STOP push button with two (2) NO and two (2) NC contacts.

27.06.00 Support structure for mounting in local motor starters shall be supplied by the Contractor.

28.00.00 LOCAL MOTOR STARTERS

28.01.00 Local motor starters shall be suitable for manual switching of 415 V, 3-phase, squirrel cage motors rated up to 5.5 kW. They shall have constructional features similar to those specified for local push button stations.

28.02.00 Each starter shall comprise of :

1.	A 3-pole contactor, mechanically latched type.
2.	Start push button, coloured green.
3.	Stop push button, coloured red.
4.	Ambient temperature compensated, thermal over load relay with single phasing protection. The continuously variable relay setting range shall be suitable for the motor rating which shall be advised to the Contractor in due course. The relay shall trip the contactor.

28.03.00 The start push button, when pressed, shall preferably remain in depressed position and shall be released along with the contactor when the stop push button is pressed or when thermal overload relay operates.

28.04.00 Local starters shall be suitable for loop-in and loop-out of incoming cable and for one outgoing cable to motor. Support structure for mounting in local motor starters shall be supplied by the Contractor.

29.00.00 Name Plates and Labels

29.01.00 All Switchgears, MCCs, Distribution Boards, all feeders, local push-button stations and local motor starters shall be provided with prominent, engraved identification plates. The

module identification plate shall clearly give the feeder number and feeder designation. For single front switchboards, similar panel and board identification labels shall be provided at the rear switchgear also.

29.02.00 All name plates shall be of non-rusting metal or 3-ply Lamicoid, with white engraved lettering on black background. Inscription & lettering sizes shall be subject to Employer's approval.

29.03.00 Suitable stenciled paint mark shall be provided inside the panel/module for identification of all equipment in addition to the plastic sticker labels, if provided. These labels shall be positioned so as to be clearly visible and shall have the device number, as mentioned in the module wiring drawings.

29.04.00 Caution name plate "Caution Live Terminals" shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end.

30.00.00 METAL ENCLOSED NON SEGREGATED PHASE BUSDUCT(AIR INSULATED)

30.01.00 Three phase and neutral metal enclosed non segregated phase busduct assemblies shall be supplied for incoming connections from the transformers to the switch boards and inter connecting sections between switch boards, wherever applicable. The rating of the incoming and interconnecting busducts shall be same as the rating of the switchboard.

30.02.00 The enclosure shall be made of minimum 3 mm thick Aluminium alloy. The section of the busduct shall be rectangular. The design of the busduct enclosures shall be of sturdy construction such that it will withstand the internal or external forces resulting from the various operating conditions.

30.03.00 The entire busduct shall be designed for dust, vermin and weather proof construction. A suitable Aluminium sheet flange-protection hood shall be provided to cover all outdoor busduct enclosure joints to facilitate additional protection against rain water ingress. All horizontal runs of busducts shall have a suitable sloped enclosure top to prevent retention of water for both indoor and outdoor portion of busducts. Busduct enclosure shall have a degree of protection of IP-55.

30.04.00 The inside of the bus enclosure may be treated with black paint to enable efficient heat dissipation. The matt paint used shall be suitable for temperature experienced during continuous loading of the bus conductor. The busduct exterior paint shade shall be RAL 5012.

30.05.00 Flexible expansion joints for the enclosure shall be provided wherever deemed necessary by the Contractor. Necessary bonding shall be provided at the expansion joints if made of insulating materials.

30.06.00 Enclosures shall be provided with flanged ends with drilling dimensions to suit the flanges at the switchgear and transformer terminals. Any adapter boxes required for this purpose are in the Contractor's scope of supply. The flanges shall be provided with gaskets, nuts, bolts, etc. Details of the flanges provided on transformer ends will be furnished to the successful Contractor.

30.07.00 Suitable Inspection covers shall be provided for periodic inspection of insulators. Handle shall be provided on each inspection cover to facilitate easy lifting.

30.08.00 The EPDM / Neoprene gaskets shall be provided so as to satisfy the operating conditions imposed by temperature, weathering, durability etc. Flange gaskets shall be provided at the

equipment terminal connections.

30.09.00 Necessary earthing arrangement as applicable shall be provided with clamps to receive station earthing bus. All accessories and hardware required for the earthing arrangement shall be provided by the Contractor. This shall be a GI strip of adequate size, continuously running along the busduct and shall be earthed at both ends. Busduct enclosures shall be bolted type.

30.10.00 The material of the conductor shall be Aluminium. The minimum clearance in air between phase to phase, phase to neutral and phase to earth for the entire run of busduct shall be 25 mm The bus bars shall be rated in accordance with the service conditions and the rated continuous and short time current ratings calculated for specific application / specified elsewhere.

30.11.00 All steel structures required for busduct support shall be hot dip galvanized.

30.12.00 Space heaters shall be provided in the busduct wherever the manufacturer considers them necessary and recommends their provision for preventing harmful moisture condensation.

30.13.00 The space heaters shall be suitable for continuous operation on 240 V AC, 50 Hz single phase supply and shall be automatically controlled by thermostats. Necessary wiring upto junction boxes mounted on busduct and from junction boxes to switch boards shall be provided by the Contractor.

31.00.00 Deleted

32.00.00 LIGHTING / WELDING TRANSFORMERS

Each AC Lighting Distribution Board (LDB) / Welding DB shall be fed from 415V / 415V, 100kVA isolating transformer. The lighting / welding transformer may, preferably, be located inside the LDB / Welding DB panel itself. Otherwise, the same shall be located by the side of respective LDB / Welding DB. Lighting / Welding transformers shall be dry type, natural air cooled with class B insulation or better. Impedance of lighting / Welding transformer shall be so selected that the fault level of lighting /Welding system shall be reduced to 3 to 5 KA. Lighting / Welding transformers shall be tested as per IS: 2026. Off-circuit tap changer with ± 2.5% and ± 5% tapping shall be provided. In case the transformers are not mounted inside the LDB panels, the same shall be housed in a separate 2 mm thick CR sheet steel enclosure with IP-42 degree of protection as per IS/IEC 60947. However, the transformer terminal box shall have IP-52 degree of protection.

33.00.00 PAINTING

All sheet steel work shall be pre-treated, in tanks, in accordance with IS: 6005. Degreasing shall be done by alkaline cleaning. Rust and scales shall be removed by pickling with acid. After pickling, the parts shall be washed in running water. Then these shall be rinsed in slightly alkaline hot water and dried. The phosphate coating shall be "Class-C" as specified in IS: 6005. The phosphated surfaces shall be rinsed and passivated. After passivation, Electrostatic Powder Coating shall be used. Powder should meet requirements of IS 13871 (Powder costing specification). Finishing paint shade for complete panels excluding end covers shall be RAL9002 & RAL5012 for extreme end covers of all boards, unless required otherwise by the Employer. The paint thickness shall not be less than 50 microns. Finished parts shall be suitably packed and wrapped with protective covering to protect the finished surfaces from scratches, grease, dirt and oil spots during testing, transportation, handling and erection.

34.00.00 GASKETS

The gaskets, wherever specified, shall be of good quality EPDM / Neoprene with good ageing, compression and oil resistance characteristics suitable for panel applications.

35.00.00 TEMPERATURE –RISE

The temperature rise of the horizontal and vertical busbars and main bus links including all power draw-out contacts when carrying 90% of the rated current along the full run shall in no case exceed 55^0 C with silver plated joints and 40^0C with all other types of joints over an outside ambient temperature of 50^0C. The temperature rise of the accessible parts/external enclosures expected to be touched in normal operation shall not exceed 20^0C. The temperature rise of manual operating means shall not exceed 10^0C for metallic & 15^0C for insulating material. Temperature rise for the busbars shall be carried out at 90% of the rated current. The above temperature rise limits are applicable for busducts also without any current derating.

36.00.00 DERATING OF EQUIPMENTS

The Contractor shall ensure that the equipment offered will carry the required load current at site ambient conditions specified and perform the operating duties without exceeding the permissible temperature as per Indian Standards / Specification. Continuous current rating at 50^0C ambient in no case shall be less than 90% of the normal rating specified.

The Contractor shall indicate clearly the derating factors if any employed for each component and furnish the basis for arriving at these derating factors duly considering the specified current ratings and ambient temperature of 50^0C.

37.00.00 PROTECTION CO-ORDINATION

It shall be the responsibility of the Contractor to fully coordinate the overload and short circuit tripping of the circuit breakers with the upstream and downstream circuit breakers / motor starters, to provide satisfactory discrimination. Further the various equipment supplied shall meet the requirements of Type 2 class of Co-ordination as per IS: 8544.

38.00.00 TESTS AND TEST REPORTS

38.01.00 **GENERAL**

(a.) All equipment to be supplied shall be of type tested design. The Contractor shall submit for Employer's approval the reports of all the type tests as listed in this specification and carried out not earlier than five years prior to the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.

(b.) In case the Contractor is not able to submit report of the type test(s) conducted not earlier than five years prior to the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Contractor shall conduct all such tests under this contract at no additional cost either at third party lab or in presence of client/Employer's representative and submit the reports for approval.

(c.) All routine tests as per the specification and relevant standards shall be carried out.

38.2.1 The following type test certificates on each type & rating of LT Switchgear and MCC panels shall be submitted.

1) Switchgear / MCC panels of each rating

	a)	Short time withstand test.	
	b)	Temperature rise test.	
	c)	Degree of protection test	
2)	Circuit breaker of each rating		
	a)	Test sequence 1	
		-	Dielectric properties.
		-	Mechanical operation and operational performance capability
		-	Verification of dielectric withstand.
		-	Verification of temperature-rise
	b)	Combined test sequence (With Circuit breakers mounted inside the Switchgear panel)	
		-	Rated short-time withstand current
		-	Rated service short-circuit breaking capacity
		-	Verification of dielectric withstand
		-	Verification of temperature-rise
3)	MCC modules of any three ratings, as selected by the Employer, for class - II protection Co-ordination.		
4)	Test for single phasing protection feature on 3 nos. bimetallic thermal overload relay selected by Employer. The relay shall be tested for compliance with manufacturer's printed / declared characteristic curve.		

38.03.00 For the following equipment the contractor shall submit the reports of all the type tests as per applicable standards and carried out not earlier than five years prior to the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client. In case the Contractor is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Contractor shall conduct all such tests under this contract at no additional cost to the Employer either at third party lab or in presence of client/Employer's representative and submit the reports for approval.

(a.) NUMERICAL RELAYS

(b.) LOCAL PUSH BUTTON STATION

(c.) LOCAL MOTOR STARTER

38.04.00 Type test reports for the following tests on the model of the Numerical relays, Ethernet switches shall be submitted for Employer's review.

S. No.	TEST ITEMS	Standard
1	Dimensions of structure and visual inspection	IEC 60297-3-101
2	Functional requirements:	Relevant IEC 60255-100 series
	– Steady-state simulation	
	– Dynamic simulation	
3	Product safety requirements	IEC 60255-27
	(including the dielectric tests and thermal short time rating)	
4	EMC requirements:	IEC 60255-26
	– Emission	
	– Immunity	
5	Energizing quantities:	
	– Burden	N/A
	– Change of auxiliary energizing quantity	IEC 60255-11
6	Contact performance	N/A
7	Communication requirements	Relevant IEC protocol standards
8	Climatic environmental requirements:	IEC 60068-2-14, IEC 60068-2-1, IEC 60068-2-2, IEC 60068-2-78, IEC 60068-2-30, IEC 60255-27
	– Cold	
	– Dry heat	
	– Change of temperature	
	– Damp heat	
9	Mechanical requirements: – Shock	IEC 60255-21-1, IEC 60255-21-2, IEC 60255-21-3
	– Vibration	
	– Bump	
	– Seismic	
10	Enclosure protection	IEC 60529, IEC 60255-27

38.05.00 The type test reports once approved for any projects shall be treated as reference.

38.06.00 All routine tests as per the specification and relevant standard IS 8623 shall be carried out.

38.07.00 An indicative lists of tests / checks is mentioned as QA chapter. However, the manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

38.8.1 All procedures for type tests shall be approved by Employer before commencement of type tests. However, the following points may be specifically noted.

1) For temperature rise tests, the connection arrangement between the source and the test equipment shall be such that the temperature gradient in the connection piece of cable at a distance of one meter away from the test equipment shall be restricted to 5^0C.

2) Milli-Volt drop test shall be done on switching devices before and after the type tests.

3) Bolt tightness of busbar joints shall be checked with torque wrench before and after short time rating tests on the circuit breaker and MCC panels.

38.09.00 Routine checking to observe compliance to degree of protection, first numeral, on switchboard enclosures and busbar chambers shall be as under :

1) IP -4 X	It shall not be possible to insert a one mm dia. Steel wire into the enclosure from any direction, without using force.
2) IP-5X	It shall not be possible to insert a thin sheet of paper under gaskets and through enclosure joints.

39.00.00 ERECTION / INSTALLATION OF SWITCHBOARDS AND OTHER EQUIPMENTS

39.01.00 Each equipment shall be installed in a neat, workman-like manner so that it is levelled, plumbed, squared and properly aligned and oriented. Tolerances shall be as established in Contractor's drawings or as stipulated by Employer. No equipment shall be permanently fixed down to foundations until the alignment has been checked and found acceptable by the Employer.

39.02.00 Contractor shall furnish all supervision, labour, tools, equipment, rigging materials, bolts, wedges, anchors, etc.., in proper time, required to completely install, test and commission the equipment.

39.03.00 Manufacturer's and Employer's instructions and recommendations shall be correctly followed in handling, setting, testing and commissioning of all equipment.

39.04.00 Contractor shall move all equipment into the respective rooms through the regular door or openings specifically provided for this purpose. No part of the structure shall be utilised to lift or erect any equipment without prior permission of Engineer.

39.05.00 All switchboards shall be installed in accordance with Indian Standard, IS: 3072, and Employer's instructions.

39.06.00 Switchboard panels shall be installed on concrete floor or supported on steel channel / edge angle in concrete trenches. The Contractor shall provide steel insert plates in the concrete floor and / or steel channels / edge angle on the trenches as applicable. The base frame of switchboards shall be welded to the insert plates by the Contractor. The Contractor shall be required to install and align the panels using suitable metallic shims before welding the base frame. In joining shipping sections of switchboards together, adjacent housing of panel sections or flanged throat sections shall be bolted together after alignment has been completed.

39.07.00 Contractor shall take utmost care in handling instruments, relays and other delicate mechanisms. Wherever the instruments and relays are supplied separately they shall be mounted only after the associated panels have been erected and aligned. the blocking materials employed for safe transit of instruments and relays shall be removed after ensuring that panels have been completely installed and no further movement of the same would be necessary. Any damage shall be immediately reported to Engineer.

39.08.00 Equipment furnished with finished coats of paint shall be touched up by Contractor if their surface is spoiled or marred during erection / commissioning.

39.09.00 The room and floor finishing work would be done after erection of the panels and the Contractor shall suitably cover up the panels to protect them from injury and marring of finish.

40.00.00 COMMISSIONING CHECKS / TESTS

40.01.00 After installation of panels, power and control wiring and connections, Contractor shall perform operational tests on all switchboards, to verify proper operation of switchboards / panels and correctness of all equipment in each and every respect.

40.02.00 The Contractor shall carry out the following commissioning checks, in addition to other checks and tests recommended by the manufacturers.

40.03.00 GENERAL

(a.) Check name plate details according to the approved drawings.

(b.) Check for physical damage.

(c.) Check tightness of all bolted connections, by torque wrench.

(d.) Check earth connections.

(e.) Check cleanliness.

(f.) Check all moving parts for proper lubrication.

40.04.00 Circuit Breakers

(a.) Check alignment of breaker truck for free movement.

(b.) Check correct operation of shutters.

(c.) Check control wiring for correctness of connections, continuity And IR values.

(d.) Manual operation of breakers completely assembled.

(e.) Closing /opening operation, manually and electrically.

(f.) Trip free and anti-pumping operation.

(g.) I.R. values of contacts.

(h.) Contact resistance.

(i.) Check on spring charging motor, correct operation of limit switches and time or charging.

(j.) All functional checks

(k.) Breaker closing and tripping time, if required.

40.05.00 Current Transformers

(a.) Visual inspection.

(b.) IR Value

(c.) Ratio check.

(d.) Magnetising current.

(e.) Wiring connection.

(f.) Spare CT cores, if any, to be shorted and earthed

40.06.00 Voltage Transformers

(a.) Visual inspection.

(b.) IR Value

(c.) Ratio check

(d.) Magnetising current

(e.) Line connection as per connection diagram

40.07.00 Cubicle Wiring

(a.) Check all switch developments

(b.) Each wire shall be traced by continuity tests and it shall be ensured that the wiring is as per relevant drawing. All inter-connections between panels / equipment shall be similarly checked.

(c.) IR Value of all the wires shall be checked to earth.

(d.) Functional checking of all control circuit e.g., closing, tripping, control, interlock, supervision and alarm circuit.

40.8.1 Relays

1. Check connections and wiring.
2. IR Value to be checked for
   a) all terminals to body.
   b) AC to DC terminals.
3. Check operating characteristics by secondary injection.
4. Check minimum pick up voltage of DC coils.
5. Check operation of electrical / mechanical targets.
6. Relay settings.
7. Check CT and VT connections with particular reference to their polarities.

40.09.00 Meters

(a.) Visual inspection.

(b.) Check IR Value of all insulated partitions.

(c.) Check CT and VT connections with particular reference to their polarities for power type meters.

(d.) Calibration.

41.00.00 AC MODULES DESCRIPTION

41.1.1 Module type DAE (Circuit Breaker Module)

41.02.00 Module Type DAET (Circuit Breaker Incomer From Transformer)

41.03.00 Module Type CC (Contactor Changeover Between Two In Coming Supplies)

41.04.00 Module Type CS (AC Control Supply Module)

41.6.1 Module Type E/E1/E2 (MCB/MCCB for rating 100 A and above)

41.07.00 Module Type G1 (VT Module with Under Voltage / No Volt Relay)

41.08.00 Module Type H (Isolating Switch Module)

41.9.1 Module type K1 (Non-Reversible Motor Rated Below 30 kW Controlled from MCC)

41.10.00 Module Type K11 (Non-reversible Motor Rated 30kW to 55 kW Controlled from MCC)

41.11.1 Module type DK2 (Non-Reversible Motor rated below 30kW Controlled from DDCMIS)

41.12.1 Module Type DK21 (Non-Reversible Motor rated 30kW to up to 55 KW (* See Remark) controlled from D D C M I S).

41.13.00 Module Type DN1 (Reversible Motor Controlled from DDCMIS)

41.14.00 Module Type VM (Voltmeter Module)

41.15.00 Module Type DM (Circuit Breaker (DDC /PLC Controlled) Motor Feeder for motor rated 75 KW & above

43.00.00 **SELECTION TABLES**

43.01.00 Feeder Module, Other than Motor Selection Table (415 V AC)

Sl. No.	Feeder Rating (Amp.)	MCB/MCCB Rating (Amp.)
1.	0-10	16 MCB
2.	11-22	32 MCB
3.	23-45	63 MCB
4.	46-99	100A MCCB
5.	100-160	160A MCCB
6.	161-250	250A MCCB
7.		
8.	251-400	400A MCCB
	401-1120 (Breaker)	
9.	1121-1680 (Breaker)	

SUB-SECTION-B – 08

HT LT & CONTROL CABLES

HT, LT Power Cables & Control Cables

This chapter has to be read in conjunction with sub-section B-0 "General electrical specification" of Technical specification.

1.00.00 CODES AND STANDARDS

All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those (IS: codes, standards, etc.) referred to herein, the former shall prevail. All the cables shall conform to the requirements of the following standards and codes:

IS:7098 (Part -II)	**Specification for Cross linked polyethylene insulated PVC sheathed cables. Part-II: For working voltages from 3.3 KV upto and including 33 KV.**
IS : 3975	Low Carbon Galvanized steel wires, formed wires and tapes for armouring of cables.
IS:4905	Methods for random sampling.
IS : 5831	PVC insulation and sheath of electrical cables.
IS : 8130	Conductors for insulated electrical cables and flexible cords.
IS : 10418	Specification for drums for electric cables.
IS : 10810	Methods of tests for cables.
ASTM-D - 2843	Standard test method for density of smoke from the burning or decomposition of plastics.
IEC-754 (Part-I)	Tests on gases evolved during combustion of electric cables.
IS :1554 - I	PVC insulated (heavy duty) electric cables for working voltages upto and including 1100V.
IS : 3961 IEC- 332	Recommended current ratings for cables Tests on electric cables under fire conditions. Part-3: Tests on bunched wires or cables (Category-B).
IS:7098 (Part -I)	Cross linked polyethylene insulated PVC sheathed cables for working voltages upto and including 1100V.

2.00.00 TECHNICAL REQUIREMENTS

2.01.00 All cables (HT Power, LT power and control cables) shall be Armoured type irrespective of anything contrary mentioned elsewhere in the specification.

2.02.00 All cables including EPR cables shall be flame retardant, low smoke (FRLS) type designed to withstand all mechanical, electrical and thermal stresses developed under steady state and transient operating conditions as specified elsewhere in this specification.

2.03.00 Aluminium conductor used in power cables shall have tensile strength of more than 100 N/ sq.mm. Conductors shall be multi stranded.

2.04.00 XLPE insulation shall be suitable for a continuous conductor temperature of 90 deg. C and short circuit conductor temperature of 250 deg C. PVC insulation shall be suitable for continuous conductor temperature of 70 deg C and short circuit conductor temperature of 160 deg. C.

2.05.00 The cable cores shall be laid up with fillers between the cores wherever necessary. It shall not stick to insulation and inner sheath. All the cables, other than single core unarmored cables, shall have distinct extruded PVC inner sheath of black color as per IS: 5831.

2.06.00 For single core Armoured cables, armoring shall be of aluminum wires. For multicore Armoured cables armouring shall be of galvanized steel as follows: -

Calculated nominal diameter of cable under armour		**Size and Type of armour**
i)	Upto 13 mm	1.4mm dia GS wire
ii)	Above 13 & upto 25mm	0.8 mm thick GS formed wire / 1.6 mm dia GS wire
iii)	Above 25 & upto 40 mm	0.8mm thick GS formed wire / 2.0mm dia GS wire
iv)	Above 40 & upto 55mm	1.4 mm thick GS formed wire/2.5mm dia GS wire
v)	Above 55 & upto 70mm	1.4 mm thick GS formed wire/3.15mm dia GS wire
vi)	Above 70mm	1.4 mm thick GS formed wire / 4.0 mm dia GS wire

2.06.01 The aluminum used for armouring shall be of H4 grade as per IS: 8130 with maximum resistivity of 0.028264 ohm-sq.mm/mtr at 20 deg.C. The types and sizes of aluminum armouring shall be same as mentioned for galvanized steel at 2.05.00 above.

2.06.02 The gap between armour wires / formed wires shall not exceed one armour wire / formed wire space and there shall be no cross over / over-riding of armour wire / formed wire. The minimum area of coverage of armouring shall be 90%. The breaking load of armour joint shall not be less than 95% of that of armour wire / formed wire. Zinc rich paint shall be applied on armour joint surface of G.S. wire/ formed wire.

2.06.03 Distinct extruded PVC inner sheath of black color as per IS:5831 shall be provided for the cables as follows:

a) For all multicore cables.

b) For single core Armoured cables, where armouring is not being used as metallic screen.

CLAUSE NO.	TECHNICAL REQUIREMENTS
2.07.00	Outer sheath shall be of PVC black in colour. In addition to meeting all the requirements of Indian standards referred to, outer sheath of all the cables shall have the following FRLS properties. a) Oxygen index of min. 29 (Test method as per IS 10810 Part-58) b) Acid gas emission of max. 20% as per IEC-754 (Part-I) c) Smoke density rating shall not be more than 60% during Smoke Density Test as per ASTMD-2843.
2.08.00	Allowable tolerances on the overall diameter of the cables shall be +\-2 mm maximum over the declared value in the technical data sheets.
2.09.00	Cable lengths shall be considered in such a way that straight through cable joints is avoided.
2.010.00	Multicore cable is allowed upto 300sq mm only. All LT power cables shall be XLPE insulated.. For LT cables, Same cable sizes to be used for same type & rating of motor i.e if there are three drives for one application, all three-drive motor should be provided with same cables sizes. **However due to layout constraints no of runs of same size cable may be increased.**
2.011.00	Cores of the cables shall be identified by coloring of insulation. Following color scheme shall be adopted: i. 1 core - Red, Black, Yellow or Blue ii. 2 core - Red & Black iii. 3 core - Red, Yellow & Blue iv. 4 core - Red, Yellow, Blue and Black
2.012.00	For reduced neutral conductors, the core shall be black.
2.013.00	In plant repairs to the cables shall not be accepted. Pimples, fisheye, blow holes etc. are not acceptable.
2.014.00	The cross-sectional area of the metallic screen strip/tape/wires shall be considered in sizing calculations.
2.015.00	The eccentricity of the core shall not exceed 10% and ovality not to exceed 2%.
3.00.00	**CABLE SELECTION & SIZING**
3.00.01	Cables shall be sized based on the following considerations: a) Rated current of the equipment b) The voltage drops in the cable, during motor starting condition, shall be limited to 10% and during full load running condition, shall be limited to 3% of the rated voltage c) Short circuit withstand capability
3.00.02	**Derating Factors** Derating factors for various conditions of installations including the following shall be considered while selecting the cable sizes: a) Variation in ambient temperature for cables laid in air b) Grouping of cables c) Variation in ground temperature and soil resistivity for buried cables.

CLAUSE NO.	TECHNICAL REQUIREMENTS
	The bidder shall furnish detailed cable selection/sizing criteria for Employer's approval.
4.00.00	**CONSTRUCTIONAL FEATURES**
4.00.01	**19/33, 11/11 KV Grade Power Cables:**
	Cables shall conform to IS 7098 Part-II. These cables shall be multi-stranded, compacted circular aluminum conductor, XLPE-insulated, metallic screened PVC outer sheathed. The conductor screen and insulation screen shall both be of extruded semiconducting compound and shall be applied along with the XLPE insulation in a single operation of triple extrusion process so as to obtain continuously smooth interfaces. Method of curing for 11/11, 6.35/11 KV Cables shall be "dry curing / gas curing/steam curing ". Method of curing for 33/33 KV Cables shall be "dry curing / gas curing ". The metallic screen for each core shall be capable of carrying the system earth fault current and shall consist of copper wires or tape with minimum overlap of 20%. However, for single core Armoured cables, the armouring shall constitute the metallic part of the screening.
4.00.02	**3.3/3.3kV Grade Power Cables:**
	Cables shall conform to IS: 7098 Part - II. These cables shall be multi- stranded, compacted circular aluminum conductor, XLPE insulated, metallic screened, PVC outer sheathed. The metallic screen of each core shall consist of copper wires or tape with minimum overlap of 20%. However, for single core Armoured cables, the armouring shall constitute the metallic part of the screening. The metallic screen of each core shall be capable of carrying the system earth fault current. Method of curing for cables shall be "dry curing / gas curing / steam curing".
4.00.03	**Trailing Cables:**
	Trailing cables shall have tinned copper (class 5) conductor, insulated with heat resistant elastomeric compound based on Ethylene Propylene Rubber (EPR) suitable for withstanding 90 deg.C continuous conductor temperature and 250deg C during short circuit, inner-sheathed with heat resistant elastomeric compound, nylon cord reinforced, outer-sheathed with heat resistant, oil resistant and flame-retardant heavy-duty elastomeric compound conforming to IS 9968
4.00.04	**1.1 KV Grade Power Cables**
	(a) 1.1 KV grade XLPE power cables shall have compacted aluminum conductor, XLPE insulated, PVC inner-sheathed (as applicable), Armoured-PVC outer-sheathed conforming to IS: 7098. (Part-I). (b) 1.1KV grade PVC power cables shall have aluminum conductor (compacted type for sizes above 10 sq.mm), PVC Insulated, PVC inner sheathed (as applicable) Armoured, PVC outer-sheathed conforming to IS:1554 (Part-I). (c) 1.1 KV grade Trailing cables shall have tinned copper (class 5) conductor, insulated with heat resistant elastomeric compound based on Ethylene Propylene Rubber(EPR) suitable for withstanding 90 deg.C continuous conductor temperature and 250deg C during short circuit, inner-sheathed with heat resistant elastomeric compound, nylon cord reinforced, outer-sheathed with heat resistant, oil resistant and flame retardant heavy duty elastomeric compound conforming to IS 9968.
4.00.05	**CABLE DRUMS**

a) Cables shall be supplied in wooden drums of heavy construction for LT Cable and Steel drum for HT Cable. The drum shall be designed on the basis of weight, diameter, bending radius and length of cable. The surface of the drum and the outer most cable layer shall be covered with waterproof 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.

b) Each drum shall carry manufacturer's name, purchaser's name, address and contract number, item number and type, size and length of cable and net gross weight stenciled on both sides of the drum. A tag containing same information shall be attached to the leading end of the cable. An arrow and suitable accompanying wording shall be marked on one end of the reel indicating the direction in which it should be rolled.

c) The standard drum length for **HT power cables** with a maximum tolerance of +/- 5%, may be decided by the bidder subject to condition that there shall not be any joint in cable, where application length of cable is up to & including 1000 meter for single core cable, and 750 meter for multicore cable.

d) The standard drum length of **LT power cable** with a maximum tolerance of +/- 5% may be decided by the bidder subject to condition that there shall not be any joint in cable, where application length of cable is up to & including 1000 meter for single core cable excluding 630 sq.m size, and 750 meter for multicore cable & single core 630 sq.m.

e) The standard drum length for **Control cables** with a maximum tolerance of +/- 5% may be decided by the bidder subject to condition that there shall not be any joint in cable, where application length of cable is up to & including 1000 meter.

f) One drum length of each cable size can be of non-standard length (not less than 500 meter) so as to match the ordered quantity subject to condition that there shall not be any joint in cable.

5.00.00 **TYPE, ROUTINE AND ACCEPTANCE TESTS**

5.01.00 **Type Tests**

The reports for the following type tests shall be submitted for one size each of LT XLPE, LT PVC Power and control cables. The following type tests shall be carried out on one size each of 19/33 KV & 11/11 KV, 3.3/3.3 KV HT Cables. Size shall be decided by the employer during detailed engineering

S. No	Type Test	Remarks
Conductor		
1.	Resistance test	
For Armour Wires / Formed Wires		
2.	Measurement of Dimensions	
3.	Tensile Test	
4.	Elongation test	
5.	Torsion test	For round wires only
6.	Wrapping test	
7.	Resistance test	
8(a)	Mass & uniformity of Zinc Coating tests	For GS wires/formed wires only.
8(b)	Adhesion test	For GS wires/formed wires only
	For XLPE insulation & PVC Sheath	
9.	Test for thickness	
10.	Tensile strength and elongation test before ageing and after ageing	
11.	Ageing in air oven	
12.	Loss of mass test	For PVC outer sheath only.
13.	Hot deformation test	For PVC outer sheath only.
14.	Heat shock test	For PVC outer sheath only
15.	Shrinkage test	
16.	Thermal stability test	For PVC outer sheath only
17.	Hot set test	For XLPE insulation only
18.	Water absorption test	For XLPE insulation only
19.	Oxygen index test	For PVC outer sheath only
20.	Smoke density test	For PVC outer sheath only
21.	Acid gas generation test	For PVC outer sheath only
22	Flammability test as per IEC-332 Part-3 (Category -B)	For completed cable only

5.02.00

The following type tests reports for HT Cables shall be submitted for each type (voltage grade) & size of the cable:

S. No.	Type Test For all cables	
1.	Insulation resistance test (Volume Resistivity method)	
2.	High voltage test	
For cables of 19/33kV, 11/11KV,3.3/3.3KV Grade only.		
3.	Partial discharge test	
4.	Bending test	
5.	Dielectric power factor test	
	a)	As a function of voltage
	b)	As a function of temperature
6.	Heating cycle test	
7.	Impulse withstand test	

Indicative list of tests/ checks, Routine and Acceptance tests shall be as per Quality Assurance & Inspection table of H.T. Cables enclosed.

SUB-SECTION-B – 10

CABLING, EARTHING AND LIGHTNING PROTECTION

CLAUSE NO.	TECHNICAL REQUIREMENTS
1.00.00	**CODES AND STANDARDS**
1.01.00	All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those (IS codes, standards, etc.) referred to herein, the former shall prevail. All work shall be carried out as per the following standards/ codes as applicable.

IS:513	Cold rolled low carbon steel sheets and strips.
IS:802	Code of practice for the use of Structural Steel in Overhead Transmission Line Towers.
IS:1079	Hot Rolled carbon steel sheet & strips
IS:1239	Mild steel tubes, tubulars and other wrought steel fittings
IS:1255	Code of practice for installation and maintenance of power cables up to and including 33 KV rating
IS:1367 Part-13	Technical supply conditions for threaded Steel fasteners. (Hot dip galvanized coatings on threaded fasteners).
IS:2147	Degree of protection provided by enclosures for low voltage switchgear and control gear
IS:2309	Code of Practice for the protection of building and allied structures against lightning.
IS:2629	Recommended practice for hot dip galvanising of iron & steel
IS:2633	Method for testing uniformity of coating on zinc coated articles
IS:3043	Code of practice for Earthing
IS:6745	Methods for determination of mass of zinc coating on zinc coated iron & steel articles.
IS:8308	Compression type tubular in- line connectors for aluminium conductors of insulated cables
IS:8309	Compression type tubular terminal ends for aluminium conductors of insulated cables.
IS:9537	Conduits for electrical installation.
IS:9595	Metal - arc welding of carbon and carbon manganese steels – recommendations.
IS:13573	Joints and terminations for polymeric cables.
BS:476	Fire tests on building materials and structures
IEEE:80	IEEE guide for safety in AC substation grounding
IEEE:142	Grounding of Industrial & commercial power systems
DIN 46267 (Part-II)	Non-tension proof compression joints for Aluminium conductors.
DIN 46329	Cable lugs for compression connections, ring type, for Aluminium conductors
BS:6121	Specification for mechanical Cable glands for elastomers and plastic insulated cables.
	Indian Electricity Act.
	Indian Electricity Rules.

1.02.00	Equipment complying with other internationally accepted standards such as IEC, BS, DIN, USA, VDE, NEMA etc. will also be considered if they ensure performance and constructional features equivalent or superior to standards listed above. In such a case, the Bidder shall clearly indicate the standard(s) adopted, furnish a copy in English of the latest revision of the standards along with copies of all official amendments and revisions in force as on date of opening of bid and shall clearly bring out the salient features for comparison.
2.00.00	**DESIGN AND CONSTRUCTIONAL FEATURE**

CLAUSE NO.	TECHNICAL REQUIREMENTS
2.01.00	**Inter Plant Cabling**
2.01.01	Interplant cabling for main routes shall be laid along overhead trestles/duct banks. Cables from main plant to switchyard control room shall be laid in overhead trestles or duct bank. In case of Duct banks, pull-pits shall be filled with sand and provided with a PCC covering. Directly buried cables, if essential, shall not have concentration of more than 4 cables in one route. Cables crossing Railway line (if applicable) shall be laid underground through nearest culvert/through hume pipes/ overhead trestle. Necessary statutory clearance if required shall be taken by Bidder. All HT, LT and control and Instrumentation cable shall be armoured.
2.01.02	**Transformer yard** In transformer yard cables shall be laid in overhead trestle. The main cable routes coming out from Main plant building and crossing the Transformer yard shall be laid in overhead trestles. In transformer yard, trestle height for rail/road crossing shall be suitable for movement of Generator Transformer with bushing.
2.01.03	**Trenches** PCC flooring of built up trenches shall be sloped for effective drainage with sump pits and sump pumps.
2.01.04	No sub zero level cable vault/trenches shall be provided below control building/switchgear rooms in main plant.
2.01.05	**Cable Vault** The cable vault/ / cable spreader room space below the HT / LT switchgear room, Control Rooms, unit control equipment room, Programmer room, UPS, Charger & Battery Rooms, shall have **800 mm wide** and 2.1 m high movement passage all around the cable trays in the cable vault/ cable spreader room for easy laying/maintenance of cables. Cable vaults shall be provided with adequate drainage facilities for drainage of fire water. Each cable vault should have at least two fire proof doors preferably diagonallly opposite.. Exit signs shall be provided near doors for personnel escape in case of emergency
2.01.06	**Boiler Area** Cable trays in boiler & ESP area shall be supported from the boiler and ESP structures. The same shall be coordinated with SG/ESP contractor. Cable trays in these areas shall be in vertical formation to avoid dust accumulation. No cable trenches shall be provided in boiler/ESP area.
2.01.07	Two separate cable routes shall be provided for cable routing of working and standby drives or different set/group (say 50% capacity) of auxiliaries.
2.01.08	**OffSite Area** For feeder in bidder's scope for offsite areas such as Pump house etc, overhead cable tray arrangement shall be followed. However, cable trenches/slit may also be acceptable, for some areas, if found to be required during detailed engineering.
2.01.09	Cable trenches provided shall be separated from fuel oil area to avoid oil accumulation. The cable slits to be used for motor/equipment power/control supply shall be sand filled & covered with PCC after cabling.
2.01.10	Sizing criteria, derating factors for the cables shall be met as per respective chapters. However, for the power cables, the minimum conductor size shall be 6 sq.mm. for aluminium conductor and 2.5 sq.mm. for copper conductor cable.

CLAUSE NO.	TECHNICAL REQUIREMENTS
2.01.11	Conscious exceptions to the above guidelines may be accepted under special conditions but suitable measures should be taken at such location to: • Meet all safety requirements • Safeguard against fire hazards, mechanical damage, flooding of water, oil accumulation, electrical faults/interferences, etc.
3.00.00	**EQUIPMENT DESCRIPTION**
3.01.00	Cable trays shall be ladder/perforated type as specified complete with matching fittings (like brackets, elbows, bends, reducers, tees, crosses, etc.) accessories (like side coupler plates, etc. and hardware (like bolts, nuts, washers, G.I. strap, hook etc.) as required. Cable tray shall be ladder type for power & control cables and perforated for instrumentation cables.
3.01.02	Cable trays, fittings and accessories shall be fabricated out of rolled mild steel sheets free from flaws such as laminations, rolling marks, pitting etc. These (including hardware) shall be hot dip galvanized as per relevant clause of this chapter.
3.01.03	Cable trays shall have standard width of 150 mm, 300 mm & 600 mm and standard lengths of 2.5 metre. Thickness of mild steel sheets used for fabrication of cable trays and fittings shall be 2 mm. The thickness of side coupler plates shall be 3 mm.
3.01.04	Cable troughs shall be required for branching out few cables from main cable route. These shall be U-shaped, fabricated of mild steel sheets of thickness 2 mm and shall be hot dip galvanised as per relevant clause of this chapter. Troughs shall be standard width of 50 mm & 75 mm with depth of 25 mm.
3.01.05	The tolerance for cable tray and accessories shall be as per IS 2102 (Part-1). Tolerance Class: - Coarse
3.02.00	**Support System for Cable Trays**
3.02.01	Cable tray support system shall be pre-fabricated out of single sheet as per enclosed tender drawings.
3.02.02	Support system for cable trays shall essentially comprise of the two components i.e. main support channel and cantilever arms. The main support channel shall be of two types: (i) C1: -having provision of supporting cable trays on one side and (ii) C2: -having provision of supporting cable trays on both sides. The support system shall be the type described hereunder: a) Cable supporting steel work for cable racks/cables shall comprise of various channel sections, cantilever arms, various brackets, clamps, floor plates, all hardware's such as lock washers, hexagon nuts, hexagon head bolt, support hooks, stud nuts, hexagon head screw, channel nut, channel nut with springs, fixing studs, etc. b) The system shall be designed such that it allows easy assembly at site by using bolting. All cable supporting steel work, hardware's fittings and accessories shall be prefabricated factory galvanized. c) The main support and cantilever arms shall be fixed at site using necessary brackets, clamps, fittings, bolts, nuts and other hardware etc. to form various arrangements required to support the cable trays. Welding of the components shall not be allowed. However, welding of the bracket (to which the main support channel is bolted) to the overhead beams, structural steel, insert plates or reinforcement bars will be permitted. Any cutting or welding of the galvansied surface shall be brushed and red lead primer, oil primer & aluminium paint shall be applied.

d) All steel components, accessories, fittings and hardware shall be hot dip galvanised after completing welding, cutting, drilling and other machining operation.

e) The typical arrangement of flexible support system is shown in the enclosed drawings and described briefly below:
The main support channel and cantilever arms shall be fabricated out of 2.5 thick rolled steel sheet conforming to IS 1079.

f) Cantilever arms of 170mm, 320 mm, 620mm and 750 mm in length are required, and shall be as shown in the enclosed drawing. The arm portion shall be suitable for assembling the complete arm assembly on to component constructed of standard channel section. The back plate shall allow sufficient clearance for fixing bolt to be tightened with tray in position.

g) Support system shall be able to withstand
- weight of the cable trays
- weight of the cables (75 Kg/Metre run of each cable tray)
- Concentrated load of 75 Kg between every support span
- Factor of safety of minimum 1.5 shall be considered

3.02.03 The size of structural steel members or thickness of sheet steel of main support channel and cantilever arms and other accessories as indicated above or in the enclosed drawings are indicative only. Nevertheless, the support system shall be designed by the bidder to fully meet the requirements of type tests as specified. In case the system fails in the tests, the components design modification shall be done by the Bidder without any additional cost to the Employer. The bidder shall submit the detailed drawings of the system offered by him alongwith the bid.

3.02.04 Four-legged structure shall be provided wherever there is change in elevation and change in direction

3.02.05 FOR COAL HANDLING PLANT/ASH HANDLING PLANT/**FGD PLANT**/ **ESP AREA** THE FOLLOWING SHALL ALSO BE APPLICABLE:

a) All overhead cable routes shall be along the route of the conveyor gallery on separate supporting structures and cables shall be laid in vertical trays. The bottom of the steel shall be such that the existing facilities, movement of trucks/human beings etc. does not get affected. The cable trestle shall have a minimum 600mm clear walk way and shall have maintenance platforms as required. The bottom of the steel supporting structure shall be generally at 3.0M above the grade level except for rail/road crossings. However, at all road/rail crossings, the level of bottom of steel of the gallery shall be at least 8.0m from the top of road surface and 8.5 m from top of rail track. Tap offs from the overhead cable trestle can be through shallow trenches with prior approval of the Employer. Directly buried cable, if essential, shall not have concentration of more than 4 cables on one route.

b) Cable vault shall be provided in Switchgear/MCC rooms for CHPLHP/GHP/AHP area.

c) Cables shall not be routed through the conveyor galleries except for the equipment located in the conveyor galleries for a particular conveyor i.e. protection switches, receptacles etc. and bunker TP related conveyors.

d) Cables for PCS and BSS shall be routed along the conveyors through GI conduits.

CLAUSE NO.	TECHNICAL REQUIREMENTS
3.03.00	**Pipes, Fittings & Accessories**
3.03.01	Pipes offered shall be complete with fittings and accessories (like tees, elbows, bends, check nuts, bushings, reducers, enlargers, coupling caps, nipples etc.) The size of the pipe shall be selected on the basis of maximum 40% fill criteria.
3.03.02	GI Pipes shall be of medium duty as per IS: 1239
3.03.03	Duct banks shall be High Density PE pipes encased in PCC (10% spare of each size, subject to minimum one) with suitable water-proof manholes.
3.03.04	Hume pipes shall be NP3 type as per IS 458.
3.03.05	Flexible conduit shall be water proof, rust proof, made of heat resistant steel with temperature rating of 150 deg C. Conduit diameter shall be uniform throughout its length. Internal surface of the conduit shall be free from burrs and sharp edges. Conduits shall be complete with necessary accessories for proper termination of the conduit with junction boxes and lighting fixtures.
3.03.06	HDPE pipes and conduits shall be PE-80, PN-10 type as per IS 4984/IS 8008 part-I.
3.04.00	**Junction Boxes**
3.04.01	Junction box shall be made of Fire-retardant material. Material of JB shall be Thermoplastic or thermosetting or FRP type. The box shall be provided with the terminal blocks, mounting bracket and screws etc. The cable entry shall be through galvanized steel conduits of suitable diameter. The JB shall have suitable for installing glands of suitable size on the bottom of the box. The JB shall be suitable for surface mounting on ceiling/structures. The JB shall be of grey color RAL 7035. All the metal parts shall be corrosion protected. Junction box surface should be such that it is free from crazings, blisterings, wrinkling, colour blots/striations. There should not be any mending or repair of surface. JB's will be provided with captive screws so that screws don't fall off when cover is opened. JB's mounting brackets should be of powder coated MS. Type test reports for the following tests shall be furnished: a) Impact resistance for impact energy of 2 Joules (IK07) as per BS EN50102 b) Thermal ageing at 70deg C for 96 hours as per IEC60068-2-2Bb c) Class of protection shall be IP 55 d) HV test
3.04.02	Terminal blocks shall be 1100V grade, of suitable current rating, made up of unbreakable polyamide 6.6 grade. The terminals shall be screw type or screw-less (spring loaded) / cage clamp type with lugs. Marking on terminal strips shall correspond to the terminal numbering in wiring diagrams. All metal parts shall be of non-ferrous material. In case of screw type terminals, the screw shall be captive, preferably with screw locking design. All terminal blocks shall be suitable for terminating on each side the required cables/wire size. All internal wiring shall be of cu. Conductor PVC wire.
3.05.00	**Terminations & Straight Through Joints**
3.05.01	Termination and jointing kits for 33kV, 11 kV, 6.6 KV and 3.3 kV grade XLPE insulated cables shall be of proven design and make which have already been extensively used and type tested. Termination kits and jointing kits shall be Pre-moulded type or heat shrinkable type. Further Cold shrinkable type termination and jointing kits are also acceptable. The Cold shrinkable type kits shall be type tested as per relevant standards. Calculation to withstand the required fault level shall also be furnished in case of cold shrinkable type kits. 33 kV, 11 kV, 6.6 KV and 3.3kV grade joints and terminations shall be type tested and Type test reports as per IS:13573 Part-II and IEC60502 shall be furnished. Also, heat shrink material shall comply with

	requirements of ESI 09-13 (external tests). Critical components used in cable accessories shall be of tested and proven quality as per relevant product specification/ESI specification. Cable joints and terminations should be with FRLS properties as per IEC 60754-1&2. Kit contents shall be supplied from the same source as were used for type testing. The kit shall be complete with the tinned copper solderless crimping type cable lugs & ferrule or mechanical connectors (wherein bolts are tightened that shear off at an appropriate torque) as per DIN standard suitable for aluminium compacted conductor cables.
3.05.02	Straight through joint and termination shall be capable of withstanding the fault level of 21 KA for 0.12 Sec. with dynamic peak of 52 KA for 33 KV system & of 40 kA for 0.12 sec with a dynamic peak of 100 kA for 11 kV, 6.6 KV & 3.3 KV system. Straight through joints shall have provisions for shield connection and earthing wherever required and complete with all accessories and consumables suitable for storage without deterioration at a temperature of 50 deg. C with shelf life of more than five years. 1.1 kV grade straight through joints shall also be of proven design
3.05.03	1.1 KV grade Straight Through Joint shall be of proven design
3.06.00	**Cable glands** Cable shall be terminated using double compression type cable glands. Testing requirements of Cable glands shall conform to BS:6121 and gland shall be of robust construction capable of clamping cable and cable armour (for armoured cables) firmly without injury to insulation. Cable glands shall be made of heavy-duty brass machine finished and nickel chrome plated. Thickness of plating shall not be less than 10 microns. All washers and hardware shall also be made of brass with nickel chrome plating Rubber components shall be of neoprene or better synthetic material and of tested quality. Cable glands shall be suitable for the sizes of cable supplied/erected.
3,07.00	**Cable lugs/ferrules**
3.07.01	Cable lugs/ferrules shall be solderless crimping type suitable for power and control cables as per the DIN 46239. Aluminium solderless crimping lugs/ ferrules shall be used for Aluminium cables and Copper lugs/ferrules shall be used for Copper cables. Bimetallic washers or bimetallic type lugs shall be used for bimetallic connections. Crimping tool for crimping (from 1.5sqmm cable to 630sqmm cables) above mentioned lugs shall be of Hexagonal Type crimp profile, with suitable die of crimp match code. Characteristics of crimping tool: 1) To should generate enough pressure to pass pull out test as per IEC 61238-1. Relevant type test to be produced for the sizes specified in the tender. 2) Tool die shall be replaceable for assorted sizes and crimp code to be mentioned on both part the die 3) Tool should be compliant of testing according to IEC, UL and GS standards Tool shall have features such as • Auto retraction system • Manual retraction stops • Feedback signals for improper pressure • Better battery capacity and with status display • Flexible and rotating head for easy crimping
3.08.00 3.08.01	**Trefoil clamps** Trefoil clamps for single core cables shall be pressure die cast aluminum or fibre glass or nylon and shall include necessary fixing accessories like G.I. nuts, bolts, washers, etc. Trefoil clamps shall have adequate mechanical strength, when installed at 1 mtr intervals, to withstand the forces generated by the peak value of maximum system short circuit current

3.09.00 **Cable Clamps & Ties**

3.09.01 The cable clamps/ties required to clamp multicore cables shall be of SS-316 material, 12mm wide, polyster coated ladder lock type. The clamps/ties shall have self-locking arrangement & shall have sufficient strength. The cable clamps/ties shall be supplied in finished individual pieces of suitable length to meet the site requirements.

3.10.00 **Receptacles**

3.10.01 Receptacles boxes shall be fabricated out of MS sheet of 2mm thickness and hot dipped gavanised or of die-cast aluminium alloy of thickness not less than 2.5 mm. The boxes shall be provided with two nos. earthing terminals, gasket to achieve IP55 degree of protection, terminal blocks for loop-in loop-out for cable of specified sizes, mounting brackets suitable for surface mounting on wall/column/structure, gland plate etc. The ON-OFF switch shall be rotary type heavy duty, double break, AC23 category, suitable for AC supply. Plug and Socket shall be shrouded Die-cast aluminium. Socket shall be provided with lid safety cover. Robust mechanical interlock shall be provided such that the switch can be put ON only when the plug is fully engaged and plug can be withdrawn only when the switch is in OFF position. Also cover can be opened only when the switch is in OFF position. Wiring shall be carried out with 1100 V grade PVC insulated stranded aluminium/copper wire of adequate size. The Terminal blocks shall be of 1100 V grade. The Terminal blocks shall be of 1100 V grade made up of unbreakable polymide 6.6 grade with adequate current rating and size. The welding receptacles shall be provided with RCCB/RCD of 30mA sensitivity having facility for manual testing/checking of operation of RCCB/RCD.

Welding receptacle: 63A, 3-phase, 415V AC welding receptacles with isolating switch will be provided at specific points near all major equipment, and at an average distance of 50m (location will be decided during detailed engineering). Maximum 04 nos. receptacles will be fed through one feeder.

3.11.00 **Cable Drum Lifting Jack**

The jack for cable drum lifting shall be of screw type with 10-ton capacity. The cable drum jacks shall be manufactured from fabricated steel. The spindles supplied with the cable drum jack shall be manufactured using BSEN-24 grade steel bar with locking collars. Jack nests shall be of SG cast steel. Cable drum jack supplied shall have undergone load testing and reports for the same shall be submitted. At least Two Nos. of jacks shall be supplied for customer use. Contractor has to make arrangements for his own jacks for cable reeling/unreeling under his scope of installation.

3.12.00 **Galvanising**

3.12.01 Galvanising of steel components and accessories shall conform to IS:2629, IS4759 & IS:2633. Additionally galvanising shall be uniform, clean smooth, continuous and free from acid spots.

3.12.02 The amount of zinc deposit over threaded portion of bolts, nuts, screws and washers shall be as per IS:1367. The removal of extra zinc on threaded portion of components shall be carefully done to ensure that the threads shall have the required zinc coating on them as specified.

3.13.00 **Welding**

3.13.01 The welding shall be carried out in accordance with IS:9595. All welding procedures and welder's qualification shall also be followed strictly in line with IS:9595.

4.00.00 **INSTALLATION**

4.01.00 **Cable tray and Support System Installation**

CLAUSE NO.	TECHNICAL REQUIREMENTS
4.01.01	Cables shall run in cable trays mounted horizontally or vertically on cable tray support system which in turn shall be supported from floor, ceiling, overhead structures, trestles, pipe racks, trenches or other building structures.
4.01.02	Horizontally running cable trays shall be clamped by bolting to cantilever arms and vertically running cable trays shall be bolted to main support channel by suitable bracket/clamps on both top and bottom side rails at an interval of 2000 mm in general. For vertical cable risers/shafts cable trays shall be supported at an interval of 1000mm in general. Fixing of cable trays to cantilever arms or main support channel by welding shall not be accepted. Cable tray installation shall generally be carried out as per the approved guidelines/ drawings. Vendor shall design the support system along with tray, spacing etc in line with tray loadings/drawings.
4.01.03	The cantilever arms shall be positioned on the main support channel with a minimum vertical spacing of 300 mm unless otherwise indicated
4.01.04	The contractor shall fix the brackets/ clamps/ insert plates using anchor fasteners. Minimum size of anchor fasteners shall be M 8 X 50 and material shall be stainless steel grade 316 or better. Anchor fastener shall be fixed as recommended by manufacturer and as approved by site engineer. For brick wall suitable anchor fasteners shall be used as per the recommendations of manufacturer. Make of anchor fasteners subject to QA approval and the same shall be finalized at pre-award stage.
4.01.05	All cable way sections shall have identification, designations as per cable way layout drawings and painted/stenciled at each end of cable way and where there is a branch connection to another cable way. Minimum height of letter shall be not less than 75 mm. For long lengths of trays, the identification shall be painted at every 10 meters. Risers shall additionally be painted/stenciled with identification numbers at every floor.
4.01.06	In certain cases it may be necessary to site fabricate portions of trays, supports and other nonstandard bends where the normal prefabricated trays, supports and accessories may not be suitable. Fabricated sections of trays, supports and accessories to make the installation complete at site shall be neat in appearance and shall match with the prefabricated sections in the dimensions. They shall be applied with one coat of red lead primer, one coat of oil primer followed by two finishing coats of aluminium paint.
4.01.07	In fire prone areas, like Gassifier, fuel oil area and any other strategic location etc, fire retardant paint to be applied after installation cables.
4.02.00	**Conduits/Pipes/Ducts Installation**
4.02.01	The Contractor shall ensure for properly embedding conduit pipe sleeves wherever necessary for cabling work. All openings in the floor/roof/wall / cable tunnel/cable trenches made for conduit installation shall be sealed and made water proof by the Contractor.
4.02.02	GI pull wire of adequate size shall be laid in all conduits before installation. Metallic conduit runs at termination shall have two lock nuts wherever required for junction boxes etc.
4.02.03	Conduit runs/sleeves shall be provided with PVC bushings having round edge at each end. All conduits/pipes shall have their ends closed by caps until cables are pulled. After cables are pulled, the ends of conduits/pipes shall be sealed with Glass wool/Cement Mortar/Putty to prevent entrance of moisture and foreign material
4.02.04	Exposed conduit/pipe shall be adequately supported by racks, clamps, straps or by other approved means. Conduits /pipe support shall be installed square and true to line and grade with an average spacing between the supports as given below, unless specified otherwise

	Conduit /pipe size (dia). **Spacing** Upto 40 mm 1 M 50 mm 2.0 M 65-85 mm 2.5 M 100 mm and above 3.0 M
4.02.05	For bending of conduits, bending machine shall be arranged at site by the contractor to facilitate cold bending. The bends formed shall be smooth.
4.03.00	**Junction Boxes Installation**
4.03.01	Junction boxes shall be mounted at a height of 1200mm above floor level or as specified in the drawings and shall be adequately supported/mounted on masonry wall by means of anchor fasteners/ expandable bolts or shall be mounted on an angle, plate or other structural supports fixed to floor, wall, ceiling or equipment foundations.
4.04.00	**Cable Installation**
4.04.01	Cable installation shall be carried out as per IS:1255 and other applicable standards.
4.04.02	For Cable unloading, pulling etc following guidelines shall be followed in general: a. Cable drums shall be unloaded, handled and stored in an approved manner on hard and well drained surface so that they may not sink. In no case shall be drum be stored flat i.e. with flange horizontal. Rolling of drums shall be avoided as far as possible. For short distances, the drums may be rolled provided they are rolled slowly and in proper direction as marked on the drum. In absence of any indication, the drums may be rolled in the same direction as it was rolled during taking up the cables. For unreeling the cable, the drum shall be mounted on suitable jacks or on cable wheels and shall be rolled slowly so that cable comes out over the drum and not from below. All possible care shall be taken during unreeling and laying to avoid damage due to twist, kink or sharp bends. Cable ends shall be provided with sealed plastic caps to prevent damage and ingress of moisture. b. While laying cable, ground rollers shall be used at every 2 meter interval to avoid cable touching ground. The cables shall be pushed over the rollers by a gang of people positioned in between the rollers. Cables shall not be pulled from the end without having intermediate pushing arrangements. Pulling tension shall not exceed the values recommended by cable manufacturer. Selection of cable drums for each run shall be so planned so as to avoid using straight through joints. Care should be taken while laying the cables so as to avoid damage to cables. If any particular cable is damaged, the same shall be repaired or changed to the satisfaction of Project Manager.
4.04.03	Cables shall be laid on cable trays strictly in line with cable schedule
4.04.04	Power and control cables shall be laid on separate tiers in line with the approved guidelines/drawings. The laying of different voltage grade cables shall be on different tiers according to the voltage grade of the cables. In horizontal tray stacks, H.T. cables shall be laid on top most tier and cables of subsequent lower voltage grades on lower tiers of trays. Single core cable in trefoil formation shall be laid with a distance of four times the diameter of cable between trefoil center lines and clamped at every one metre. All multicore cables shall be laid in touching formation. Control and instrumentation cable can be laid in 3 layers subject to maximum cable tray filling upto 80% tray depth only. Power and control cables shall be secured fixed to trays/support with cable clamps/ties with self-locking arrangement. For horizontal trays arrangements, multicore power cables and control cables shall be secured at every five-meter interval. For vertical tray arrangement, individual multicore power cables and control cables shall be secured at every one meter. After completion of cable laying work in

	the particular vertical tray, all the control cables shall be binded to trays/supports by cable clamps/ties with self-locking arrangement at every five-meter interval and at every bend. Fibre Optical cable shall be laid in trenches/trays or as decided by Employer
4.04.05	Bending radii for cables shall be as per manufacturer's recommendations and IS:1255.
4.04.06	Where cables cross roads/rail tracks, the cables shall be laid in hume pipe/ HDPE pipe/overhead trestle.
4.04.07	No joints shall be allowed in trip circuits, protection circuits and CT/PT circuits. Also joints in critical equipment in main plant area shall not be permitted. Vendor shall identify and accordingly procure the cable drum length.
4.04.08	In each cable run some extra length shall be kept at suitable point to enable one LT/two HT straight through joints to made, should the cable develop fault at a later stage. Control cable termination inside equipment enclosure shall have sufficient lengths so that shifting of termination in terminal blocks can be done without requiring any splicing.
4.04.09	Wherever few cables are branching out from main trunk route troughs shall be used.
4.04.10	Wind loading shall be considered for designing support as well Cable trays wherever required
4.04.11	Where there is a considerable risk of steam, hot oil or mechanical damage cable routes shall be protected by barriers or enclosures
4.04.12	The installation work shall be carried out in a neat workman like manner & areas of work shall be cleaned of all scraps, water, etc. after the completion of work in each area every day. Contractor shall replace RCC/Steel trench covers after the Installation work in that particular area is completed or when further work is not likely to be taken up for some time
4.04.13	**Separation** At least 300mm clearance shall be provided between: - HT power & LT power cables, - LT power & LT control/instrumentation cables
4.04.14	**Segregation** 1) Segregation means physical isolation to prevent fire jumping 2) All cables associated with the unit shall be segregated from cables of other units 3) Interplant cables of station auxiliaries and unit critical drives shall be segregated in such a way that not more than half of the drives are lost in case of single incident of fire. Power and control cables for AC drives and corresponding emergency AC or DC drives shall be laid in segregated routes. Cable routes for one set of auxiliaries of same unit shall be segregated from the other set 4) In switchyard, control cables of each bay shall be laid on separate racks/trays
4.04.15	Minimum number of spare cores required to be left for interconnection in control cables shall be as follows: No. of cores in cable — No. of spare cores 2C,3C, 5C — 1 6C-10C — 2 14C and above — 3
4.04.16	**Directly Buried Cables** **a)** Cable trenches shall be constructed for directly buried cables. Construction of cable trench for cables shall include excavation, preparation of sieved sand bedding, riddled soil cover, supply and installation of brick or concrete protective covers, back filling and compacting,

	supply and installation of route markers and joint markers. Laying of cables and providing protective covering shall be as per IS:1255 and the enclosed drawings showing cabling details.
	b) RCC cable route and RCC joint markers shall be provided wherever required. The voltage grade of the higher voltage cables in route shall be engraved on the marker. Location of underground cable joints shall be indicated with cable marker with an additional inscription "Cable Joint". The marker shall project 150 mm above ground and shall be spaced at an interval of 30 meters and at every change in direction. They shall be located on both sides of road crossings and drain crossings. Top of cable marker/joint marker shall be sloped to avoid accumulation of water/dust on marker.
4.04.17	Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct/conduit entry, and at every 20 meters in cable tray/trench runs. Cable tags shall also be provided inside the switchgear, motor control centers, control and relay panels etc. where a number of cables enter together through a gland plate. Cable tag shall be of rectangular shape for power cables and control cables. Cable tag shall be of 2 mm thick aluminum with number punched on it and securely attached to the cable by not less than two turns of 20 SWG GI wire conforming to IS:280. Alternatively, the Contractor may also provide cable tags made of nylon, cable marking ties with cable number heat stamped on the cable tags. The cable tag requirements mentioned above shall prevail over Tag requirements mentioned elsewhere in this document for HT power, LT power & control cables.
4.04.18	While crossing the floors, unarmoured cables shall be protected in conduits upto a height of 500 mm from floor level if not laid in tray.
4.05.00	**Cable Terminations & Connections**
4.05.01	The termination and connection of cables shall be done strictly in accordance with cable termination kit manufacturer" instructions, drawings and/or as directed by Project Manager. Cable jointer shall be qualified to carryout satisfactory cable jointing/termination. Contractor shall furnish for review documentary evidence/experience reports of the jointers to be deployed at site
4.05.02	Work shall include all clamps, fittings etc. and clamping, fitting, fixing, plumbing, soldering, drilling, cutting, taping, preparation of cable end, crimping of lug, insulated sleeving over control cable lugs, heat shrinking (where applicable), connecting to cable terminal, shorting and grounding as required to complete the job to the satisfaction of the Project Manager.
4.05.03	The equipment will be generally provided with undrilled gland plates for cables/conduit entry. The Contractor shall be responsible for punching of gland plates, painting and touching up. Holes shall not be made by gas cutting. The holes shall be true in shape. All cable entry points shall be sealed and made vermin and dust proof. Unused openings shall be effectively sealed by 2mm thick aluminium sheets.
4.05.04	Control cable cores entering control panel/switchgear/MCC/miscellaneous panels shall be neatly bunched, clamped and tied with self locking type nylon cable ties with de interlocking facility to keep them in position.
4.05.05	All the cores of the control cable to be terminated shall have identification by providing ferrules at either end of the core, each ferrule shall be indelible, printed single tube ferrule and shall include the complete wire number and TB number as per the drawings. The ferrule shall fit tightly on the core. Spare cores shall have similar ferrules with suffix sp1, sp2, ---etc along with cable numbers and coiled up after end sealing.

4.05.06 All cable terminations shall be appropriately tightened to ensure secure and reliable connections.

5.00.00 EARTHING SYSTEM

5.01.00 Earthing system shall be in strict accordance with IS:3043 and Indian Electricity Rules/Acts. The earthing system shall be designed for a life expectancy of at least forty (40) years, for a system fault current of as specified in relevant chapter of the specification. The minimum rate of corrosion of steel for selection of earthing conductor shall be 0.12mm per year.

Earthing system network/earthmat shall be interconnected mesh of mild steel rods buried in ground in the plant. All areas under contractor scope of supply shall be interconnected together by minimum two parallel conductors. The Contractor shall furnish the detailed design and calculations for Employer's approval. Contractor shall obtain all necessary statutory approvals for the system. All the columns shall be earthed by nearby risers and earthmat grid spacing shall be maximum 15 mts Separate dedicated riser shall be provided for C&I earthing purpose and also for Lightning down conductor connection purpose. Sufficient nos of risers near the equipment shall be provided as per the system requirement. Ring type earthing around the offsite building shall be provided with interconnection of with main grid at minimum two points.

5.02.00 The earth conductors shall be free from pitting, laminations, rust, scale and other electrical, mechanical defects.

5.03.00 The material of the earthing conductors shall be as follows:

1.	Conductors above ground level and in built up trenches.	-	Galvanized steel
2.	Conductors buried in earth	-	Mild steel
3.	Earth electrodes	-	Mild steel rod

5.04.00 The sizes of earthing conductors for various electrical equipments shall be as below:

	Equipment	Earth conductor buried in earth	Earth conductor above ground level & in built-up trenches
i.	Main earth grid	Min 40 mm dia. MS rod or as per actual calculation whichever is more	65 x 8mm GS flat
ii.	33kV/11kV/6.6kV/3.3 kV/ switchgear equipment and 415V switchgear	---	65 x 8mm GS flat
iii.	415 V MCC/ Distribution boards / Transformers	---	50 x 6mm GS flat
iv.	LT Motors above 125 KW	---	50 x 6mm GS flat
	25 KW to 125 KW	---	25 x 6mm GS flat
	1KW to 25 KW	---	25 x 3mm GS flat
	Fractional House power motor	---	8 SWG GS wire
v.	Control panel & control desk	---	25 x 3 mm GS flat
vi.	Push button station / Junction	---	8 SWG GI wire
vii.	Columns, structures, cable trays and bus ducts enclosures	---	50 x 6mm GS flat
viii.	Crane, rails, rail tracks & other non-current carrying metal parts		25 x 6mm GS flat

CLAUSE NO.	TECHNICAL REQUIREMENTS
5.05.00	Metallic frame of all electrical equipment shall be earthed by two separate and distinct connections to earthing system, each of 100% capacity, Crane rails, tracks, metal pipes and conduits shall also be effectively earthed at two points. Steel RCC columns, metallic stairs and rails etc. of the building housing electrical equipment shall be connected to the nearby earthing grid conductor by one earthing ensured by bonding the different sections of hand rails and metallic stairs. Metallic sheaths/screens, and armour of multi-core cables shall be earthed at both ends. Metallic Sheaths and armour of single core cables shall be earthed at switchgear end only unless otherwise approved. Every alternate post of the switchyard fence shall be connected to earthing grid by one GS flat and gates by flexible lead to the earthed post. Railway tracks within the plant area shall be bonded across fish plates and connected to earthing grid at several locations. Portable tools, appliances and welding equipment shall be earthed by flexible insulated cable.
5.06.00	Each continuous laid lengths of cable tray shall be earthed at minimum two places by G.S. flats to earthing system, the distance between earthing points shall not exceed 30 meter. Wherever earth mat is not available, necessary connections shall be done by driving an earth electrode in the ground.
5.07.00	Transformer neutral shall be connected to earth mat through 2No,treated earthing pit and shall meet the statutory requirements. Neutral points of HT transformer shall be earthed through NG resistors. The Contractor shall connect the NGR earthing point to 2No treated earth pit by suitable earth conductors.
5.08.00	Neutral connections and metallic conduits/pipes shall not be used for the equipment earthing. Lightning protection system down conductors shall not be connected to other earthing conductors above the ground level.
5.09.00	Connections between earth leads and equipment shall normally be of bolted type. Contact surfaces shall be thoroughly cleaned before connections. Equipment bolted connections after being tested and checked shall be painted with anti corrosive paint/compound.
5.10.00	Suitable earth risers as approved shall be provided above finished floor/ground level, if the equipment is not available at the time of laying of main earth conductor.
5.11.00	Connections between equipment earthing leads and between main earthing conductors shall be of welded type. For rust protection the welds should be treated with red lead compound and afterwards thickly coated with bitumen compound. All welded connections shall be made by electric arc welding.
5.12.00	Resistance of the joint shall not be more than the resistance of the equivalent length of conductors.
5.13.00	Earthing conductors buried in ground shall be laid minimum 600 mm below grade level unless otherwise indicated in the drawing. Back filling material to be placed over buried conductors shall be free from stones and harmful mixtures. Back filling shall be placed in layers of 150 mm.
5.14.00	Earthing conductors embedded in the concrete floor of the building shall have approximately 50 mm concrete cover.
5.15.00	A minimum earth coverage of 300 mm shall be provided between earth conductor and the bottom of trench/foundation/underground pipes at crossings. Earthing conductors crossings the road can be installed in pipes. Wherever earthing conductor crosses or runs at less than

300 mm distance along metallic structures such as gas, water, steam pipe lines, steel reinforcement in concrete, it shall be bonded to the same.

5.16.00 Earthing conductors along their run on columns, walls, etc. shall be supported by suitable welding / cleating at interval of 1000mm and 750mm respectively.

5.17.00 Earth pit shall be of treated type & shall be constructed as per IS:3043. Electrodes shall be embedded below permanent moisture level. Minimum spacing between electrodes shall be 600mm. Earth pits shall be treated with salt and charcoal as per IS:3043. Test links shall be provided with bolted arrangement along with each earth pit, in order to facilitate measurement of earth resistance as & when required.

5.18.00 On completion of installation continuity of earth conductors and efficiency of all bonds and joints shall be checked. Earth resistance at earth terminations shall be measured and recorded. All equipment required for testing shall be furnished by contractor.

5.19.00 Earthing conductor shall be buried at least 2000mm outside the fence of electrical installations. Every alternate post of the fences and all gates shall be connected to earthing grid by one lead.

5.20.00 Other Requirements of Earthing System:

Standard/Code	IEEE 80, IS 3043	
Earthing System		
Life expectancy	40 Years	
System Fault Level	As per System Fault Level	
Soil resistivity	Actual as per site conditions	
Min. Steel corrosion	0.12mm/year	
Depth of burial of main earth conductor	600mm below grade level; where it crosses trenches, pipes, ducts, tunnels, rail tracks, etc., it shall be at least 300mm below them.	
Conductor joints	By electric arc welding, with resistance of joint not more than that of the conductor.	
Surface resistivity	- Gravel	3000 ohm-meter
	- Concrete	500 ohm-meter

Welds to be treated with red lead for rust protection and then coated with bitumen compound for corrosion protection

6.00.00 LIGHTNING PROTECTION SYSTEM

6.01.01 Lightning protection system shall be in strict accordance with IEC : 62305 and latest IS standards.

6.01.02 Lightning conductor shall be of 25x6mm GS strip when used above ground level and shall be connected through test link with earth electrode/earthing system.

6.01.03 Lightning system shall comprise of air terminations, down conductors, test links, earth electrode etc. as per approved drawings.

6.02.00 Down Conductors

1. Down conductors shall be as short and straight as practicable and shall follow a direct path to earth electrode.
2. Each down conductor shall be provided with a test link at 1000 mm above ground level for testing but it shall be in accessible to interference. No connections other than the one direct to an earth electrode shall be made below a test point.

3. All joints in the down conductors shall be welded type.
4. Down conductors shall be cleated on outer side of building wall, at 750 mm interval or welded to outside building columns at 1000 mm interval.
5. Lightning conductor on roof shall not be directly cleated on surface of roof. Supporting blocks of PCC/insulating compound shall be used for conductor fixing at an interval of 1500 mm.
6. All metallic structures within a vicinity of two meters of the conductors shall be bonded to conductors of lightning protection system.
7. Lightning conductors shall not pass through or run inside GI Conduits.
8. Testing link shall be made of galvanized steel of size 25x 6mm.
9. Pulser system for lightning shall not be accepted.
10. Hazardous areas handling inflammable/explosive materials and associated storage areas shall be protected by a system of aerial earths.

7.00.00 **TESTS**

7.01.00 **Type Test reports shall be furnished for the following**

7.01.01 Type tests on Cable Trays support system

a) **Test 1A:**
On main support channel type-C2 for cantilever arms fixed on one side only. A 3.5 meter length of main support channel shall be fixed vertically at each end to a rigid structure as per the fixing arrangement as shown in the enclosed drawing. Eight (8) nos. 750 mm cantilever arms shall be fixed to the main channel and each arm shall be loaded over the outboard 600 mm with a uniform working load of 100 kg. Subsequently a point load of 100 kg shall be applied on arm 2. A uniform proof load on all the arms equal to twice the working load shall be then be applied. Deflections shall be measured at the points shown in the enclosed drawings and at the following load intervals:

i. Working load
ii. Working load + point load
iii. Off load
iv. Proof load + point load
v. Off load

The deflection measured at working loads shall not exceed 16mm. The permanent deflection after removing the combination of working load and point load shall not exceed 10 mm at the arm tips and 6 mm on the channel. No collapse of the structure shall occur with a combination of proof load and point load applied

b) **Test 1B**
Test 1A shall be repeated with Eight Cantilever arms uniformly loaded and with the same point load on arm 2

Test 2: On Main support channel type -C2 for cantilever arms fixed on both sides

a) **Test 2A:** A 3.5 m length of main support channel C2 for cantilever arms fixing on both sides shall be fixed at each end to rigid structure as per the fixing arrangement as shown in the enclosed drawing. Six (6), 750 mm cantilever arms shall be attached to each sides and each arm uniformly loaded to a working load of 100 kg over the out board 600 mm. A point load of 100 kg shall than be applied to arm 2, followed by a uniform proof load of twice the working load on all the arms; deflection shall be measured at points shown in the enclosed drawings at the following load intervals.

i. Working load
ii. Working load + point load

iii. Off load
iv. Proof load + point load
v. Off load

The deflection measured at working loads shall not exceed 16mm. The permanent deflection after removing the combination of working load and point load shall not exceed 10 mm at the arm tips and 6 mm on the channel. No collapse of the structure shall occur with a combination of proof load and point load applied

b) **Test 2 B:** The test 2 A shall be repeated with the assembly but with an asymmetrical load on the C2 column and point load applied to arm 8. The 100 kg and 200 kg uniformly distributed loads shall be applied to the upper three arms on one side and the lower three arms on the opposite side

Test 3: Tests on Channel Fixed on Beam/Floor

A length of main support channel section shall be fixed to steel structure/floor and have loads applied as shown in the drawing enclosed and as detailed below:

a) Test 3A: A length of steel structure shall be rigidly supported. It should be fitted on a meter length of channel section using beam clamps welded/bolted. A point load of 1200 kg shall be applied to the centre point via two brackets. No distortion or pulling of the components shall take place

b) Test 3B: With the components assembled as in Test 3A, two perpendicular point loads of 600 kg shall be simultaneously applied at positions 150 mm either side of the centre line, no distortion or pulling of the components shall take place

c) Test 3C: With the components assembled as in Test 3A, a perpendicular point load shall be applied at a point 150 mm on one side of the centre line

The load shall be gradually increased to the maximum value that can be applied without causing distortion or pulling of the components. This value shall be recorded

Test 4 : Channel Insert Test

A 2.5 m length of C1 channel fixed to the concrete wall/ steel structure as per actual site installation conditions. 6 nos. of 750 mm cantilever arms shall be attached to C1 channel as shown in enclosed drawing. Each arm uniformly loaded to a working load of 100 kg over the out board 600 mm. A point load of 100 kg shall than be applied to arm 2, followed by a uniform proof load of twice the working load on all the arms; deflection shall be measured at points shown in the enclosed drawings at the following load intervals.

i. Working load
ii. Working load + point load
iii. Off load
iv. Proof load + point load
v. Off load

The deflection measured at working loads shall not exceed 16mm. The permanent deflection after removing the combination of working load and point load shall not exceed 10 mm at the arm tips and 6 mm on the channel. No collapse of the structure shall occur with a combination of proof load and point load applied.

Test 5 : Channel nut slip characteristics (what ever applicable)

Tests 5A1,5A2,5A3 : A length of channel C1 section 200mm long shall have fitted bracket with the two bolt fixing as shown in drawing enclosed.

With loads applied at the position shown in drawing enclosed nut slip shall be determined with bolt torque of 30NM, 50 NM and 65 NM No fewer than three measurements shall be made for each torque setting.
A minimum loading of 720 kg shall be obtained before nut slip with bolt torque of 65 NM

Tests 5B1,5B2,5B3: The length of channel C1 section 200 mm long shall have fitted bracket with the one bolt fixing as shown in drawing enclosed. With loads applied at the position shown in drawing, nut slip shall be determined with bolt torques of 30 NM, 50 NM and 65 NM. No fewer than three measurements shall be made for each torque setting

A minimum loading of 350 kg shall be obtained before nut slip with a bolt torque of 65 NM

Test 6 Weld Integrity Test

After deflection test as per test 1A, 1B, 2, 3 & 4 weld integrity shall be checked by magnetic particle inspection to detect sub-surface cracks developed, if any.

7.02.02 Cable termination kit and straight through joints should have been tested as per IS:13573 for 3.3kV grade & above.

7.03.00 **Routine/ Acceptance Tests**

7.03.01 Routine Tests

a) Routine tests as per specification and applicable standards shall be carried out on all requirements/items covered in the specification

b) Physical & dimensional check on all equipments as per approved drawings/standards

c) HV/IR as applicable

d) Check/measurement of thickness of paint/zinc coating/nickel-chrome plating as per specification & applicable standard

7.03.02 Acceptance Test

a) Galvanising Tests as per applicable standards
b) Welding checks
c) Deflection tests on cable trays

One piece each of 2.5m length of cable tray of 300mm & above shall be taken as sample from each offered lot. It shall be supported at both end & loaded with uniform load of 76 kg/meter along the length of cable tray. The maximum deflection at the mid-span of each size shall not exceed 7mm

d) Proof load tests on cable tray support system
   i. Tests on Main Support Channel shall be done if only C1 Channel are in scope of supply and cantilever arms shall be fitted on one side. This test shall be same as test 4 of type test.
   ii. Test on Main Support Channel shall be done with C2 channel and cantilever arms fitted on both sides, if C2 channels are in scope of supply. This test shall be same as test 2A of type test. Then test (i) above shall not be done.

iii. Nut slip characteristic test (it shall support minimum load of 350kg before nut slips with a bolt torque of 65 NM). This test shall be same as test 5B3 of type test

The procedure for carrying out tests at "d" above shall be as per details given in Type Tests in specification thereafter Die-Penetration test shall be carried out to check weld integrity

e) The above acceptance tests shall be done only on one sample from each offered lot.

8.00.00 COMMISSIONING

8.01.01 The Contractor shall carry out the following commissioning tests and checks after installation at site. In addition the Contractor shall carry out all other checks and tests as recommended by the Manufacturers or else required for satisfactory performance

8.01.02 **Cables**

i. Check for physical damage
ii. Check for insulation resistance before and after termination/jointing
iii. HT cables shall be pressure tested (test voltage as per IS:7098) before commissioning
iv. Check of continuity of all cores of the cables
v. Check for correctness of all connections as per relevant wiring diagrams. Any minor modification to the panel wiring like removing/inserting, shorting, change in terminal connections, etc., shall be carried out by the Contractor.
vi. Check for correct polarity and phasing of cable connections
vii. Check for proper earth connections for cable glands, cable boxes, cable armour, screens, etc.
viii. Check for provision of correct cable tags, core ferrules, tightness of connections

8.02.00 Cable trays / supports and accessories

1. Check for proper galvanizing/painting and identification number of the cable trays/supports and accessories.
2. Check for continuity of cable trays over the entire route.
3. Check that all sharp corners, burrs, and waste materials have been removed from the trays supports.
4. Check for earth continuity and earth connection of cable trays.

8.03.00 Earthing and Lightning protection system

1. Earth continuity checks.
2. Earth resistance of the complete system as well as sub-system.

9.00.00 ELECTRICAL LAYOUT PHILOSOPHY:

While developing the layout the bidder must give due consideration to the following requirements:

a) Adequate distance shall be maintained between the transformers. As basic guidelines following norms will be adhered to:
   1. Transformers shall be separated from the adjacent building/structures and from each other by a minimum distance as defined below or by a fire wall of two hours of fire resisting of height at least 600 mm above bushing / pressure relief vent whichever is higher.

Oil capacity of individual transformer (in liters)	Clear separating distance (in meters)
5,000 to 10,000	8.0
10,001 to 20,000	10.0
20,001 to 30,000	12.5
Over 30,001	15.0

2. In case of auxiliary transformers having an aggregate oil capacity in excess of 2300 liters but individual oil capacity of less than 5000 liters, the maximum separating distance between transformers and surrounding building shall be at least 6M unless they are separated by fire separating walls or are protected by high velocity spray system

3. Rail track shall be provided in Transformer yard for movement of each transformer. The rail track in Transformer yard shall be connected with TG area rail track The Foundation top of transformer & rail top shall be at EL +/- 0.0M. Bus duct support or Transformer body shall be at least 8.0M from A-Row of TG building to clear the movement of GT/ Stator/UT/ST/UAT on rail line. Jacking pads shall be provided where the rail track changes the direction. Mooring post shall be provided on rail track for handling the transformers

4. For each transformer a pit shall be provided all around at a distance of 1.5 m (minimum) from transformer outer edge. A sump pit shall be provided for each pit. A common oil retention pit per unit shall be provided to hold oil quantity of the largest transformer (by volume) & 10 minutes of water quantity of HVW spray system for the largest transformer. Sump pit of individual transformer shall be connected to common oil retention pit of that unit.

5. Rail track shall be provided for all outdoor transformers up to road for movement of each transformer of size more than or equal to 7.5MVA Transformer. Jacking pads shall be provided where the rail track changes the direction. Jacking pad shall also be provided at the location of installation of transformer and mooring post shall be provided on rail track for handling the transformers.

6. The Transformer fencing shall be at 1.0 M (minimum) distance from the pit wall. The Height of fencing shall be 2.5 M (minimum) and fencing shall have personal entry gate and removable type fencing/gate for transformer withdrawal.

7. The transformer firewall, pit sizing and clearances from adjacent building/structures etc. shall be as per IS 1646/CBIP manual on Transformer

8. However, for all outdoor transformers of oil capacity less than 2000 litre, a trench of suitable size shall be provided all around at a distance of 1.0 m (minimum) from transformer outer edge. A sump pit shall be provided for each trench.

b) Layout requirements for Electrical MCC/switchgear rooms

1. Separate Switchgear Rooms shall be provided for each unit. For TG building, all HT boards shall be provided in HT switchgear room at only one floor and all LT boards shall be provided in LT switchgear room located at various floor

2. **The following clearances shall be maintained for HT Switchboard**

i) For one Row of Swgr.	-	2.0 M (Min)
ii) For two Rows of Swgr.	-	2.5 M (Min)
b.) Back Clearance	**-**	**1.5 M (Min.)**

c.) Side Clearance

Min. 800 mm, however provision to be made for any additional panel in future at both ends. Therefore, end clearance shall be 800+width of panel (including spare panels/dummy panels etc.)

3. The following clearances shall be maintained for LT Switchboard.

a.) Front Clearance

i) For one Row of Swgr - 1.5M (Min)
ii) For two Rows of Swgr - 1.5/1.75M depending upon the depth of panels etc

b.) Back Clearance

i) For single front - 1.0M (Min)
ii) For double front - 1.5M (Min)

c.) Side Clearance:Min. 800 mm, however provision to be made for any additional panel in future at both ends. Therefore end clearance shall be 800 mm + width of panel.

For offsite areas, HT Switchboard clearances shall be followed wherever both LT & HT switch boards are in the same MCC room

4. Height of HT/LT Switchgear Room and Boiler MCC room
   i. With Bus Duct – 4.5 m (min)
   ii. Without Bus Duct – 4.0 m (min)

   Further no vertical bracings shall be envisaged in HT/LT switchgear room and associated cable vault area.

5. Cable trench/Cable vault
   For LT switchgear/MCC room at EL 0.0M, 1400 wide x 1400 deep cable trench shall be provided to route the cables. Horizontal cable trays shall be routed in cable trenches

6. The following clearances to be maintained for C&I DDCMIS cabinets:
   i) Inter panel spacing - 1200mm
   ii) Clearance from back wall - 1200mm
   iii) Clearance from front wall - 1200mm
   iv) Clearance from side wall - 1000mm
   The above clearances are the minimum requirement and may increase with increase in door swing of the cabinets

7. Battery room shall be provided for 24V/220V/110V/UPS systems batteries.

c) Minimum clear working space around the equipment 1200mm

d) In buildings having MCC, minimum 2 fire door along with one rolling shutter of adequate size/capacity shall be provided.

e) Monorail with Electric hoist shall be provided in Switchgear building with cable cellar for Panels/Transformer erection & maintenance purpose

f) The cable entry and exit from switchgear room shall be from 1.5 mtr (minimum) above FGL

g) Wash basin with mirror shall be provided in battery room.

SUB-SECTION-B – 11

LIGHTING

LIGHTING

1.00.00 GENERAL

1.01.00 This specification covers the general description of design, manufacture and construction features, testing, supply, installation and commissioning of the Station Lighting system equipment.

2.00.00 CODES AND STANDARDS

2.01.00 All standards and codes of practice referred to herein shall be the latest edition including all applicable official amendments & revisions as on date of bid opening. In case of conflict between this specification and those (IS codes, standards etc.) referred to herein, the former shall prevail. All work shall be carried out as per the following standards & codes.

2.02.00 Lighting Fixtures and Accessories

IS:1913	General and safety requirements for luminaries.
IS:2148	Flame proof enclosures of electrical apparatus.
IS:1534	Ballast for fluorescent lamps.
IS:1777	Industrial luminaire with metal reflectors.
IS:2418	Tubular fluorescent lamps for general lighting services.
IS:4013	Dust-tight electric lighting fittings.
IS:8224	Electric Lighting fittings for Division 2 areas.
IS:10276	Edison screw lamp holders.
IS:10322	Luminaires.
IS:13021	AC Supplied Electronic Ballasts for tubular fluorescent lamps.
IS 16103	LED Luminaire Standards

2.03.00 Lighting Panels, Switch-boxes, Receptacles and Junction Boxes

IS:2147	Degree of protection provided by enclosures for low-voltage switchgear and control gear.
IS:1293	Plugs & socket outlets of rated voltage upto and Including 250volts & rated current upto and including 16 Amps.
IS:2551	Danger notice plates.
IS:13947	Low voltage switchgear and control-gear
IS:3854	Switches for domestic and similar purposes.
IS:6875	Control switches (switching devices for control and auxiliary circuits including contactor relays) for voltages upto and including 1000 V AC and 1200 V DC.
IS:13703	Low voltage fuses for voltages not exceeding 1000V AC or 1500 V DC.

2.04.00 **Conduits, Pipes and Accessories**

IS:2667	Fittings for rigid steel conduit for electrical wiring.
IS:3837	Accessories for rigid steel conduits for electrical wiring.
IS:9537	Conduits for electrical installations.

2.05.00 **Lighting Wires/Cables**

IS:694	PVC insulated cables for working voltages up to and including 1100 V
IS:3961	Recommended current ratings for cables. (PVC Insulated and PVC sheathed heavy duty cables and light duty cables).
IS:8130	Conductors for insulated electric cables and flexible cords.
IS:10810	Methods of tests for cables.

2.06.00 **LED Luminaries**

16101:2012	General Lighting. LEDs and LED modules Terms and definitions
16102(Part 1):2012	Self Ballasted LED Lamps for General Lighting Services. Part-1 Safety Requirements.
16102(Part 2):2012	Self Ballasted LED Lamps for General lighting Services. Part-2 Performance Requirements.
16103(Part I):2012	LED modules for General lighting Safety Requirements.
15885(Part 2/Sec. 13) :2012	Lamp control gear Part 2 particular Requirements Section 13 d.c. or a.c. Supplied Electronic control gear for LED modules
16104:2012	d.c. or a.c. Supplied Electronic control gear for LED modules - Performance Requirements.
16105:2012	Method of Measurement of Lumen maintenance of Solid-state Light (LED) Sources.
16106:2012	Method of Electrical and photometric Measurements of Solid-State Lighting (LED) Products
16107:2012	Luminaires Performance
16108:2012	Photo-biological safety of Lamps and Lamp Systems
IS 513	Cold rolled low carbon steel sheets and strips

	IS 12063	Classification of degree of protection provided by enclosures.
	IS 14700 (Part 3/Sec. 2)	Electromagnetic compatibility (EMC) – Limits for Harmonic current emission – THD < 15% (equipment, input current < 16 Amps. per phase.
	IS 9000 (Part 6)	Environment testing: Test Z – AD: composite temperature/humidity cyclic test.
	IS 15885 (Part 2/Sec. 13)	Lamp control gear: particular requirements for DC or AC supplied electronic control gear IS 16004 – 1 and 2) for LED modules.
	IS 4905	Method for random sampling
2.07.00	**Electrical Installation Practices & Miscellaneous**	
	IS:1944	Code of practice for lighting of public thorough fare
	IS:3646	Code of practice for interior illumination.
	IS:5572	Classification of Hazardous areas (other than Mines) having flammable gases and Vapours for electrical installation
	S:6665	Code of practice for industrial lighting.
	.	National Electrical Code
	-	Indian Electricity Rules.
	IS:5	Indian Electricity Act Colour for ready mixed paints & enamels.
	IS:280	Mild steel wires for general engineering purposes.
	IS:374	Electric ceiling type fans & regulators.
	IS:732	Code of practice for electrical wiring installations.
	IS:1255	Code of practice for installation and maintenance of power cables Upto and including 33KV rating.
	IS:2062	Steel for general structural purposes
	IS:2629	Recommended practice for hot-dip galvanizing of iron and steel.
	IS:2633	Methods for testing uniformity of coating of zinc coated articles.
	IS:2713	Tubular steel poles for overhead power lines.
	IS:3043	Code of practice for earthing

	IS:5216	Guide for safety procedures and practices in electrical work.
	IS:5571	Guide for selection of electrical equipments for hazardous areas.
	BS:6121	Mechanical cable glands

3.00.00 LIGHTING SYSTEM DESCRIPTION

3.01.00 The illumination of various indoor and outdoor areas in the ~~main plant &~~ offsite area shall be provided as described here. The lighting system of various areas shall comprise of the following systems as identified in Annexure-B:

(a) Normal AC Lighting System

(b) Deleted

(c) DC Lighting System

3.02.01 **Normal AC Lighting System**

Normal AC lighting system 415V, 3Phase, 4wire, will be fed from lighting panels (LPs) which in turn will be fed from the lighting distribution boards (LDBs)/Switch board MCC.

3.02.02 Deleted

3.03.00 **DC Lighting System**

3.03.01 At strategic locations in the plant, a few lighting fixtures fed from 220V, DC supply, shall be provided to enable safe movement of operating personnel and access to important control points during an emergency, when both the normal AC Lighting system fail. These lighting fixtures will be fed from 220V DC LDBs which in turn will be fed from DC lighting panels.

3.03.02 The supply to the DC lighting panels shall be automatically switched ON in case of loss of AC supply. The DC supply will be automatically switched OFF after about 3 minutes following the restoration of supply to normal AC lighting system.

3.03.03 Emergency DC lighting is to be provided, through self-contained DC emergency fixtures with four hours back-up duration, at strategic locations, in auxiliary/offsite buildings wherever DC supply system is not available. The fixtures shall be switched 'ON' automatically in case of failure of AC supply.

3.03.04 For Coal Handling plant/FGD Plant Area
18W, 220V DC Lighting fixture shall be provided in underground portion of conveyor, each switchgear room, control room, office room, pump house, each drive floor of TPs, staircases of various TPs and buildings and each local control area. DC lighting fixtures shall be fed from 220V DC LDB which in turn will be fed from CHP DC system. The supply to the DC lighting panels shall be automatically switched ON in case of loss of normal AC supply.

4.00.00 DESIGN PHILOSOPHY

1. A comprehensive illumination system shall be provided in the entire project areas under bidder's scope.

2. All outdoor lighting system shall be automatically controlled by synchronous timer. Provision to bypass the timer shall be provided in the panel.

3. The system shall include distribution boards, normal/ emergency lighting panels, lighting fixtures, junction boxes, receptacles, switch boards, lighting pole/masts, conduits, cables and wires, etc. The system shall cover all interior and exterior lighting such as area lighting, including Transformer yard ~~& Switch yard area~~, aviation obstruction lighting, Street lighting, security lighting, etc. The constructional features of lighting distribution boards shall be similar to AC/DC distribution boards described in chapter of LT Switchgear. Outgoing circuits in LPs shall be provided with MCBs and RCBOs of adequate ratings.

4. The illumination system shall be designed on the basis of best engineering practice and shall ensure uniform, reliable, aesthetically pleasing and glare free illumination. The lighting fixtures shall be designed for minimum glare. The design shall prevent glare/luminous patch seen on VDU/ Large video screens, when viewed from an angle. The finish of the fixtures shall be such that no bright spots are produced either by direct light source or by reflection. The diffusers/ louvers used in fixtures shall be made of impact resistant polystyrene sheet and shall have no yellowing property over a prolonged period. The Lux levels to be adopted for various area are indicated at Annexure - A. (placed at the end of this Chapter).

5. Different Lighting Systems envisaged for various plant areas are indicated in Annexure-B: While finalizing the detailed layout of lighting fixtures, the position/location and layout of equipment should be taken into account to have adequate illumination at desired locations.

6. **LED Luminaires:**

LED Luminaires shall be used for the lighting of all the indoor & outdoor areas in bidder's scope. However for ~~DC lighting,~~ hazardous areas & aviation lighting etc. conventional/LED type luminaires shall be used. However, aviation light in Lighting Mast shall be of LED type. In false ceiling area LED luminaires shall be recessed mounting type & in non-false ceiling area the LED luminaires shall be surface mounting type.

The individual lamp wattage for LED shall be upto 3 watt. Fractional wattage LEDs are also acceptable. The LED chip efficacy shall be min 120 Lm/W. The luminaire efficacy shall be not less than 100 Lm/W. Suitable heat sink shall be designed & provided in the luminaire. The LED used in the luminaires shall have colour rendering index (CRI) of Min 80. Colour designation of LED shall be "cool day light" (min 5700K) type for indoor areas. However for outdoor areas, the colour temperature of LED shall be min. 4000K, including rough & dust prone areas. The LED luminaries shall have a minimum life of 25000 burning hours with 80% of lumen maintenance at the end of the life. LED shall conform to the LM 80 requirements.

The max. junction temperature of LED shall be 85 deg C. Further the lumen maintenance at this temperature shall be min 90%. The THD of LED Luminaires shall be less than 10%. Further the EMC shall be as per IS 14700. The power factor of the luminaire shall not be less than 0.9. The marking on luminaire & safety requirements of luminaire shall be as per IS standards. Suitable heat sink with proper thermal management shall be designed & provided in the luminaire.

The connecting wires used inside the system, shall be low smoke halogen free, fire retardant type and fuse protection shall be provided in input side specifically for LED luminaires.

Care shall be taken in the design that there is no water stagnation anywhere in the housing of luminaire. The entire housing shall be dust and waterproof protection as per IS 12063.

7. **Driver Circuit**

LED modules and drivers shall be compatible to each other. The LED module driver's ratings and makes shall be as recommended by corresponding LED chip manufacturer.

LED Drivers shall have following control & protections: -

- Suitable precision current control of LED.
- Open Circuit Protection
- Short Circuit Protection
- Over Temperature Protection
- Surge Protection

8. Apart from maintenance factor as given below, Temperature correction factor shall be considered in the lighting design for fixtures located in non air conditioned area.

(a.)	Office area (air conditioned)	:	0.8
(b.)	Office area (non air conditioned) and other indoor area	:	0.7
(c.)	Dust prone indoor and outdoor area	:	0.6
(d.)	Coal Handling area, Ash Handling Conveyor /Transfer Points etc.	:	0.5

Reflectance Factor:-

Ceiling :0.8
Wall : 0.5
Floor : 0.2

Reflectance factor for CHP areas such as Bunker floor, TPs etc and AHP outdoor areas including compressor houses :-

Ceiling :0.3
Wall :0.3
Floor :0.1

9. (i) All outdoor fixtures shall be weather proof and of min. IP65 degree of protection.

(ii) For Indoor type of fixtures:-

(a) Surface/Pendent mounting: - IP 54 class of protection.
(b) Recess Mounting (False ceiling):- IP 20 class of protection.

10. (a) Lighting panels shall be constructed out of 2 mm thick CRCA sheet steel. The door shall be hinged and the panel shall be gasketted to achieve specified degree of protection. Lighting panels shall be powder coated with color shade RAL9002. Lighting panels shall have min. IP55 degree of protection.

(B) All MCBs/Isolators/Switches/Contactors etc. shall be mounted inside the panel and a fibre glass sheet shall be provided inside the main door such that the operating knobs of MCBs etc., shall project out of it for safe operation against accidental contact.

(c) Terminal bocks shall be 1100 V grade, clip-on stud type, made up of polymide 6.6 or better suitable for terminating multicore min 70 Sq. mm. stranded aluminium conductor incoming cable and 10 Sq. mm. for each outgoing circuits voltage. All terminals shall be shrouded, numbered and provided with identification strip for the feeders.

(d) MCB's and RCBOs shall be current limiting type with magnetic and thermal release suitable for manual closing and automatic tripping under fault

condition. MCB's/RCBOs shall have short circuit interrupting capacity of min 9 KA rms. MCB/RCBOs knob shall be marked with ON/OFF indication. A trip free release shall be provided to ensure tripping on fault even if the knob is held in ON position. MCB/RCBOs terminal shall be shrouded to avoid accidental contact. RCBOs shall be of 30mA sensitivity having facility for manual testing/checking of operation.

(e) Contactors of AC lighting panels shall be 63 A, with neutral link, load make-break type suitable for 415 V, 3 phase 4 wire system.

(f) DC switches shall be rotary type, 2 pole, continuous duty, load break type, quick make quick break, suitable for 220 V DC, 2 wire system. Switch knob shall be provided with ON/OFF indication.

(g) Programmable Digital Timer shall be Electronic Astronomical Time switch with LED display, 24 hours range, manual override facility, 10 Amp relay output with NO/NC Contacts suitable for operation on 240V single phase AC supply.

(h) Lighting Panels shall have 20% spare outgoing feeders and shall be of following types:-

TYPE	INCOMER FEEDER	OUTGOING FEEDERS	DETAILOFCONTENTS
LP-1	415V, 63 A, MCB (31/2Cx70sq.mm cable)	18Nos.,20A, 220/240V, RCBO 30mA	415V, 63A(min.), AC2 duty contactor and Astronomical Programmable Digital Timer of 24 hour range 10A, 240V selector switch, fuse, etc. outdoor type and IP:55 degree of protection
LP-2	415V, 63 A, MCB (31/2Cx70sq.mm cable)	9 Nos.,20A, 220/240V RCBO 30mA	415V, 63A(min.), AC2 duty contactor and Astronomical Programmable Digital Timer of 24 hour range 10A, 240V selector switch, fuse, etc. outdoor type and IP:55 degree of protection

LP-D1	1No. 220V,32 A, DP Isolator (2Cx35sq.mm cable)	6Nos.,16A, 220V DP Switch & Fuse	220V,32A DC Fuse, etc. outdoor type IP:55 degree of protection.

11. Wires of different phase shall normally run in separate conduit.

12. Power supply shall be fed from 415 / 240 V normal AC supply, and 220V DC supply through suitable number of conveniently located lighting distribution boards (LDB) and lighting panels (LP). AC lighting supply shall be isolated from main supply by 2x100% isolation transformers of max. rating of 50/100 KVA for 10/15 nos. outgoing feeder with changeover switch facility. The isolation transformer shall be fed from two different bus sections of MCC and fault level restricted to 3 KA at Lighting Panels. 20% spare feeder (Min 2 two no.) shall be provided in each lighting DBs.

13. Atleast one 6/16A, 240V AC universal socket outlet with switch shall be provided in offices, cabins, etc. Further 20A, 240V AC industrial receptacle with switch shall be provided strategically in all industrial areas.
Suitable number of 63A, 3ph, 415V AC industrial receptacles shall be provided for entire plant for welding purposes, particularly near all major equipment and at an average distance of 50m. Atleast one 63A, 3ph, 415V AC receptacle shall be provided in each drive floor of off-site buildings/ structures.
Receptacles boxes shall be fabricated out of 2 mm thick MS steel hot dip galvanized or of not less than 2.5 mm thick die-cast aluminium alloy or fabricated out of 2 mm thick CRCA sheet with electro static powder coating. IP-degree of protection shall be applicable to receptacles Type 'RA &''RC' only.

Receptacles shall be of following types:

Type	Switch rating	Socket & plug rating	Type & make of plug & Socket	Terminal Block size
RA	20 A, SP240V AC(Industrial)	20A, 3 pin240 V AC	BHEL appd. make	1-4 way, suitable for loop-in loop-out of 10 sq.mm. Al. Conductor
RB	16A, S.P240V AC	6A+16A6 Pin decorative Piano-key Type Switch	BHEL appd.make	1-4 way, suitable for loop-in loop-out of upto 10 sq.mm. Al. Conductor

RC	20 A, SP24 V AC(Industrial)	20A, 3 pin24 V AC	BHEL appd. make	1-4 way, suitable for loop-in loop-out of 2 core - 16 sq.mm. Al. Cable.

14. In the hazardous areas like Hydrogen generation plant, fuel oil handling areas or any other gas/ liquid fuel storage/ handling areas in bidder's scope, lighting shall be flame proof.

15. The type of fixtures, LP, JB, and receptacle used in Hydrogen generation plant building shall be suitable for group II C as per IS: 2148 or class I, Division II as per NEC 70-428.

16. All fittings shall be have "Cool day light" colour designation. The mirror optics type fixtures shall have no iridescence effect. Fixtures with better efficiency and upgraded proven system may also be considered

17. Aviation warning lights shall be provided as per the recommendations of ICAO and Director general of civil aviation, India. The arrangement of light should be marked such that the object is indicated from every angle in azimuth. The aviation warning lighting system shall also conform to the latest Indian standard IS 4998.

18. Contractor shall demonstrate the average lux level achieved for different areas as per specification requirements, after completion of the lighting work, at site to the satisfaction of engineer-in-charge.

19. 70W (min) LED light fixture shall be provided at every column of MPH/MCC/pump house/shed/store/buildings etc for the peripheral lighting. 120W (min) LED fitting shall be provided wherever column spacing is more than 5m.

4.01.00 **NOT USED**.

4.02.00 All luminaires and their accessories and components shall be of type readily replaceable by available Indian makes.

4.03.00 **Fans & Regulator**

4.03.01 Ceiling Fans, to be provided in non air-conditioned office/control room area. Further tentatively one (1) no. ceiling fan shall be provided for 10 sq.m area, at suitable mounting height. The ceiling fans shall be suitable for operation on 240 V +/-10%, 50 Hz, AC supply comprising of class 'E' or better insulated copper wound single phase motor, 1200mm sweep, aerodynamically designed well balanced AL blades (3 Nos.), down rod, BEE 5 star rated,die cast aluminium housing, capacitor, suspension hook, canopies etc. finished in stove enameled white or with electro static powder coating. Power factor of fans shall not be less than 0.9. Fan regulators shall be stepped electronic type suitable for operation on 240V +/-10% AC supply.

4.04.00 Junction Boxes, Conduits, Fitting & Accessories, Pull Out Boxes:

Junction box for indoor lighting shall be made of fire retardant material. Material of JB shall be Thermoplastic or thermosetting or FRP type.

Junction boxes for street lighting poles and lighting mast if applicable , shall be deep drawn or fabricated type made of min. 1.6 mm thick CRCA Sheet. The box shall be hot dip galvanized. The degree of protection shall be IP55.

All switches and receptacles upto 16A shall be modular type. These shall be provided with pre-galvanized/galvanized modular switchbox & plate.

Conduits, Pipes and Accessories Galvanised heavy duty steel conduits for normal area and galvanised heavy duty steel conduits with an additional epoxy coating for corrosive area shall be offered. Alternatively glass reinforced epoxy conduits with comparable compressive and impact strength with that of heavy duty steel conduits may be offered.

Conduits in walls in false ceiling buildings shall be concealed. Rigid steel conduits shall be heavy duty type,hot dip galvanised conforming to IS : 9537 Part-I & II shall be suitable for heavy mechanical stresses, threaded on both sides and threaded length shall be protected by zinc rich paint. Conduits shall be smooth from inside and outside.

Flexible conduit shall be water proof, rust proof, made of heat resistant steel with temperature rating of 150 deg C.

Pull out boxes shall be provided at suitable interval in a conduit run .Boxes shall be suitable for mounting on Walls, Columns, Structures, etc.. Pull-out boxes shall have cover with screw and shall be provided with good quality gasket lining. Pull out boxes used outdoor shall be weather proof type suitable for IP: 55 degree of protection and those used indoor shall be suitable for IP: 52 degree of protection. Pull out box & its cover shall be hot dip galvanized.

4.05.00 **Lighting Wires**

4.05.01 Lighting wires shall be 1100 V grade, light duty PVC insulated unsheathed FRLS, stranded copper/ wire for fixed wiring installation. Colour of the PVC insulation of wires shall be Red, Yellow, Blue and Black for R, Y, B phases & neutral, respectively and white & grey for DC positive & DC negative circuits, respectively. Minimum size of wire shall not be less than 1.5.sq.mm. copper.

4.06.00 **Lighting Poles**

4.06.01 The Street Light system and peripheral lighting shall be designed generally in line with design guidelines. The Poles shall be mounted above ground using base plate and minimum height of pole shall be 8 mtrs The poles shall be hot-dip galvanized as per IS2629/ IS2633/ IS4759. The average coating thickness of galvanizing shall be min. 70 micron. The System shall be capable of withstanding the appropriate wind load etc as per IS 875 considering prevailing soil/ site condition considering all accessories mounting on pole.

The street light poles shall have loop in loop out arrangement for cable entry and light fixture / wiring protected with suitably rated MCB.

4.07.00 **Lighting Masts**

4.07.01 Suitable number of lighting masts shall be provided for entire area as decided by BHEL/owner. Minimum SIX number of high mast shall be considered for CHP/LHP area and 3 Nos for AHP area. Lighting Mast shall be of continuously tapered polygonal cross section hot dip galvanised. The Mast shall be of 30 M or suitable height with lantern carriage to enable raising/lowering for ease of maintenance, including the Head Frame, Double Drum Winch, continuous stainless-steel wire rope, in built power tool, luminaires, suitable aviation warning light, lightning along with necessary power cables within the mast. The mast shall be delivered in not more than three sections & shall be joined together by slip stressed fit method at site. No site welding or bolted joints shall be done on the mast

The Mast together with the fixtures shall be capable of withstanding the appropriate wind loads as per IS: 875. The Mast shall be fabricated from special steel plates conforming to BS-EN10-025 and folded to form a polygonal section.

	Suitable feeder pillar with TPN MCB, contactors, timer, MCB and other necessary accessories for operation & protection of the mast and fixtures shall be provided.
4.08.00	Lighting fixtures shall generally be group controlled directly from lighting panel. However, in office areas, control room shall be provided through switch boxes. Each switch shall control a maximum of three fixtures.
4.09.00	A.C. normal and DC system wiring shall run throughout in separate conduits. Wires of different phase shall run in different conduits.
4.10.00	Lighting panels, etc. shall be earthed by two separate and distinct connections with earthing system. Switch boxes, junction boxes, lighting fixtures, fans, single phase receptacles etc. shall be earthed by means of separate earth continuity conductor. The earth continuity conductor 14 SWG GI wire shall be run along with each conduit run. Cable armours shall be connected to earthing system at both the ends.
4.11.00	Alternately Vendor may offer technically superior and proven product subject to approval of employer.
4.12.00	**Occupancy based Passive Infra-red sensors** For Control Room and DCS Equipment room
5.00.00	**TESTS**
5.01.00	**For LED Fixture** a) The contractor shall carry out the type tests as listed in this specification on the following types of LED fixtures to be supplied under this contract. The bidder shall indicate the charges for each of these type tests separately in the relevant price schedule of bid document and the same shall be considered for the evaluation of the bids. LED fixtures (Type test shall be conducted on one rating each of following type of LED fixtures. Rating for test conduction shall be decided by the employer during detailed engineering) a) High bay fixture. b) Well glass fixture. c) Street light fixture d) Surface mounted type fixture. e) Recessed mounted type fixture.
5.02.00	**For all other Station lighting equipment:**
5.03.00	All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price.
5.04.00	Selection of samples for type test, acceptance test & routine test and acceptance criteria for all the items shall be as per relevant I.S
5.05.00	Type test reports of the following items as per technical specification requirements/ standards shall be submitted for approval. **SL NO. DESCRIPTION** i. Lighting fixtures of each type

ii. Lighting panel of each type (Degree of Protection)

iii. Junction Box of each type.

Type test reports for LED as per standards for following shall be submitted for approval.

1. Visual and Dimension check
2. Deleted
3. Safety tests
a) Marking
b) Construction
c) Provision for Earthing
d) External and Internal wiring
e) Protection against electrical shock
f) Endurance and Thermal
g) Insulation resistance & electrical strength
h) Resistance to heat fire & tracking
i) Resistance to Humidity
4. Fire Retardant test
5. Performance tests (electrical, Photometric color and Life)
6. Burn-in Test
7. Power Cycling
8. Temperature rise test
9. Emission Tests
a) Radiated & conducted emission
b) Harmonics & flickers
10. Immunity tests

In addition, following test reports to be submitted for LED chip/LED luminaire:

a) LED parameters like Lumen per watt, CRI, Beam angle from manufacturer.

b) LM 80/IS: 16105 report.

c) LM 79/IS: 16106 report.

5.06.00 Acceptance Test and Routine Test

5.06.01 All lighting fixtures, lamps and other items shall be subjected to acceptance and routine test, as per relevant specified standards.

5.06.02 Junction boxes, switch boxes, receptacle enclosure etc. shall be subjected to physical and dimensional checks also. Switch boxes shall be made of 1.6 mm thick MS sheet with 3 mm thick decorative, Perspex cover. Switch box shall be hot dip galvanized.

Switch boxes shall be of following types :

TYPE No.	Switch	Fan Regulator*	Socket
SWB 1	5 A - 2 Nos.	-	-
SWB 2	5 A - 3 Nos.	-	5A - 1.No.
SWB 3*	5 A - 5 Nos.	1	5A - 1.No
SWB 4*	5 A - 7 Nos	3	5A - 1.No.
SWB 5**	5 A - 5 Nos	-	5A - 1.No.

* Space provision shall be kept for fan regulator in switch boxes.

** Shall have the provision for mounting the 16 A contactor.

5.07.00 **Galvanizing Tests**

5.07.01 The quality of galvanizing shall be smooth, continuous, free from flux stains and shall be inspected visually.

5.07.02 In addition following tests shall be conducted as acceptance tests.

(a) Uniformity of coating - The coating of any article shall withstand for one (1) minute dips in standard copper sulphate solution without the formation of an adherent red spot of metallic copper upon the basic metal.

(b) The quality of cadmium/zinc plating on items with screw threads shall be free from visible defects such as unplated areas, blisters and modules and shall be inspected visually.

(c) In addition, the plating thickness shall be determined microscopically/ chemically or electronically.

6.00.00 COMMISSIONING CHECKS

1. On completion of installation work, the Contractor shall request the Project manager for inspection and test with minimum of fourteen (14) days advance notice.

2. The Project manager shall arrange for joint inspection of the installation for completeness and correctness of the work. Any defect pointed out during such inspection shall be promptly rectified by the Contractor.

3. The installation shall be then tested and commissioned in presence of the Project manager.

4. The contractor shall provide all, men material and equipment required to carry out the tests.

5. All rectifications repair or adjustment work found necessary during inspection, testing and commissioning shall be carried out by the Contractor without any extra cost. The handing over the lighting installation shall be effected only after the receipt of written instruction from the Employer/his authorized representative.

6. The testing shall be done in accordance with the applicable Indian Standards and codes of practices. The following tests shall be specifically carried out for all lighting installation.

   (a) Insulation Resistance.

   (b) Testing of earth continuity path.

   (c) Polarity test of single phase switches.

   (d) Functional checks.

7. The lighting circuits shall be tested in the following manner:

   (a) All switches ON and consuming devices in circuit, both poles connected together to obtain resistance to earth.

   (b) Insulation resistance between poles with lamps and other consuming devices removed and switches ON.

ANNEXURE-A

Sl No.	Location**	Average Illumination Level (Lux)	Type of Fixture
(c)	Switchgear rooms, Charger, Rectifier room	200	Industrial type LED Luminaire
(d)	Control room, computer room, control equipment room	350	LED luminaire equivalent to Mirror optics with anti-glare features or down-lighter.
(e)	Offices, conference rooms, etc.	300	Decorative mirror optics Type LED luminaire or LED down-lighter

	(f)	Battery rooms	100	Totally enclosed corrosion Proof LED Luminaire
	(g)	Transformer yard	20 (general) 50 (on equipment)	LED Luminaire
	(i)	Diesel generating room /enclosure, Compressor room, pump house etc.	150	LED medium bay/ Industrial type LED Luminaire
	(k)	Cable galleries/vault	50	Industrial type LED Luminaire
	(l)	Street lighting- primary roads secondary roads	 20 10	LED street lights
	(m)	Outdoor storage handling and unloading area	20	LED Luminaire
	(n)	Cement stores	150	Industrial dust proof type LED Luminaire
	(o)	Chemical stores/House	150	Corrosion proof LED Luminaire
	(p)	Permanent stores	150	LED high/medium bay / Industrial trough LED Luminaire
	(q)	Workshop. Building	150	LED high/medium bay / Industrial trough LED Luminaire
	(v)	Transfer points, Sheds, tunnels, bunker house, Crusher house, Conveyor Gallery etc. in bidders scope	100	LED Dust tight/Well glass type Luminaire
	(y)	DC Lighting- Control room	-	LED down light fixtures, Decorative recessed type with cylindrical reflector
	(z)	DC Lighting- Other Area	-	LED Industrial Bulkhead
	(aa)	Corridors, Walkways	50	LED Luminaire
	(ab)	Building Periphery Lighting	10	LED Street Light fixture/ LED Luminaire
	(ac)	Security Lighting along Boundary	10	LED Street Light fixture/ LED Luminaire

(ag)	DM plant, water treatment plant 150 CW Pump house, Raw water PH, Fire Water PH	LED high/medium bay / Industrial trough LED Luminaire

ANNEXURE-B

Sl.	Plant Areas	Normal AC Lighting System	Emergency AC Lighting System	220 V DC Lighting System	Portable DC Fixtures
1	Area Lighting	100%			
2	Street Lighting	100%			
3	Transformer Yard and Storage Yard	100%			
4	Coal Handling Plant	100%		√	
5	Ash Handling Plant	100%		√	

DC Emergency Lighting:

Sl.	Area	Average Lux Level
1	Strategic Control Points (For Safe Movement of Persons)	20
2	Cable Vault & Galleries	1 fixture at every 10 metres spacing along walkways
3	Exit/ Entry of Plant Building	1 fixture
4	Fire Exit Sign	1 fixture

SUB-SECTION-B – 12

FIRE PROOF CABLE PENETRATION SEALING SYSTEM

FIRE PROOF CABLE PENETRATION SEALING SYSTEM

1.00.00 CODES AND STANDARDS

1.01.00 The fire proof cable penetration (FPCP) sealing system shall conform to the requirement of latest edition including amendments of BS:476 Part-20 Fire tests on Building materials and structures.

1.02.00 Fire penetration seal complying with any other international standards will also be considered if it ensures performance equivalent or superior to standard listed above.

1.03.00 The Bidder shall clearly indicate the standards adopted and furnish a copy of the English version of the latest editions of standards along with the bid, and shall clearly bring out the salient features for comparison.

2.00.00 SYSTEM DESCRIPTION

2.01.00 The fire proof cable penetration sealing system shall be of the following types;

i) Type - A

Type A fire sealing system is either Silicone foam or equivalent foam system or using individual blocks for each cable along with suitable frame work rated for one hour. Type A is to be implemented at floor openings below C&I panels, control panels/Boards etc. in CER & CCR/Control Room/switchyard control room/offsite control room etc.

ii) Type-B

Type B fire sealing system is any proven fire sealing system rated for one hour. This will comprise of rest of wall and floor crossings of cables/cable trays, opening below HT/LT Switchgears/board other than those covered under Type A.

2.02.00 The penetration system, shall be installed immediately after the completion of cable termination in a particular switchboard/control panel/area after clearance from the Project Manager.

3.00.00 GENERAL INFORMATION

3.01.00 The cables shall generally be laid in cable trays/racks, conduits, ducts. The fire proof cable penetration system shall be designed in such a way that the existing supporting structure/cable is not disturbed.

3.02.00 The penetration system shall be suitable for site condition at 50^0C ambient temperature and relative humidity of 100%.

3.03.00 The penetration system of each wall/floor crossing shall be adequately designed/sized such that 20% addition of cables is possible at any later date without disturbance/wastage of material in the penetration system.

3.04.00	Contractor shall plan the schedule of supply of the materials in consultation with Project Manager and use the material within stipulated shelf life of material. After award of work, drawings for each penetration seal shall be prepared by the contractor after verifying the actual installation of cables at site and approval shall be taken from the Project Manager's representative before proceeding with the actual work. The requirement of fire sealing material shall be quantified accordingly. Fire sealing material to be supplied shall be based on the net area to be sealed, wastage, thickness, density and other parameters as per the type test report approved under this contract.
4.00.00	**TECHNICAL REQUIREMENTS**
4.01.00	The fire proof cable penetration system shall fully comply with the requirements of BS:476 Part-20 and also to the requirements specified in this specification.
4.02.00	The penetration system shall prevent spreading of fire in cable beyond the seal system in case of fire and shall have minimum 1-hour fire resistance rating.
4.03.00	The penetration system shall be physically, chemically, thermally stable and shall be mechanically secure to the masonry/concrete/structural members. The system shall be mechanically robust and capable of giving satisfactory performance under vibrations encountered in power stations.
4.04.00	The penetration system shall be capable of withstanding mechanical loads, foot traffic drop loads, vibrations, wind pressure, etc.
4.05.00	The penetration system shall be completely gas and smoke tight.
4.06.00	The penetration system shall retain integrity and perform satisfactorily even after remaining in water for long period.
4.07.00	The materials used in FPCP sealing system shall be non-toxic and harmless to the working personnel.
4.08.00	The penetration materials shall have no reaction with cable sheath/galvanizing/painting of structural steel.
4.09.00	The penetration materials shall have anti-rodent and anti-termite properties.
4.10.00	The penetration materials shall have no shrinkage or cracking after the setting for the complete life of the power Plant.
4.11.00	Under normal load, short circuit and fire conditions, cables may be subjected to movement and vibration. The FPCP sealing system shall be designed to withstand and perform satisfactorily under these conditions.
4.12.00	The penetration system shall not affect the current carrying capacity of cables passing through it.

4.13.00	Asbestos shall not be used in the construction of fire penetration seal system.
4.14.00	The penetration system shall have life expectancy of 40 years.
4.15.00	The penetration system shall not emit any corrosive or toxic fumes or smoke on the unexposed face of the barrier.
4.16.00	Any wastage of the compound during the process of mixing for preparing the FPCP sealing compound shall be to Contractor's account.
4.17.00	For foam type of systems, only the foam shall form the penetration seal of specified rating, having the damming board removed after curing of the foam.
5.00.00	**PACKING AND STORAGE**
5.01.00	All materials and components of penetration system shall be supplied in packing to avoid contamination of materials due to dust/moisture and temperature during transit and storage. All packing shall be of durable quality and the date of expiry and the date of manufacture shall be printed on it.
6.00.00	**INSTALLATION**
6.01.00	The contractor shall take adequate care to ensure that cables are not damaged in any manner during penetration system installation.
6.02.00	Wherever the floor/wall opening provided in the vicinity of penetration seals larger or smaller than that required for the cable fire penetration, these opening sizes can be reduced or increased in an approved manner by the contractor using the same materials as provided around the opening and of the same thickness. Generally, the walls in the power station comprises of brickwork and the floors are made of RCC/steel work.
6.03.00	The work to be carried out under this specification shall be done under the supervision of Project Manager’s representative.
6.04.00	All work shall be carried out in accordance with the agreed “field quality plan” and approved drawings. The “field quality plan” shall additionally specify the fire sealing material thickness, minimum cured density and other related parameters achieved in the approved type tests for the contract. The work shall be done to the satisfaction of the Project Manager and the same shall be subject to Project Manager’s approval for acceptance.
6.05.00	The installation shall be carried out in a neat workman like manner by the skilled, experienced and competent workmen.
6.06.00	Installation work at site shall be properly coordinated with other services.
6.07.00	All materials being supplied or consumed during installation by the Contractor in the process of installation shall be of the best quality and according to standards. All materials shall be inspected and approved by the Project Manager before the same is used for

	installation work. Also, regarding inspection of work, the engineer shall have the right to inspect at any stage during installation, testing and commissioning.
6.08.00	The drilling and welding of building-steel or fixing supports etc. shall be carried out by contractor after taking prior approval of Project Manager.
7.00.00	**TYPE TESTS, ROUTINE & ACCEPTANCE TESTS**
7.01.00	All equipment to be supplied shall be of type tested design. During detail engineering, the contractor shall submit for Owner's approval the reports of all the type tests as listed in this specification and carried out within last five years from the date of bid opening. These reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.
7.02.00	However if the contractor is not able to submit report of the type test(s) conducted within last five years from the date of bid opening, or in the case of type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests under this contract at no additional cost to the owner either at third party lab or in presence of client/owners representative and submit the reports for approval.
7.03.00	All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price.
7.04.00	The type test reports once approved for any projects shall be treated as reference. For subsequent projects of BHEL, an endorsement sheet will be furnished by the manufacturer confirming similarity and “No design change”. Minor changes if any shall be highlighted on the endorsement sheet.
7.05.00	Following Type test reports as per the setup and procedures given in subsequent clauses for the Fire proof cable penetration sealing system shall be submitted: a) The accelerated ageing tests b) Water absorption test c) Fire rating test d) Hose stream test e) Vibration test followed by fire rating test
7.05.01	Tests a, b, c and d should have been carried out on same test sample subsequently one after the other without any touching up/repair/modifications in the same sequence and in accordance with the clause 9.00.00. The test sample shall be assembled as per clause 8.00.00.
7.05.02	Test indicated in clause 7.05.00 (e) above should have been carried out on a separate sample and as per the procedure indicated under clause 9.05.00.

7.05.03 Physical, chemical and mechanical properties of various components/ingredients used should have been also be tested as a part of type tests.

7.05.04 Test reports shall contain the following information:

1. Type of penetration material tested
2. Details of various components/ingredients used alongwith their catalogue.
3. Physical, chemical and mechanical properties of various components/ ingredients used.
4. Description of the various test assemblies tested.
5. Details of method of conditioning.
6. The observations as called for in BS:476 Part-20 and technical specification.

7.06.00 **ROUTINE & ACCEPTANCE TESTS**

Routine and acceptance tests to be carried out on Type-A and Type-B cable fire sealing system shall be mutually agreed based on the type of fire sealing material offered before placement of award.

8.00.00 TEST SPECIMEN ASSEMBLY

8.01.00 The test specimen shall be assembled as per enclosed drawing and shall resemble typical floor crossing cable penetration system.

8.02.00 The test specimen shall be designed to seal an opening of adequate size in a concrete slab of 200 mm thickness. Two lengths of 300/600 mm wide ladder type cable tray shall be assembled with required layer of XLPE/PVC insulated, PVC sheathed unarmoured cables in touching formation. Type and number of cables in the cable tray shall be as per enclosed drawing. Cables shall be adequately clamped with tray at both the sides of the penetration as shown in the drawings. However, for penetration system with blocks which require staggered arrangement, cables can be clamped at an adequate distance from the penetration and the tray need not pass through the penetration seal.

8.03.00 The opening in the test specimen then shall be sealed with fire proof cable penetration sealing materials.

9.00.00 TEST PROCEDURES

9.01.00 **ACCELERATED AGEING TEST**

The test specimen assembled as per clause 8.01.00 with damming board removed shall be subjected to accelerated ageing test by storing in air furnace where the temperature of the inside air shall be maintained at 85 degree centigrade for 168 hours. The temperature-controlled furnace should have 7 air changes per hour approx.

9.02.00	**WATER ABSORPTION TEST**
9.02.01	The test specimen shall be immersed in fresh clean water at a temperature of 20 deg. C $\pm$ 2 deg C. The test specimen must be separated from the bottom and sides of the soak tank by at least 10 mm and it shall be covered by approximately 25 mm of water. At the end of the 24-hour soak period the specimen shall be removed from water and mopped up with a damp cloth.
9.03.00	**FIRE RATING TEST**
9.03.01	The test specimen after withstanding water absorption test shall be subjected to fire rating test as per BS: 476 part-20.
9.03.02	Oil/Gas fired furnace shall be used for heating. The furnace shall have achieved standard time/temperature characteristics for fire tests as per BS:476 part-20.
9.03.03	The pressure inside the furnace at the time of test shall be within 1.5 $\pm$ 0.5 mm water gauge.
9.03.04	Cables in the test specimen shall be anchored on the hot side to a structure independent of the barrier and its penetrations. This is to ensure that any differential movement between the penetration and the cable that could occur during a fire, is produced in the type tests and the reliability of the integrity of the penetration is checked.
9.03.05	Cables shall be protruding between 1 to 2 meters, from the penetration face on the unexposed side and protruding into the furnace as far as it is practicable with a minimum length 750 mm. The ends of the cables shall be capped on the unexposed face to prevent gases and fumes to escape from the furnace during the fire.
9.03.06	The test specimen shall be subjected to fire test with surface exposed to controlled fire in the furnace confirming to time/temperature characteristics specified in BS:476(20).
9.03.07	During the test the temperature of both the faces of the fire stop i.e. one which is exposed to fire and other unexposed shall be measured by calibrated thermo couples after regular interval of 5 minutes.
9.03.08	Atleast 3 thermo couples shall be provided for temperature measurement of each face. The results at the end of the test shall be interpreted for failure criteria as under. 1. The system is deemed to have failed to maintain stability if there is a total collapse of the fire proof seal. 2. In case cracks are seen on the face of the fire stop or cracks through which the flame/ hot gas can pass the systems deemed to have failed to maintain integrity. The development of crack is characterized by appearance of black soot on cotton wool held near the penetration on the unexposed surface at a distance of about 100mm. 3. Failure shall be deemed to have occurred when the mean temperature of the unexposed surface of the specimen assembly increases by more than 140^0C

above the initial temperature or if the temperature of the unexposed surface is increased at any point by more than 180^0C above the initial temperature.

During the test the specimen shall meet all the three criteria simultaneously.

9.03.09 Temperature measurement on the unexposed side of penetration seal shall be measured by thermocouples at a distance of 25 mm from unexposed side of fire stop.

9.04.00 **HOSE STREAM TEST**

9.04.01 A hose stream test shall be conducted on the test specimen immediately following a fire resistance test on that assembly. The specimen must first be removed from the furnace since the hose stream is to be applied to the exposed face. This must be done quickly since it is the intention of the test that the stream be applied to the specimen whilst it is hot.

9.04.02 The hose stream shall be long range narrow angle, (20^0 - 90^0 set at 30^0 included angle). High velocity water spray provided from a 28 mm hose discharging through an appropriate nozzle. The water pressure shall be 5 bar calculated at the base of the nozzle and the minimum flow rate shall be 4.7 litres/second. The stream shall be supplied perpendicularly to the exposed face of the test specimen with nozzle 3 m away from the exposed face.

9.04.03 Application shall be for minimum of two and a half minutes per 9 sq.m. of the test specimen including the barrier.

9.05.00 **VIBRATION TEST**

9.05.01 The test assembly is to comprise a single ladder rack penetration in 1 m x 1m high normal section of fire barrier which is securely supported. The penetration seal shall be formed in the middle of the barrier around 1 m length of 600 mm ladder rack. The tray shall be fully loaded with cables in touching formation. The penetration assembly shall be formed symmetrically through the fire barrier as in service. The penetration sealant material shall then be allowed to cure for atleast as long as the time required for conditioning to constant mass. A vibration test shall then be conducted on the sample as set out below.

9.05.02 The vibration shall be of 100 Hz frequency and of 0.5 mm amplitude (1.0 mm peak to peak) and this shall be applied to one rail of the ladder rack or the centre of a cross member secured to the two rails at 250 mm from the centre line of the penetration. This vibration shall be applied to the sample for the minimum period of 3 hrs. Immediately following this vibration test the barrier/ penetration assembly shall be successfully subjected to a fire test in accordance with clause no. 9.03.00.

SUB-SECTION-B – 15

ELECTRICAL HOIST, CRANE AND ELEVATOR

ELECTRICAL HOIST, CRANE AND ELEVATOR

1.00.00 **CODES AND STANDARDS**

1.01.00 All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions. In case of conflict between this specification and those (IS codes, standards, etc.) referred to herein, the former shall prevail. All work shall be carried out as per the standards/ codes as applicable.

2.00.00 **Electric motor:**

The driving motors shall conform to IEC 60034 and suitable for the Variable Voltage Variable Frequency (VVVF) application. All motors shall be squirrel cage induction type, suitable for operation at 415V (+/- 10% variation) , 3 phase, 3 wire, 50HZ (+3% to -5% variation) supply. Motors shall be provided with thermal class 155(F) or better insulation.

3.00.00 **CAR ELECTRICAL ACCESSORIES**

The following accessories shall be provided:

a. LED light fittings for illumination level of 100 lux on car floor.

b. Portable light and alarm bell with battery and charger ventilation fan with control.

c. Car control station with position indicator inside the car and at landing platforms (both visual and audio).

d. Emergency stop switch.

e. 5/15A, 3 pin plug socket with switch on top of lift car.

f. Hand free speaker telephone set connected to plant network.

g. AUTOMATIC RESCUE DEVICE (ARD)- (BATTERY DRIVE) :

Contractor to provide a modern Advanced electronic drive system of “RESCUING Passenger Trapped in an ELEVATOR”.

h. EMERGENCY SAFETY DEVICES:

The lift shall be provided with safety Device attached to the lift car frame and placed beneath the car. The safety device shall be capable of stopping and sustaining the lift car up at governor tripping speed with full rated load in car.

4.00.00 **OPERATIONAL REQUIRMENTS:**

a. Contractor shall provide car operating panel with luminous buttons, car position indication in car (both visual and audio) combined with direction arrows, overload warning indicator, battery operated alarm bell and emergency light and fan & hands-free speaker telephone set with suitable battery, charger & controls.

b. Contractor shall provide emergency indicator to indicate the location of elevator in case of elevator being stuck up between the floors through automatic flashers (both audio & visual).

c. Contractor shall provide electronic door detector (Infra-red curtain type).

d. Digital hall position indicator at all floors, tell lights at all floors shall also be provided by the Contractor.

e. For facilitating the movement of visually & hearing-impaired persons, hall lantern and car arrival chimes shall be provided

f. All fixtures shall be in stainless steel face plates.

g. Push buttons shall be fixed in the car for holding the doors open for any length of the time required.

h. All other safety/protection/operation interlocks as required by IS:14665 (latest edition).

4.00.00 **POWER SUPPLY:**

Each elevator shall be provided with a separate three phase, three wire 415V feeder of adequate rating

5.00.00 **Controls:**

The controls shall be Variable Voltage and Variable frequency type and shall provide smooth and constant acceleration and retardation under all conditions of operation. Suitable control panel shall be provided in the machine room.

6.00.00 **Cables and wiring:**

All the cables except trailing cables shall be as per IS:1554-1 or IS-7098-I. The PVC outer sheath of these cables shall be flame retardant, low smoke (FRLS) type with the following FRLS properties.

a) Oxygen index of min. 29 (as per IS:10810 Part-58)
b) Acid gas emission of max. 20% (as per IEC-754-I).
c) Smoke density rating shall not be more than 60% (as per ASTMD-2843).

The circular trailing cables shall be either in accordance with IS 4289 Part-I (Elastomer insulated) or IS-4289 Part-II (PVC insulated). The flat type of trailing cables if offered shall be in accordance with IEC-60227-6.

All wiring / cabling between the equipment's in the lift machine room and that between the machine room and equipment's in the lift well and at the landings shall be wired in HDPE conduits/ galvanized steel conduits to be supplied by the contractor. Alternatively armored cables may be used.

7.00.00 **Earthing:**

The elevator, EOT and crane structures and all Electrical equipment, including metal conduits shall be effectively earthed with the earth conductors provided in the machine room as per IS: 3043.

8.00.00 **EOT/ Hoist and Crane Motors:**

Three phase Squirrel Cage Induction motors to be operated from VFD system shall be suitable for speed range and torque without exceeding temperature rise limits as specified elsewhere in this specification. VFD shall be used to drive three (3) phase squirrel cage inverter duty

Induction motor with VPI insulation (Resin poor) suitable for VFD application. These motors shall be provided with insulated bearing on at least one side for motor frame size above 250 frames. However, contractor's proven practice with respect to use of insulated bearing in VFD driven motor may be accepted subject to Employer's approval. Motors shall conform to latest revision of IS 15999, IS 3177 and motor subsection of this specification.

8.02.00 **Controls**:

a) Speed control of EOT crane shall be through Variable Voltage Variable Frequency System (VVVF) with minimum 6 (six) pulse design.

b) Necessary input & output devices to be provided to reduce harmonics, as per IEEE519, at supply side of the drive at the switchgear.

c) All necessary protections e.g., Input Phase Loss, Earth Fault, Over Voltage, Output Short Circuit, Load Loss, Input Transient Protection, overload etc to be provided.

d) VVVF system shall be capable of generating suitable starting torque (up to 400% typical) with / without encoder, however starting current shall not exceed 150% at rated torque.

e) VVVF system shall be capable to withstand up to 50 deg C ambient temp without derating.

f) Provision for controlling the motion from operator cabin (in case of Turbine Hall EOT crane) as well as remote control shall be available.

g) Squirrel cage Induction motor with VPI insulation shall be provided With VVVF system.

h) **Master controller - Desk** type having following features.

I. Five speed control points in each direction of hoist motion.

II. Four speed control points in each direction of bridge and trolley motion.

III. Release of operator's hand from the controls shall stop motion and set brakes automatically.

i) Protective Panel:

Shall be Provided with isolating switch, power contactor control and indication to switch ON/OFF power to starter panels, control and lighting transformer.

j) **Starter Panel**:

I. Separate VVVF system panels to be provided for CT, LT and hoist motion (main and auxiliary drives).

II. Contactors shall be of AC 4 duty for reversing application and AC 3 duty for non-reversing application

III. Switches shall be AC 23 for motor application and AC 22 for other application.

IV. Fuses: HRC

V. Overload relay shall be of Temperature compensated, bimetallic with single phasing preventor.

k) Panel shall be fabricated out of 1.6 mm thick rolled sheet steel. IP 52 degree of protection. Paint shade shall be RAL 9002 for front & rear and RAL 5012 for side covers. Space heaters to be provided.

8.03.00 **Radio remote Control of EOT Crane:**

a) The equipment should have facility to control EOT crane by radio frequency based wireless remote unit. The equipment should be supplied with transmitter unit, receiver unit, encoder unit, decoder unit, interface panel, coupling system, battery unit and any other control gear if required.

b) The equipment should be based upon the microprocessor based digital technology with almost nil hard wiring.
c) The remote unit should communicate up to the distance of approximately 100 meters.
d) The system has to integrate with the control system of crane, which operates at 110 V AC, Single phase.
e) The remote unit should have transmitter which can be mounted on shoulder by suitable belt. Main controls can be of single joystick movement or double joystick movement type stepped control with spring return. The Micro control should be toggle switch type or push control type.
f) Frequency allotment for radio remote unit from Govt. of India, Dept. of Telecommunication or any other agency shall be the responsibility of supplier.
g) The transmitter and receiver unit should have its own frequency and address code with each system having its own security code so that one particular set becomes unique and there is no interference from any other remote unit device. A microprocessor should check all security codes. The processor should have its own watchdog circuit. The receiver FM band should be sufficiently narrow to allow only passing of desired frequency and valid command. Any error should shut down the system immediately.
h) The remote unit should have safety key to prevent any unauthorized operation. All the crane operations should stop at once the communication breakdown occurs.
i) On local unit (receiver side), the system should be provided with one selector switch so that EOT crane can be operated either from Operator cabin or radio remote unit.
j) In case tandem operation is envisaged, a suitable selector switch shall be provided in the cabin for selection of Tandem/normal operation.
k) The receiver unit along with I/O interface unit should be able to bear the vibrations and shocks encountered in normal usage of EOT crane.
l) The system should have very fast response time.

8.04.00 **Power Supply:**

(a) VOID
(b) Down shop Lead (DSL):
I. DSL Shall conform to IS: 282 and shall be sized to Cater to all cranes working simultaneously with 40% cyclic duration factor for load.
II. Limit voltage drop at motor terminals within 2% at extreme positions.
III. DSL shall be sized with a margin of 10% overload requirement.
IV. Protective cover over DSL to be provided.
V. Two (2) no. isolating switches in enclosure shall be provided at extreme ends of operating floor for disconnecting supply to DSL while maintaining the crane. DSL shall be located on 'A' -row side for Turbine Hall EOT crane.

(c) Transformers
Shall be of Dry type, with insulation class B or better.
Following transformers shall be provided.
(i) Control Transformers : 2x100%, 415V / 110V
(ii) Lighting Transformers : One 415V/240V
(iii) Hand lamp : One 415V/24V

SUB-SECTION-B – 16

BATTERY CHARGER

BATTERY CHARGER

1.00.00 CODES AND STANDARDS

ANSI-C 37.90a	Guide for surge withstand capability tests
IS:5	Colours for ready mix paints.
IS : 694	PVC Insulated Cable for working voltages upto and including 1100 V.
IS : 1248	Specification for Direct acting indicating analogue electrical measuring instruments.
IS:13947 Part-1	Degree of protection provided by enclosures for low voltage switch gear and control gear.
IS : 13947	Specification for low voltage switch gear and control gear
IS : 3231	Electrical relays for power system protection.
IS : 3842	Application guide for Electrical relays for AC System
IS : 3895	Mono-crystalline semi-conductor Rectifier Cells and Stacks
IS : 4540	Mono crystalline semi-conductor Rectifier assemblies and equipment.
IS:6005	Code of practice for phosphating of Iron and Steel.
IS:6619	Safety Code for Semi-conductor Rectifier Equipment.
IS:11171/ IS:2026	Rectifier Transformer
IS:6875	Control switches (switching devices for control and auxiliary circuits including contactor relays) for voltages upto 1000 V AC or 1200 V DC.
IS : 9000	Basic environmental testing procedures for electronic and electrical items.
IS:13703	Low voltage fuses for voltages not exceeding 1000 V AC or 1500 V DC.

EEUA-45D	Performance requirements for electrical Alarm Annunciation System
	Indian Electricity Rules
	Indian Electricity Act.

2.00.00 **Technical Parameters**

1.	**Mode of Charging**	Float cum Boost Charger (Automatic and Manual Mode)
2.	**Charger Ambient Temp**	50 deg C
3.	**Voltage Rating**	220V
4.	**Trickle Charging**	1.4-1.42V per cell(Ni-Cd) 2.25V per cell(Lead-Acid)
5.	**Boost Charging Mode**	1.53-1.7V per cell(Ni-Cd) 2.3-2.7 V per cell(Lead-Acid)
6.	**Automatic Voltage regulator (rickle Mode)**	± 1% at 415 ± 10% and 0-100% Load, Automatic Controlled feeback-Closed Loop
a.	**Load Limiter current setting Range(Trickle Mode)**	80%-100%
b.	**% Stabilization of the output DC voltage**	1% for ±10% input supply variation and 0-100% DC load
c.	**Voltage Range and Stabilizing time for momentary load changes from 20%-100% and Vice versa**	+/- 6 % and less than 2 secs
d.	**Stabilizing time**	Less than 15 secs
7.	**Current setting range in Boost Charging Mode**	50-100% of rated output current
8.	**Voltage limit setting range in Boost Charging Mode**	Boost charging limit
9.	**Rectifier Type**	Full wave bridge Type
10.	**Ripple Content**	1% Peak-Peak at 0-100% of DC Load
11.	**Rectifier Transformer**	Dry and Air Cooled(AN) type Class-F Insulation with temp rise limited to Class-B at 50deg C Ambient
12.	**Charger Enclosure**	IP42

3.00.00 **EQUIPMENT DESCRIPTION**

(a.) The Battery Chargers as well as their automatic regulators shall be of static type. Battery chargers shall be capable of continuous operation at the respective rated load in Trickle mode i.e. Trickle charging the associated DC lead-acid Batteries while supplying the D.C. loads.

(b.) All Battery Chargers shall have provision to receive two input supplies along with suitable automatic changeover between the sources. Battery Chargers shall have a selector switch for selecting the battery charging mode i.e. Trickle or Boost charging and automatic/manual mode.

(c.) The chargers shall be capable of limiting the voltage or current in case DC load current exceeds the load limiter setting of the Charger. The load limiter characteristic shall be such that any sustained overload or short circuit in DC system shall neither damage the Charger nor shall it cause blowing of any of the charger fuses. The DC System shall be ungrounded and float with respect to the ground potential when healthy. An earth fault relay shall be provided by the Employer in the DC distribution board for remote annunciation.

(d.) Digital indicating instruments with built in communication port for remote data transfer shall be provided for all chargers. Ammeters & voltmeters shall have 4-20mA analog output for current and voltage respectively.

(e.) Blocking diode shall be provided in the output circuit of each Charger to prevent current flow from the D.C. Battery into the Charger.

(f.) Digital Outputs shall be configured for connection to the DC health monitoring system for real-time charger status updation.

(g.) For all Power Components (contactors, MCCBs, fuses, relays, metering instruments etc) and constructional details (sheet thickness, paint shade, gland plate thickness etc) of charger enclosure and internal wiring details, refer relevant clauses in LT switchgear specifications (as applicable).

(h.) Live busbars, parts etc shall not be accessible while the charger is in energized condition. Suitable safety interlocks to be ensured.

3.1.00 Rectifier Assembly

The rectifier cells shall be provided with their own heat dissipation arrangement along with forced air cooling for above 400A rating chargers and fan shall be temperature controlled with 100% standby redundancy. The rectifier shall utilize diodes/thyristors and heat sinks rated to carry 200% of the load current continuously and the temperature of the heat sink

shall not be permitted to exceed 85°C absolute duly considering the maximum charger panel inside temperature.

3.2.00 Annunciation System

Visual indications through indicating lamps/LEDs or annunciation fascia shall be provided in all Chargers for A.C. supply failure, Rectifier fuse failure, Surge circuit fuse failure, Filter fuse failure, Load limiter operated, Charger trip, Battery on Boost .

Potential free NO contacts of all above these conditions signals shall be provided for following remote alarms in the Employer's Unit Control Board:

(a) Battery on Boost

(b) Charger trouble (this being a group alarm initiated by any of the faults other than 'Battery on Boost')

2.00.00 TESTS

Validity of type tests is 5 years from the date of bid opening

2.01.01 LIST OF TYPE TESTS

1. The contractor shall furnish the following type tests reports for each rating of the equipment to be supplied under this contract.

a) Complete physical examination
b) Temperature rise test at full load. (For chargers of up to 400A rating, Temperature rise test report for rectifier assembly at 200% of full load shall also be submitted.)
c) Insulation resistance test.
d) High voltage (power frequency) test on power and control circuits except low voltage electronic circuits.
e) Automatic voltage regulator operation test at specified A.C. supply variations at no load, half load and full load.
f) Load limiter operation test
g) Efficiency and power factor measurement.

h) Surge withstand capability test at the following points of the Charger:

i) Across each A.C. input phase

ii) Across AC input line to ground.

iii) Across D.C. output terminals.

iv) Across each D.C. output terminal to ground

The Charger shall not exhibit any component damage and there shall be no change in performance as per (g) and (h).

i) Environmental Tests

Steady state performance tests (f) and (g) shall be carried out before and after each of the following tests.

i) Soak Test

ii) Degree of protection test.

2. Dynamic response test and Temperature rise test at full load shall be carried out on each charger before dispatch at manufacturer's works.

3.00.00 COMMISSIONING TESTS

3.01.01 Bidder shall submit commissioning test procedure including details of all commissioning checks before commissioning the system at site.

SUB-SECTION-B – 18

CONSTRUCTION POWER

Bidder to Refer NIT and CTC

SUB-SECTION-B – 19

BATTERY

1.00.00 **BATTERY RATINGS**

1.	For Ni-Cd Type Battery	
a)	Battery Voltage	220 V DC
b)	No. of Cells	As per Sizing Calculations
c)	Battery type	Stationary Nickel-Cadmium Pocket Plate High discharge type (KPH)
d)	Capacity for one(1)hour rate	As per Chapter B0, Section VI
e)	Nominal discharge voltage per Cell	1.2 V
f)	Float voltage	As per manufacturer's standards for float application

Note:
DC health monitoring system shall be offered integral with each battery set for CHP and AHP

1.01.00 **Commissioning of Battery**

Commissioning of each battery at site shall only be carried out either by the battery manufacturer himself or under the supervision of the battery manufacturer.

CLAUSE NO.	TECHNICAL REQUIREMENTS
PART-A:	**NICKEL-CADMIUM BATTERY**
2.00.00	**CODES AND STANDARDS** IEC 60623 / IS 10918 Specification for vented type Nickel Cadmium Batteries. IS 1069 Quality tolerances for water for storage batteries IEC 60993 Electrolyte for vented Nickel-Cadmium cells
3.00.00	**TESTS**
3.01.00	For conductance/report submission/validity of type tests, refer Sub Section-IIB, Section-VI, Part A of technical specifications. The Contractor shall submit for Owner's approval the reports of all the type tests carried out as per latest IS-1146 (for all applicable tests for containers) / IS-10918 (for Ni-Cd batteries). The complete type test reports shall be for any rating of battery in a particular group, based on plate dimensions being manufactured by supplier.
3.02.00	Routine and Acceptance tests shall be as per Quality Assurance & Inspection table of battery.
3.03.00	Commissioning Checks: Bidder shall submit commissioning test procedure including details of all commissioning check before commissioning the system at site
PART-B:	**DELETED**
4.00.00	**DELETED**
5.00.00	**TESTS**
5.01.00	Validity of type tests is 5 years from the date of bid opening. The Contractor shall submit for Owner's approval the reports of all the type tests carried out as per latest IS-1146 (for rubber & plastic containers for lead-acid storage batteries)/IS 1652 (for lead-acid plante batteries). The complete type test reports shall be for any rating of battery in a particular group, based on plate dimensions being manufactured by supplier.
5.02.00	Routine and Acceptance tests shall be as per Quality Assurance & Inspection table of battery.
5.03.00	Commissioning Checks: Commissioning of each battery at site shall only be carried out either by the battery manufacturer himself or under the supervision of the battery manufacturer.

SUB-SECTION-B – 20

HT LOAD BREAK SWITCH

CLAUSE NO.	TECHNICAL REQUIREMENTS
	H.T. LOAD BREAK SWITCH AND JUNCTION BOX
1.00.00	**CODE AND STANDARDS**
	IS:3427, IS:2208, IS:9920
2.00.00	**TYPE**
2.01.01	**3.3KV/6.6KV/11KV LOAD BREAK SWITCH PANEL**
	Metal enclosed, free standing, indoor, non-draw-out type, IP-55 enclosure protection, paint shade: RAL 9002. The panel shall be located in the nearest MCC room and shall be suitable for the fault level of the system.
2.02.00	**JUNCTION BOX**
	Metal enclosed, free standing, suitable for outdoor location, I.P-65 enclosure protection, paint shade-RAL-9002. 3.3 KV/6.6KV/11KV Junction Box shall be located as per requirement and shall be suitable for the fault level of the system.
3.00.00	**TEMPERATURE RISE**
	Temperature rise of busbars shall not exceed 55 deg.C for silver plated joints and 40 deg.C for other joints, over an ambient temperature of 50 deg.C.
4.00.00	**OPERATIONAL REQUIREMENT**
4.01.00	**Load break Switch**
	a) Load break switch unit shall be provided with hinged front door and suitable for front execution. The switch shall be mechanically interlocked with the door so that the door can not be opened while the switch is in closed position.
	b) Constructional details, sheet steel thickness etc. shall be as per technical specification of MCCs.
	c) Deleted.
	d) Load break switch shall have shunt trip coil, ON indicating lamp, on/OFF position mechanical indication, internal earth bus and earth switch which shall be interlocked with the main switch.
	e) Panel shall be identified on front as well as back side by large engraved plate giving detailed feeder description. Identification labels/painted (Not stickers) plates shall be provided inside the panel.
	f) The panel shall be designed to offer adequate level of safety to operating/maintenance personnel. Means shall be provided to prevent access to the live part to avoid accidents during service as well as maintenance period. Contractor shall bring out the safety means provided to achieve the same. A

CLAUSE NO.	TECHNICAL REQUIREMENTS
	detailed instruction plate suitable for wall mounting shall be provided for mounting on wall describing various safety procedure/precautions for safe operation and maintenance. Rubber mats shall be provided in front of the panels.
4.02.00	**H.T. Junction box**
	a) Junction shall be adequately sized to facilitate the HT XLPE cable as per system requirement.
	b) Constructional details, sheet steel thickness etc. shall be as per technical specification of MCCs.
5.00.00	**TYPE TESTS:**
5.04.00	Type test reports for the following type tests on HT load break switch panel shall be submitted:
	1) Short circuit test
	2) Degree of protection test
	3) Power frequency withstand test
	4) Impulse voltage withstand test

SUB-SECTION-B – 21

CONTROL PANEL FOR CHP, AHP & LHP

CONTROL PANELS FOR CHP/AHP

1.00.00 Local control panels

Coal Handling plant: Local control and starter panels for traveling trippers, metal detectors, sump pumps, SM & ILMS, belt weighers, hoists, coal sampling units, hydraulic scoop coupling and dust suppression system. shall be free standing, floor/wall mounting type.

Ash handling: Local panels shall be considered as per OEM standard proven practice. Back up of 2 executed projects for operations to be provided. Necessary controls, indications and annunciations, shall be provided in DCS/HMI.

2.00.00 CONTROL PANEL CONSTRUCTION

a)	Type	Fabricated from cold rolled sheet steel
		Frame thickness 2.0 mm Enclosure thickness 1.6 mm Gland plate thickness 3.0 mm
b)	Switches	AC22 category
c)	Fuses	HRC cartridge with visual operation indicator.
d)	Name Plates & Labels	Each panel shall be identified by a name plate. Panel internal equipment shall be identified by paint marking. Nameplates shall be non-rusting metal or 3-ply lamicoid, with engraved lettering and shall be subjected to Employer's approval.
e)	Grounding	25 x 3 mm copper ground bus to be provided for each panel
f)	Space heater	240V AC, single phase, thermostatically controlled space heaters to be provided.
g)	Terminal block	650V grade. clip-on type.
h)	Type	Elmex - CATD type for CTs. Elmex - CSLT for other application.
i)	Spare	20 percent.
j)	Wiring	650V grade. PVC insulated stranded copper wire.
k)	Panel Lighting	Each free-standing panel shall be provided with a door switch operated fluorescent lamp and a 240V AC plug point.
l)	Painting	Treatment as per IS: 6005. Two coats of lead oxide primer followed by powder painting with final paint shade of RAL 9002.

m)	Degree of enclosure protection	For panels located in i) Air conditioned areas : IP-32 ii)Other indoor areas : IP-52 iii)Outdoor areas : IP-55 iv)Dusty areas like : IP-65 bottom ash area, silo area etc.

SUB-SECTION-B – 22

MV BUSDUCTS

MV DUCTS

1.00.00 **CODES AND STANDARDS**

ANSI	C 37.20, 37.23,37.24
BS	3815, 3816
IS	2544, 2705, 3070, 3156, 5082, 8084, 9431
IEEE	298, 32

2.00.00 **TYPE**

Metal enclosed, phase segregated and natural air cooled.

3.00.00 **RATING**

The MV Busduct ratings shall be as per system requirements ~~(B0).~~

3.01.00 **MV BUSDUCT**

Rated Voltage — Equal to Max. continuous system voltage

Rated Current — As per system requirement.

4.00.00 **TEMPERATURE LIMITS** (considering effect of solar radiations)

MV Busduct Conductor/ Joints : 105 deg. C for silver plated joints,

: 90 deg. C for other joints

Enclosure : 80 deg. C

For outdoor portion the above limits shall be reduced to 97.5 deg. C, 82.5 deg. C and 72.5 deg. C respectively.

5.00.00 **FUNCTION**

5.01.00 **Bus Ducts**

MV bus ducts shall be provided for Interconnection between transformers and switchgears and between switchgears.

5.02.00 Bus Duct routings below ground level shall not be provided.

6.00.00 **OPERATIONAL REQUIREMENTS**

6.01.00 **MV Busducts**

6.01.01 Enclosure

Aluminum alloy with minimum thickness of 3mm, naturally cooled. Each section shall be welded construction. Sections may be joined through bolted connections. Suitable rain hoods for outdoor joints shall be provided. Adequate number of thermostat-controlled space heaters or any other proven arrangement to prevent condensation to be provided.

6.01.02 Phase barriers

MV busduct phase barriers shall be made of Aluminum alloy of minimum thickness of 3.0 mm.

6.01.03 Conductor

	Shall be of high conductivity, aluminum alloy or Copper, sections shall be welded or bolted.
6.01.04	Flexibles for Conductors to be provided at all equipment termination and in bus duct run to accommodate thermal expansion / contraction, vibration and misalignment as also for providing adequate clearances for independently testing the equipment being connected.
6.01.05	The busduct shall be provided with adequate number of thermostatically controlled space heaters of adequate capacity to maintain the internal temperature above the dew point to prevent moisture condensation within the busduct. Space heaters shall be rated for 240V, single phase, 50Hz AC supply.
6.01.06	Joints Shall be bolted and flexible joints for conductor and enclosures.
6.01.07	NOT USED.
6.01.08	Bimetallic connectors Shall be provided in case equipment terminals and material of bus conductor are different for the non-silver-plated joints.
6.01.09	Insulators Glazed porcelain/ high strength epoxy cast resin with a minimum creepage distance of 20 mm/kV. The insulators shall be designed and mounted to facilitate easy inspection, removal & inspection along with provision of conductor fastening by fixed and sliding joints.
6.01.10	Seal Off Bushing Shall be provided at terminations and wall crossing and at each of the switchgear terminations.
6.01.11	Wall Frame Assembly Shall be provided wherever bus-duct penetrates plant walls Expansion bellows Neoprene/EPDM or metallic expansion bellows shall be provided on enclosures for thermal expansion, vibrations and misalignment. To be provided at terminations and as required.
6.01.12	Enclosure supports Shall be provided Hot dip galvanised mild steel support structures to withstand normal operation, vibration, thermal expansion and short circuit forces.
6.01.13	Minimum clearances for MV busduct shall be: Phase to phase : 100 mm (for 6.6KV) 130 mm (for 11KV) 70 mm (for 3.3 kV) Phase to earth : 90 mm (for 6.6KV) 120 mm (for 11KV) 60 mm (for 3.3 kV)
6.01.14	Openings covered with louvers backed up with removable dust filters shall be provided at appropriate location to enable the MV busduct enclosure to breathe in a manner so that possibility of condensation is minimised.
6.01.15	Earthing of Enclosure Adequately sized Galvanised mild steel earth bar shall run along the length of busduct. Each enclosure section shall be connected to the earth bar at both ends. Both ends of earth bar shall be connected to the plant earth mat.
7.00.00	**TYPE TESTS**
8.01.00	**A. LIST OF TESTS TO BE CONDUCTED**

Following type tests shall be conducted on each type & rating of MV busduct.

a) Heat run test on an assembly of representative sections and fittings with all types of flexibles, CTs etc.

b) Short circuit withstand test (set up same as for heat run) for one (1) sec. duration and current as per system requirement on assembly of representative section with CT's bellows, flexibles.

c) Impulse withstand test on an assembly of representative section containing Flexibles, Bellows, Seal of bushing, CT's mounted in position (wherever applicable).

d) One-minute high voltage power frequency withstand test (set up as for short circuit test).

e) Water tightness test as per IS:8084 for generator busduct (set up shall include inspection cover, flanged joint and below).

f) Air leakage test as per IS:8084 on a typical section (set up shall include inspection cover, flanged joint and bellow)

B. LIST OF TESTS FOR WHICH REPORTS HAVE TO BE SUBMITTED

Type test reports shall be submitted for following type tests on auxiliary equipment:

(a.) Panels, cubicles and marshalling boxes shall be type tested for the degree of protection provided by enclosure as specified below:

(1.) For5X-it shall not be possible to insert a thin sheet of paper under gaskets and through enclosure joints.

(2.) For 4X-It shall not be possible to insert a one mm diameter steel wire into enclosure from any direction without force.

(3.) For 2X-It shall not be possible to insert a twelve (12) mm dia steel wire into the enclosure from any direction without any force.

(4.) Test for second digit shall be in line with IS:13947 pt.1

8.03.00 **Routine Test**

Routine test shall be conducted at manufacturer's works on each busduct and all other components as per relevant Indian Standards & Quality Assurance Sub-section.

PART C
C&I

C&I

C – 00	CONTROL & INSTRUMENTATION SYSTEM
C – 01	MEASURING INSTRUMENTS (PRIMARY AND SECONDARY)
C – 02	ELECTRICAL POWER SUPPLY SYSTEM
C – 03	PROCESS CONNECTION AND PIPING
C – 04	INSTRUMENTATION AND POWER SUPPLY CABLES
C – 05	CONTROL VALVES & ACTUATOR
C – 06	Programmable Logic Controller System
C – 07	TYPE TEST REQUIREMENTS
C – 08	Control desk and Panel
C – 09	WIRELESS INSTRUMENTS & SYSTEMS

CONTROL AND INSTRUMENTATION SYSTEM

1.00.00 GENERAL

1.01.00 The Contractor shall provide Control & Instrumentation system for control, monitoring and operation of all the systems of CHP & AHP in all regimes of operation in safe and most efficient manner. The scope of work for the equipment, material and system to be furnished in accordance with this specification shall include design, engineering, manufacture, fabrication, assembly, pre-shipment testing at manufacturer's works, proper packing for transportation, delivery at plant site, unloading, storage, installation, interconnection with related plant and equipment, calibration, testing, commissioning and putting the Control and Instrumentation System together with all accessories, auxiliaries and associated equipment as specified hereinafter in a fully operational condition and in the manner acceptable to the Employer as covered under this specification**..** The Contractor shall also provide all material, equipment and services which may not be specifically stated in the specifications but are required for completeness of the equipment/systems furnished by the Contractor and for meeting the intent and requirements of these specifications. The work shall be consistent with modern power plant practices and shall follow all applicable codes, standards, guidelines and safety requirements in force on the date of award of the contract. The requirements of statutory Authorities shall be complied even if not actually spelt out.

1.02.00 It shall be the responsibility of the Contractor to coordinate with Employer and offer Control and Instrumentation System to meet the actual requirements of the plant and furnish a complete system as per clause 1.01.00 above, and also to coordinate with other system vendors for proper interfacing of Control and Instrumentation system vendors with all other related equipment and systems.

1.03.00 The brief scope of the above is described in following clauses. It is intended to provide the brief scope only, any other equipment/system required for ensuring the safe, reliable and trouble-free operation of the plant under the present scope of the work shall be provided within the lump sum quoted price of the contract. The detailed technical specifications are stipulated under various Control and Instrumentation Sub-sections, Part - B, Section-VI of the specification as well as in various other Parts of the Technical Specifications including all annexure, appendixes etc.

1.04.00 In the event of conflict between requirements of any two clauses of specification documents, the more stringent requirements shall apply unless otherwise confirmed by the Employer in writing before the award of this contract, based on a written request from the Contractor for such clarification.

CLAUSE NO.	SCOPE OF SUPPLY AND SERVICES
1.05.00	The scope of work shall also include all material, equipment and services so as to make a totally integrated Instrumentation and Control System together with all accessories, auxiliaries and associated equipment ensuring operability, maintainability and reliability.
1.06.00	Further bidder shall also include in his proposal and shall furnish all equipment, devices and services which may not be specifically stated in the specification but are needed for completeness of the equipment/systems furnished by the bidder and for meeting the intent and requirements of the specification.
1.07.00	Where ever in the specification, Bidder's offering as per his "standard and proven practice" are identified to be acceptable, the same shall be accepted (with project/plant specific customisation as necessary) based on the documentary evidence of the reference project/plant indicated in the bid document. Any other reference project, if proposed by the bidder during detailed engineering, shall be strictly as agreed by the employer during detailed engineering.
1.08.00	Where ever in the specification, Bidder's offering as per his "standard and proven practice" are identified to be acceptable, the bidder is required to provide the detailed explanation / concepts, if required by the employer, of such implementation along with the standard documentation.
1.09.00	All electrical devices like switches/ transmitters/ controller/ analyzer/ solenoid valves which are located in the in hazardous areas like hydrogen gas area, seal oil area etc. shall be made intrinsically safe by providing suitable type of transformer isolated barrier/ Zener barrier of standard make in case it is a standard and proven practice of the bidder. Otherwise such instruments shall be provided with explosion proof enclosure suitable for hazardous areas described in National Electric Code (USA), Article 500, Class-I, Division-I or EN60079-14 oshall comply with the essential requirements of ATEX directives. All fittings, cable glands etc. shall be provided complying to above safety requirements.
1.10.00	The contract quantity shall be as per Appendix-I to C&I section, part- A, Section-VI of Technical specification read in conjunction with detailed technical specification. Unless explicitly stated to be common for all the unit(s), the Contractor shall provide all system/equipment described in this specification for each of the unit(s).
2.00.00	**DISTRIBUTED DIGITAL CONTROL, MONITORING & INFORMATION SYSTEM (DDCMIS)**

CLAUSE NO.	SCOPE OF SUPPLY AND SERVICES
2.01.00	The DDCMIS system to be provided for this project shall be as follows: - a. AHP DDCMIS: AHP control room. b. C HP DDCMIS: CHP control room.
2.02.00	**The Control systems (Including its Measurement system) to be provided for this project shall be as follows:**
2.03.01	The control system shall broadly consist of the following system(s):- **a. AHP System.** Ash Handling Control System comprising of binary and modulating controls of bottom ash handling system, fly ash handling system, Ash Water recirculation (if applicable), ash conveyors and associated system/equipment etc. **b. CHP System.** Coal Handling System Control System comprising of binary and modulating controls In case on line programming HART Management System is not allowed for the Instruments/Devices, the instruments/devices/DDCMIS system would be provided with the necessary capability to be interfaced with HART Management System after the system is handed over to the employer.
2.03.02	Wireless Link: -For the following system identified below, Bidder shall consider wireless link:
3.00.00	**MEASURING INSTRUMENTS PRIMARY AND SECONDARY)** (a) All the instruments which are required to implement the control philosophy as specified in corresponding Mechanical sections or as finalised during detailed engineering shall be provided by the Contractor within his quoted price. (b) All Instruments which are Integral to equipment like pumps, motors etc. / skid mounted instruments and are not indicated in enclosed drawings (as applicable) or in BOQ etc. included in relevant sub-sections, but are required for control, monitoring and operation of the equipment/plant/ Systems are to be provided by the Contractor to meet actual system requirements. Specification / type of instruments shall be as per standard and proven practice of equipment supplier. (c) NOT USED (d) Redundancy requirements: For instruments whose non-availability may result in loss of generation double-sensing devices shall be provided.

CLAUSE NO.	SCOPE OF SUPPLY AND SERVICES
4.00.00	**INSTRUMENTATION CABLES, CONTROL & POWER SUPPLY CABLES & CABLES SUB-TRAYS**
4.01.01	All instrumentation cables (twisted & shielded, PVC insulated & sheathed with FRLS properties) thermocouple extension cables (PVC / extruded FEP insulated & sheathed) and prefabricated cables (with plug-in connectors), Control Cables, Power Supply distribution cables, optical fibre cables as applicable for interconnection of all equipment/system/devices DDCMIS/PLC/MCC/LT SWGR/HT SWGR/ etc. shall be supplied, terminated and laid by the contractor on as required basis.
4.02.00	For all the cables mentioned above at 7.01.01, all necessary laying & termination accessories, hardware, sub trays, main trays etc. for meeting requirements specified under Sub-section INST CABLE, Part -B, Section-VI of Technical Specification shall be supplied by the contractor on as required basis.
4.03.00	Separate cables are to be provided for dual / triple redundant instruments used for protection of Unit and HT drives. These cables are also to be laid in separate routes to the extent feasible.
4.04.00	Instrumentation cables for PA system, CHP and AHP system shall be armoured.
4.05.00	Heat resistant instrumentation cable shall be provided for all instruments / equipment's/drives / devices located in hot areas such as Burner tilt, Hot air gates, Air Heater areas, furnace areas, Steam Drain & Vent Valves, Turbine – Generator areas, Oil system, HP/LP BP areas etc. This cable shall be laid from instruments / equipment's / drives / devices from hot area application to a field JB / panel located in areas where ambient temperature is below 50 Deg. C. Heat resistant instrumentation cable shall have same specification as of G/F type instrumentation cable specified under Sub-Section IIIC-07, Instrumentation Cables, Part-B of Technical specification, except that insulation and outer sheath material shall be Teflon. This cable shall be suitable for continuous operation at 205 Deg C.
05.00.00	**OTHER SERVICES**
	The Contractor shall conduct all shop and site tests as per the requirements of this specification and Employer approved "Quality Assurance Programme" to be finalised before the award of this Contract.
06.00 .00	**TOOLS & TACKLES**
06.01.00	The Contractor shall furnish a complete new set of all special tools and tackles of reputed make and model which are required for erection, ease in maintenance to have minimum down time, testing and calibration of all the equipment's and systems to be provided by the Contractor under this specification for C&I systems. The Contractor shall hand over all the tools (Mechanical, Electrical and Electronic) in working condition to Owner, used by him during erection, commissioning and troubleshooting of the system.

CLAUSE NO.	TECHNICAL REQUIREMENTS
1.00.00	**MEASURING INSTRUMENTS (PRIMARY AND SECONDARY)**
1.01.00	Measuring instruments/equipment and subsystems offered by the Bidder shall be from reputed experienced manufacturers of specified type and range of equipment, whose guaranteed and trouble-free operation has been proven. Refer Sub-section Basic Design Criteria. Further, all instruments shall be of proven reliability, accuracy, and repeatability requiring a minimum of maintenance and shall comply with the acceptable international standards and shall be subject to Employer's approval.
1.02.00	Every panel-mounted instrument requiring power supply shall be provided with easily replaceable glass cartridge fuses of suitable rating. Every instrument shall be provided with a grounding terminal and shall be suitably connected to the panel grounding bus.
1.03.00	All transmitters, sensors, switches and gauges for parameters like pressure, temperature, level, flow etc. as required for the safe and efficient operation and maintenance as well as for operator and management information (including all computation) of equipment in the system under the scope of specification shall be provided on as required basis with in quoted lump sum price. The Contractor shall furnish all Instrumentation / Control equipment & accessories under this specification as per technical specification, ranges, makes & model as approved by the Employer during detailed engineering.
1.04.00	The necessary root valves, impulse piping, drain cocks, gauge-zeroing cocks, valve manifolds and all the other accessories required for mounting/erection of these local instruments shall be furnished, even if not specifically asked for, on as required basis. The contacts of equipment mounted instruments, sensors, switches etc. for external connection including spare contacts shall be wired out in flexible/rigid conduits, independently to suitably located common junction boxes. The proposal shall include the necessary cables, flexible conduits, junction boxes and accessories for the above purpose. Double root valves shall be provided for all pressure tapping where the pressure exceeds 40 Kg./sq.cm.
1.05.00	All instruments envisaged for sea water applications, shall be provided with wetted parts made of Monel/ Hastelloy C or any other material (if provenness experience of the proposed material for such applications is established by contractor). For Chlorine application: Instruments shall be provided with wetted parts (e.g. diaphragm seal, etc.) made of Hastelloy C. Also, filled liquid shall be Fluorolube oil/ Inert Hydrocarbon / CTFE etc., for these applications. For applications of FECL3 solution: Instruments shall be provided with wetted parts (e.g. diaphragm seal, etc.) made of Tantalum.
1.06.00	For coastal areas, all instruments shall be provided with durable epoxy/ polyurethane coating for housings and all exposed surfaces of the instruments.
1.07.00	The instruments which are proposed to be used for PG test as indicated in the tender P&IDs shall meet the minimum requirements specified in ASME PTC or subsequent clauses in this chapter whichever is better.

2.00.00 **SPECIFICATION FOR ELECTRONIC TRANSMITTERS**

2.01.00 **SPECIFICATION FOR ELECTRONIC TRANSMITTER FOR PRESSURE, DIFF PRESS AND DP BASED FLOW / LEVEL MEASUREMENTS**

Microprocessor based 2 wire loop powered electronic transmitter with 4-20 mA DC HART/ output signal shall be provided.

Range	Accuracy (For calibrated Range)	Turndown (For span)	Stability (% of Calibrated range)
<=400mmwc	0.1%	20:1	+/-0.2% for 1 year
>400mmwc	0.060%	50:1	+/-0.25 % for 10 year
>250 kg/cm2	0.065%	10:1	+/- 0.15 % for 5 years
static pressure >420 kg/cm2	0.1%	10:1	+/- 0.2 % for 5 years

Sl.No.	Features	Essential/Minimum Requirements
1	Type of Transmitter	Microprocessor based 2 wire type (loop powered), Hart protocol compatible.
2	Accuracy	± 0.1% of calibrated span (minimum)
3	Output signal range	4-20 mA DC (Analog) along with superimposed digital signal (based on HART protocol)
4	Turn down ratio (minimum)	10:1 for vacuum/very low pressure applications (i.e. pressure <= 200 mmWC)
		5:1 for very high pressure application (i.e. pressure >= 200 Kg/cm2)
		30:1 for other applications
5	Stability	± 0.1% of calibrated span for six months for Ranges up to and including 70 Kg/cm²
		± 0.25% of calibrated span for six months for Ranges more than 70 Kg/cm²
6	Zero and span drift	+/- 0.015% per deg.C at max span
		+/-0.11% per deg.C at min. Span
7	Load impedance	500 ohm (minimum)
8	Housing	Weather proof as per IP-65, metallic housing with durable corrosion resistant coating
9	Over Pressure	150% of max. Operating pressure
10	Connection (Electrical)	Plug and socket type
11	Process connection	1/2 inch NPT (F)
12	Span and Zero	Continuous, tamper proof, Remote as well as manual adjustability from instrument with zero suppression and elevation facility.
13	Accessories	Diaphragm seal, pulsation dampeners, syphon etc. as required by service and operating condition.
		2 valve manifold for absolute & Gauge pressure transmitters, 3-valve and 5 valve manifold for DP/Level/Flow applications. The valve manifold shall be non integral type (except Fuel Oil area).
		For hazardous area, explosions proof enclosure as described in NEC article 500 C24
		Mounting: 2 inch pipe mounting.
14	Diagnostics & display	Self-Indicating feature and digital display on transmitter
15	Power supply	24V DC ± 10%.
16	Adjustment/calibration/ maintenance	From hand held HART calibrator/ centralized PC based system (as applicable).

Above parameters/features of offered models shall be strictly as defined in standard published catalogue of the manufacturer only.

Transmitter shall have weatherproof IP-67 metallic housing with durable corrosion resistant coating, integral digital display with self-indicating diagnostics, Plug and socket type electrical connection for HART calibration using HART calibrater, 2/3/5 Valve non integral manifold and

rack with canopy. For HART transmitter SIL 2 certification is required. Overpressure shall be 150% of max. operating pressure.

For primary air and flue gas applications, DPT shall be provided for pressure measurement below range of 2000 mmWC.
For corrosive, viscous, solid bearing, slurry type process fluids, suitable diaphragm seal shall be provided. Parts below seal shall be removable for cleaning. Entire volume shall be completely filled with inert liquid suitable for instruments. LVDT type transmitter is not acceptable.

2.02.00 GUIDED WAVE RADAR TYPE LEVEL TRANSMITTER

Type	Microprocessor based 2 wire type (loop powered), HART protocol compatible Guided wave radar transmitter.
Principle	TDR (Time domain reflectometry)
Probe Type & Material	(i) Coaxial probe of SS316/316L. If required, probe shall be suitable for overfill prevention. (ii) Rod probe, cable probe of SS316/SS316L can be used for applications wherever coaxial probe is not suitable.
Output signal	4-20 mA DC along with superimposed digital signal (based on HART protocol), suitable for over fill prevention.
Accuracy	+/- 0.5% of calibrated span or minimum 5mm.
Power supply	24 VDC +/- 10%.
Housing	Weatherproof as per IP-65, metallic housing with durable corrosion resistance coating.
Adjustment/ calibration	Using handheld HART calibrator/ centralized PC based system (as applicable).
Zero & span adjustment	Continuous, temper proof, remote as well as manual adjustability from instrument. It should be possible to calibrate the instrument without any level in the tank/sump etc.
Display	Integral digital display.
Load Impedance	500 ohms (minimum).
Electromagnetic compatibility	Shall meet EN 61326-1 (2021) and AmdtA1, class A equipment/EN 50081-2 & EN 5008 1-2 & EN 50082-2
Mounting	(i) External cage shall be provided wherever side mounting is required. External cage and other mounting accessories to be provided by the contractor. (ii) Wherever top mounting is required, all mounting accessories, stilling well (as required) etc., shall be provided by the contractor. (iii) All weather canopy shall be provided for protection from direct sunlight and direct rain for open locations.

Note: Four wire type transmitters can also be provided for applications where 2- wire transmitter has some technical limitations, subject to employer's approval during detailed engineering stage. However, in such cases isolated 4-20 mA DC (analog) output shall be provided. Power supply required for such transmitters shall be 240V AC / 24V DC.

2.03.00 **Ultrasonic Type level Transmitter**

S.No.	Features	Essential/Minimum requirement
1.	Type of Transmitter	Non-contact Microprocessor based 2 wire type (loop powered), HART protocol compatible Ultrasonic transmitter.
2.	Output signal	4-20 mA DC (Analog) along with superimposed digital signal (based on HART protocol).
3.	Accuracy	+/- 0.5% of calibrated span or minimum 5mm.
4.	Power supply	24 V DC +/- 10%.
5.	Temperature compensation	To be provided within transducer.
6.	Housing	Weatherproof as per IP-65, metallic housing with durable corrosion resistance coating.
7.	Adjustment/calibration/ maintenance	Using handheld HART calibrator/ centralized PC based system (as applicable).
8.	Zero and Span adjustment	Continuous, tamper proof, remote as well as manual adjustability from instrument. It should be possible to calibrate the instrument without any level in the tank/sump etc.
9.	Sensor Material	Corrosion resistant material to suit individual application requirement.
10.	False signal tolerance	Transmitter shall be capable of ignoring false echoes from internal tank/sumps obstructions such as pipes, heating coils or agitator blades. Also, transmitter shall have adjustable damping circuitry.
11.	Range	Range of transmitter shall be capable of covering the complete level span of tank taking care of blocking distance, frequency attenuation due to surface, obstructions, vapors etc.
12.	Display	Integral digital display
13.	Diagnostics	Loss of echo alarm etc.
14.	Load Impedance	500 ohms (minimum).
15.	Electrical Connection	Plug and socket
16.	Accessories	• All weather canopy shall be provided for protection from direct sunlight and direct rain for open locations. • All mounting accessories required for erection and commissioning shall be provided.

		• For hazardous area, explosion proof enclosure as described in NEC article 500

Note:

1) Contractor can also provide Radar type transmitter as per above specification in place of ultrasonic transmitter subject to approval by Employer during detailed Engineering. Sonic frequency-based transmitters can also be provided under "ultrasonic transmitters" category for fly ash silo level.

2) Four wire type transmitters can also be provided for applications where 2- wire transmitter has some technical limitations, subject to employer's approval during detailed engineering stage. However, in such cases isolated 4-20 mA DC (analog) output shall be provided. Power supply required for such transmitters shall be 240V AC / 24V DC.

3) For applications where transmitter location is not accessible, the transmitter shall have separate sensor unit and electronic unit for such applications. It shall be possible to mount the electronic unit at accessible location.

2.04.00 HART Handheld Calibrator

Handheld calibrator shall be provided for adjustment/calibration/maintenance of the HART compatible transmitters. The handheld calibrator shall be suitable for all types of transmitters supplied in the package. If one type of handheld type calibrator is not suitable for communicating with all types of transmitters, then separate hand held calibrator will be provided for that specific type of transmitter.

3.00.00 Temperature Elements and accessories

3.01.00 Thermocouple

Sr. No.	Features		Essential/Minimum Requirements
1	Type of Thermocouple.	:	16 AWG wire of Chromel-Alumel (Type K) or 24 AWG wire Pt-Rhodium Pt (Type R) depending on operating temperature Range (ungrounded separate junction type).
2	No. of element	:	Duplex
3	Housing/Head	:	IP-65/Diecast Aluminium. Head of TE to be provided with sufficient space and arrangement to mount head mounted temperature transmitter (as applicable). Plug in connectors are to be provided for external signal cable connection. TE terminal head shall be spring loaded for positive contacts with the thermo well.

	4	Insulation and Sheathing of Thermocouple	:	Swaged type mineral (magnesium oxide) insulation and SS316 sheath.
	5	Calibration and accuracy	:	As per IEC-584/ ANSI-MC-96.1 (special limits of errors/ class1) for T/C.
	6	Accessories	:	Thermo well and associated fittings
	7	Standard	:	IEC-584/ ANSI MC 96.1 for Thermocouple and ASME PTC-19.3-2016 for Thermo-well

3.02.00 Resistance Temperature Detector (RTD)

Sr. No.	Features		Essential/Minimum Requirements
1	Type of RTD.	:	Four wire, Pt-100 (100 Ohms resistance at zero degree Centigrade).
2	No. of element	:	Duplex
3	Housing/Head	:	IP-65/Diecast Aluminum. Head of TE to be provided with sufficient space and arrangement to mount head mounted temperature transmitter (as applicable). Plug in connectors are to be provided for external signal cable connection. TE terminal head shall be spring loaded for positive contacts with the thermo well
4	Insulation and sheathing of RTD	:	Mineral (magnesium oxide) insulation and SS316 sheath,
5	Calibration and accuracy	:	As per As per IEC-751/ DIN-43760 Class-A for RTD
6	Accessories	:	Thermo well and associated fittings
7	Standard	:	IEC-751/ DIN-43760 for RTD and ASME PTC-19.3-2016 for Thermo-well.

NOTES :

1) The specifications for RTDs of winding/ bearings of motor/pump, can be as per their manufacturer standards. The manufacturer shall submit the adequate supporting documents for establishing their standard practice. However, the type of RTD shall be Pt100.

2) The specifications of temp elements for air conditioning & ventilation system / process can be as per system manufacturer's standards. The manufacturer shall submit the adequate supporting documents for establishing their standard practice.

CLAUSE NO.	TECHNICAL REQUIREMENTS
3.03.00	**Metal Temperature Thermocouples**

Measuring Medium	Metal Temperature
Material of Thermocouple.	Chromel Alumel Type K
Type of Thermocouple	Duplex with ungrounded separate hot junctions
Insulation	Mineral Insulation (Magnesium Oxide).
Thermocouple wire gauge	18 AWG
Protective sheath	SS 321
Protective sheath dia.	6 mm OD (minimum)
Calibration & accuracy	As per IEC-584/ ANSI-MC-96.1 (special limits of error) for T/C
Mounting accessories	1/2" BSP SS sliding end connector, weld pad, clamps of heat resistant steel SS310. Adjustable gland fitting for connection at the junction box end as per manufacturer's standard.
Cold end sealing	SS pot seal with colour coded PTFE Insulated flexible tails. Sealing compound- Epoxy resin. Length of PTFE insulated flying leads shall be minimum 750 mm.
Minimum bending radius	30 mm
Length of T/C	On as required basis considering location of measurement point and the JB/TTJB location.

Notes :

1) The specification for thermocouples of bearings metal temp measurements can be as per their manufacturer standards. The manufacturer shall submit the adequate supporting documents for establishing their standard practice. However, type of thermocouples shall be K-type.

2) For boiler metal temperature applications, considering the location of installations and response time, manufacturer's standard and proven specification for metal temperature measurement can also be accepted subject to employer's approval. The manufacturer shall submit adequate supporting documents for establishing their standard and proven practice.

3.04.00 **Thermo well** (for all process temp. elements)

(a) Shall be one-piece solid bored type of 316 SS of step-less tapered design. (As per ASME PTC 19.3, 2016)

(b) For Mill classifier outlet long life solid sintered tungsten carbide material of high abrasion resistance shall be provided.

(c) For Air & Flue gas 316 SS protecting tube with welded cap. (However, contractor shall provide better material for Flue gas service if required based on the specified boiler design parameters).

(d) For furnace zone, impervious ceramic/incoloy protecting tube along with Incoloy supporting tubes and adjustable flanges

3.05.00 **Not Used**

3.06.00 **TEMPERATURE TRANSMITTER**

1	Output	2-wire (power supply from input card of Control System) with 4-20mA output with superimposed HART protocol signal.
2	Input	Same transmitter shall be capable to handle Pt-100 RTD, Thermocouples –K & R types (input type to be selectable at site through HART terminal).
3	Isolation	Min 500V AC
4	EMC compatibility	As per EN 61326.
5	Operating ambient temperature	0 to 85 deg C (without indicator). 0 to 70 deg C (with indicator).
6	Power supply	24V DC +/- 10%.
7	Accessories	Mounting arrangements including clamps etc.
8	Composite Accuracy (Refer note 2)	(i) For head mounted and DIN-rail mounted types: RTD =<0.4% of 0-250 deg C span T/C-K type=<0.4% of 0-600 deg C span T/C-R type=<0.4% of 0-1000 deg C span CJC accuracy (for thermocouples) shall be =< 1 deg C (ii) For dual-input type: RTD=<0.25% of 0-250 deg C span T/C-K type=<0.2% of 0-600 deg C span CJC accuracy (for thermocouples) shall be =< 1 deg C

Minimum technical requirements shall be as follows:

Single input/Dual input temperature transmitter shall be 2-wire loop powered directly from 4-20mA input cards of DDCMIS. Transmitters shall be fully compatible with thermocouples and RTDs being provided. It shall be capable to handle Pt-100 RTD, Thermocouple –K, R & S types (selectable through HART/Fieldbus terminal/calibrator). Temperature compensation for T/C shall be performed in the transmitter itself.

3.07.00 **Din rail temperature transmitter** 4-20mA HART based suitable for mounting on DIN-rails in JBs. The specifications of the JBs shall be same as indicated in Subsection INST CABLE with additional DIN-rails and IP 65 Protection class. This temperature transmitter shall be the ones which are especially designed for DIN-rail mounting with IP 20 protection class. These shall have terminals for input/output provided on front side when mounted on DIN-rail. Head mounted temperature transmitter with clamps to make it suitable for DIN-rail mounting shall not be acceptable under this category. Accuracy of Din rail should be:. RTD =<0.4% of 0-250 deg C span, T/C -K type =<0.4 % of 0-600 deg C span, CJC accuracy (for T/C) shall be < 1 deg C. Other specifications shall be as mentioned in clause 3.06.00.

3.08.00 **DELETED**

4.00.00 **ELECTRICAL METERING INSTRUMENTS**

Electrical metering instruments shall be furnished in accordance with the following general specifications. Application standard for electrical metering instruments shall be as per IS: 1248- 2003 (Revised). The size of each instrument shall be as approved by Employer during detailed engg. All metering instruments shall be flush panel mounting type..

4.01.00 (a) Frequency meters for Synchronization purposes: Accuracy: ± 1.5% of full scale.

(b) Synchroscope: Accuracy class: 0.5 or better.

(c) Voltmeters: Accuracy: ± 2.0% of full scale or better.

4.02.00 **Synchronizing Relays**

Synchronizing check relay with necessary ancillary equipment shall be provided which shall permit breakers to close after checking the requirements of synchronizing of incoming and running supply. The phase angle setting shall not exceed 10 Degree and this angle shall be adjustable and shall take the account the circuit breaker closing period. This relay shall have a response time of less than 200 milliseconds when the two system conditions are met within preset limits and with the timer disconnected. The relay shall have a frequency difference setting not exceeding 0.45% at rated value and at the minimum time setting. The relay shall have a continuously adjustable time setting range of 0.5-3 secs. Additionally, a guard relay shall be provided to prevent the closing attempt by means of synchronizing check relay when control switch is kept in closed position long before the two systems are in synchronism. The Control Voltage shall be 110V DC and PT input Voltage shall be 110 V AC.

4.03.00 **Auxiliary PTs for Measurement & Synchronization**

Applicable Standard	IS : 3156
Rated Voltage	110V
Insulation Level	660V grade
Frequency	50 Hz
Mounting	Panel Mounting
Test Voltage (Power frequency)	2.5 KV for 1 min.
Operating temperature	(-) 40 Deg C to (+) 85 Deg C
Primary Voltage	63.5 V to 115V
Secondary Voltage	63.5 V to 115V
Class of accuracy	1
Burden	25 VA
Class of Insulation	E or better

5.00.00 **IMPACT HEAD TYPE FLOW ELEMENT**

The impact head type element shall be tubular insert type with four impact ports facing upstream direction, located precisely for determination of average flow velocity and shall be of SS 316 L.

Accuracy shall be 1.0% of actual value or better. Repeatability shall be + 0.1% of actual value or better.

The elements shall be supplied complete with mounting hardware; end support plugs and CS valve manifold (1/2" NPT connection) for instrument connections. All pertinent data including employer's instrument tag no. for the flow element shall be punched on a stainless-steel plate and affixed to the element.

Flushing arrangement shall be provided.

For quantity and line size etc., refer Part-A.

Dual path transit time clamp-on Ultrasonic Flow meter may also be used for measurement of CW flow.

6.00.00 **DELETED**

6.01.00 **DELETED**

6.02.00 **DELETED**

6.03.00 **DELETED**

6.04.00 DELETED

6.05.00 **Specific requirements for Particulate Matter (Dust density) monitor**

Specification Requirements	**PARTICULATE EMISSION (Dust density Stack Opacity) monitor**
Type of Instrument	Extractive type with reheating or dilution.
Principle of Measurement	Scattered Light measurement
Measurement Range	0-50 mg/Nm3 / 0 - 300 mg/Nm3 (Programmable)
Accuracy	+/- 2% of lowest measurement range or better
Filter	To be provided
Accessories purging system	Purging system to be provided.

Temperature compensation/measurement	Temperature compensation to be provided, if applicable.
	First site Calibration of the instrument should be done based on the results of an extractive IsoKinetic Test by the Contractor.

6.06.00 DELETED

6.07.00 **DELETED**

6.08.00 DELETED

6.09.00 **DELETED**

7.00.00 **DELETED**

8.00.00 **NOT USED**

9.00.00 **NOT USED**

10.00.00 **DELETED**

10.01.00 **DELETED**

10.01.01 **DELETED**

10.01.02 **DELETED**

10.01.03 **DELETED**

10.01.04 **DELETED**

10.01.05 **DELETED**

10.01.06 **DELETED**

10.01.07 **DELETED**

10.02.00 **DELETED**

10.02.01 **DELETED**

10.02.02 **Specifications of Wind Direction Sensor**

1.	Principle		Potentiometric type Sensor (Resistance proportional to Wind direction)
2.	Range		0-360 deg
3.	Accuracy		2 % of full scale
4.	Threshold		0.3 m/ sec
5.	Operating Temperature		0 to 50 deg C

10.02.03 **Specifications of Air Temperature Sensor**

1.	Principle		RTD (Platinum) Resistance proportional to temperature
2.	Range		0-50 deg C
3.	Accuracy		+ 0.2 deg C
4.	Operating Temperature		0 to 50 deg C
5.	Radiation Shield		Non-aspirated Radiation Shield

10.02.04 **Specifications of Relative Humidity (Rh) Sensor**

1.	Principle		Thin film capacitance type sensor
2.	Range		0-100% RH
3.	Accuracy		3 % for range 10% to 90%
4.	Sensitivity		0.2% RH
5.	Operating Temperature		0 to 50 deg C
6.	Radiation Shield		Non-aspirated Radiation Shield

10.02.05 **DELETED**

10.02.06 **DELETED**

10.02.07 **DELETED**

11.00.00 **DELETED**

11.01.00 **DELETED**

11.02.00 **DELETED**

11.03.00 **DELETED**

11.03.01 **DELETED**

11.03.02 **DELETED**

11.03.03 **DELETED**

12.00.00 **SPECIFICATION FOR CORIOLIS FLOW TRANSMITTER**

Type	Coriolis
Material of Wetted Parts	316 SS or better
Material of Housing	304L SS
Accuracy	± 0.2% of Rate
Repeatability	± 0.1% of Rate
Output	4-20 mA DC, HART Compatible
Power Supply	230 VAC or 24VDC operated
Instrument Temperature range	0-200 degree Celsius 0-150 degree Celsius for applications having process temperature up to 100 degree Celsius.
Others	Drain / purging arrangement shall be provided as per standard practice.

Notes: Coriolis Mass flow meter upstream of Burners shall be sized to measure minimum flow corresponding to one burner operation and maximum BMCR rating flow with 25% margin.

The offered Coriolis type flow transmitter shall be suitable for intended application. Contractor shall submit flow and sizing calculation for Employer's approval. For each type of Coriolis type flow transmitter general arrangement and assembly drawing and cable wiring diagram shall be submitted for Employer's approval.

13.00.00 **SPECIFICATION FOR FLOW ELEMENTS**

13.01.00 **Orifice Plate**

Features	Essential/Minimum Requirements
Type	Concentric as per ASME PTC-19.5 (Part-II), ISA RP-3.2, 1960 or BS-1042, ISO 5167
Material	316 SS
Thickness	3 mm for main pipe diameter up to 300 mm and 6 mm for main pipe dia. above300 mm.
Tappings	Flanged weld neck or D & D/2 with 3 pairs of tapping (as applicable). Root valves to be provided in all the tappings. However, for flow elements in CPU, DM & PT plant- 2 Pairs of Tappings shall be provided as minimum.
Beta Ratio	0.34 to 0.7

13.02.00 **DELETED**

13.03.00 **DELETED**

13.04.00 **NOT USED**

14.00.00 **NOT USED**

15.00.00 **PROCESS ACTUATED SWITCHES**

FEATURES	**ESSENTIAL / MINIMUM REQUIREMENTS**		
	Pressure/ Draft Switches/ DP Switches	Temperature switches	Level switches
Sensing Element	Piston actuated for high pressure and diaphragm or bellows for low pr./ vacuum	Vapor pressure sensing, liquid filled bellow type with SS bulb and capillary (5 m minimum, to suit application)	Capacitance types, float type, conductivity type, RF type, Ultrasonic type as per suitability to the application. .
Material	316 SS	Bulb 316 SS/ capillary 304 SS	316 SS
End connection	½ inch NPT (F)	½ inch NPT (F)	Manufacturer standard
Over range/ proof pressure	150% of maximum operating pr.	-	150% of maximum operating pr.
Repeatability	+/- 0.5% of full range		
No. of contacts	2 No.+2NC. SPDT snap action dry contact		

Rating of contacts	60 V DC, 6 VA (or more if required by DDCMIS)		
Elect. Connection	Plug in socket.		
Set point adjustment	Provided over full range.		
Dead band adjustment	Adjustable/ fixed as per requirement of application.		
Enclosure	Weather and dust proof as per IP-65, metallic housing.		
Accessories	Siphon, snubber, chemical seal, pulsation dampeners as required by process	Thermo well of 316 SS and packing glands	All mounting accessories
Mounting	Suitable for enclosure/ rack mounting or direct mounting	Suitable for rack mounting or direct mounting	-
Power Supply (wherever required)	As per Contractor's Standard practice.		

Notes: -

1) Where the process fluids are corrosive, viscous, solid bearing or slurry type, diaphragm seals shall be provided. Parts below the diaphragm shall be removable for cleaning. The entire volume above the diaphragm shall be completely filled with an inert liquid suitable for the application.

2) Pressure/ Diff pressure switches for very low press/ DP measurements can have sensor material other than SS316 in case of any technical limitation and the offered product is standard product of the manufacture for very low-pressure applications.

3) Repeatability can be upto +/-1% of full range in case of switches with diaphragm seals or very low pressure/DP range.

4) The specifications of switches for air conditioning & ventilation system / process can be as per system manufacturer's standards. The manufacturer shall submit the adequate supporting documents for establishing their standard practice.

5) For ESP Level Switches following requirements are to be met:
   i) ESP Level Switches calibration shall not be affected by changes in ambient temperature.
   ii) Active build up compensation to be provided to sense and auto correct the effect of ash deposition on level probe.
   iii) Self- -diagnostic features like health status, maintenance requirement, instrument failure, false alarm etc. to be provided.

   The manufacturer shall submit adequate supporting documents, catalogues for establishing the above features.

16.00.00 LEVEL SWITCHES

16.01.00 TYPE : RADIO FREQUENCY (DIGITAL TYPE)

a. ELECTRONIC CONTROLLER

Input supply voltage	: 240VAC ±10%
Relay output	: 2 NOS. + 2NC SPDT
Contact rating	: 5A AT 240VAC & 0.25 AT 220V DC
Enclosure protection	: IP 67 or better
Set point	: SINGLE SET POINT
Enclosure housing	: CAST ALUMINUM
Ambient temperature	: -10 TO 50 °C
Local indication (optional)	: Numeric led display of real time value of sensitivity with keypad for setting
Electrical connection	: Suitable no. of connections as per design

B. SENSING PROBE

Material	: Stainless steel – 316 (active & shield)
Mounting	: As per application

	Temperature	: 200°c (max.) for ESP & 400 deg C (max.) for ECO / APH hopper
	Enclosure protection	: IP-67
	Enclosure housing	: Cast Aluminum
	Insulation	: PTFE for ESP & Ceramic for ECO / APH
	Baffle for Protection	: To be provided if required.
16.02.00	**TYPE**	**: VIBRATING ROD TYPE**
	Transducer type	: Integral type with sensor and measuring system in the same unit fully buffed.
	Housing	: Pressure Die Cast Aluminum, Weatherproof, powder coated, IP67 or better.
	Output	: 2NO, 2NC DPDT Relay Output (rated at 6A, 230V AC for non-inductive load)
	Power Supply	: Universal (18 to 55 V DC and 90 to 265 V AC at 50 Hz)
	Switching	: Normal Switching
	Mounting	: Threaded G 1.5" (BSP) SS 304
	Vibrating Rod	: Sensing rod – 155 to 162 mm, SS316 make
	Temperature	: 200°c (max.) for ESP & 400 deg C
	Extension Material	: SS 304
	Baffle for Protection	: To be provided if required.

17.00.00 **SOLENOID VALVES**

Solenoid valves shall fulfil the following requirements:

a. Type 2/3/4-way SS 316/Forged Brass (depending on the application subject to Employer's approval during detailed Engg.)

b. Power supply: 24 V DC $\pm$ 10%.

c. Plug and socket electrical connection.

d. Insulation: Class 'H'

e. IP Class: IP65

18.00.00 **DELETED**

19.00.00 **WATER SYSTEM RELATED SPECIAL INSTRUMENTS**

19.01.00 **ANALYSER INSTRUMENTS:**

For Technical specification of Cation/Specific Conductivity, pH, Sodium, Silica, Turbidity, Total Dissolved Solids (TDS) and Concentration analyzers, please refer Specification of Analyzers, Part-B, Sub-section IIIC-13, SWAS chapter of this specification. Specification of concentration analyzer shall be similar to Conductivity analyzer except range which shall be as per process requirements.

19.02.00 **Residual Chlorine Analyser**

a An automatic chlorine residual analyzer of amperometric type shall be provided alongwith the chlorinating plant for monitoring the residual chlorine content of cooling water. The analyzer shall be suitable for accurate residual measurement in open/closed systems. The measurement accuracy shall not be affected by presence of treatment chemicals as chromates, phosphates, de-former highly polluted water, change in temperature etc.

b Circulating water as sample to residual chlorine analyzer shall be taken from hot circulating water pipe work before entry to cooling towers. Exact location and layout of sampling arrangement shall be finalized during detailed engg. stage. Bidder shall provide necessary pumping system (with 100% standby) for meeting the analyzer requirements, if needed. All the drains shall be terminated up to the nearest plant drainage system.

19.03.00 All the outdoor field instruments such as analyzers/transmitters/meters etc. shall be provided with suitable Free-standing cabinet(s)/panel/rack so that the equipments are protected against rain/ sunlight etc.

19.04.00 **Parshall Flume**

The Bidder shall provide all the control and Instrument devices including primary sensors, transmitters, flow indicator cum integrator / totalizer and shall include all required accessories for the flow measurement of raw water through the clarifier. The system shall be of reputed make and acceptable to the owner.

Level measurement shall be based on ultrasonic/radon technology. The flow compensation is to be implemented in the transmitter itself. The transmitter shall provide 4-20 mA DC in direct proportion to flow and shall be able to drive a load impedance of 500 ohms minimum

Accuracy shall be +/- 1 % or better.

All the mounting hardware and accessories required for erection and commissioning of the same are to be provided by the contractor. Mounting fittings material shall be SS316. All weather canopy is to be provided for electronics/sensor to protect the same from rain/ sunlight etc.

The Type makes and models no. shall be subject to Owner's approval.

19.05.00 **Electronic Flowmeter**

The electronic flow meter shall include flow sensor and flow indicator cum integrator / totaliser and shall include all required accessories for satisfactory operation. The flow meter shall be based on full bore electromagnetic principle and shall be electronic type of proven design, make and model acceptable to the owner.

The Bidder shall submit all necessary technical literature and details of selection criteria of the instrument offered to substantiate the model selected. The Bidder shall also furnish list of similar installation along with feedback on satisfactory performance of the instruments.

The flow meter shall meet or exceed the following requirement:

(a)	Output	:	4-20 mA DC Isolated output
(b)	Accuracy	:	± 0.5% of calibrated span or better *
(c)	Repeatability	:	± 0.2% of calibrated span or better
(d)	Power Supply	:	240V AC ± 10%, 50 HZ ± 5%/ 24 V DC, to be arranged by the contractor.
(f)	Protection class	:	IP-65
(e)	Flow tube		SS304
(f)	liner		Hard Rubber

The flow meter shall provide local indication for instantaneous flow. It should also be possible to get local display for daily and monthly discharge. The flow meter shall indicate totalizer/ integrator to get the daily and monthly discharge as stated above.

20.00.00 AC PLANT RELATED SPECIAL INSTRUNMENTS

20.01.00 HUMIDITY SENSOR

Sensor	:	Capacitance type
Accuracy	:	+/-3% R.H
Range	:	0-100% R.H
Output	:	4-20 ma
Time constant	:	2 mins.

Output from the sensor is to be connected to respective control system. Contractor can also provide combined instrument for measurement of humidity and temperature subject to Employer's approval during detailed engineering. In all such cases, 4-20 ma outputs, each for temperature and humidity measurements are to be provided.

20.02.00 TEMPERATURE/ HUMIDITY INDICATOR

Sensor	:	RTD for(Pt 100) for temperature
	:	Capacitance Type for Humidity (specs for humidity and temperature shall be as mentioned above)
Display	:	Combined enclosure with two three-digit seven segments LED display with decimal point after two digits. LED height shall be 4 inches, clearly legible from a distance of at least 10 meters.
Range	:	0-60 Deg C for temperature.
	:	0-95.0 % for Relative Humidity.
Accuracy	:	Better than +/_0.5 % for Temperature
	:	Better than +/_2.5 % for Relative Humidity
Mounting	:	Tabletop/ wall mounting.
Power supply	:	240 V AC, 50 Hz.

Output : 4-20 mA signal each for temperature.

Qty. : 15 nos. each of temperature & Humidity indicators (combined indicators for Humidity and temperature is also applicable).

One Set of output signal is to be connected to respective control system. Apart from displaying the temperature/humidity values on indicator.

21.00.00 Limit switches

Limit switches shall be non-corrosive type. Contact rating shall be sufficient to meet the requirement of DDCMIS subject to a minimum of 60 V, 6 VA rating. Protection class shall be IP 55.

22.00.00 SPECIFICATIONS OF EFFLUENT QUALITY MONITORING SYSTEM (EQMS)

22.01.00 DELETED

22.02.00 DELETED

22.03.00 pH ANALYSER

Type	Cell flow through sample
Measuring Range	0-14 units of pH
Temperature Compensation	Automatic
Power	To be arranged by the contractor.
Accuracy	<= +/- 1 %

22.04.00 DELETED

22.05.00 DELETED

22.06.00 DELETED

22.07.00 DELETED

23.00.00 DELETED

CLAUSE NO.	TECHNICAL REQUIREMENTS

23.01.00 **NOGS (Naturally Occurring Gamma Sensor) Based Level Scanner System for Buffer Hopper:-**

S. No.	Feature	Requirements
1	Type	One Set of non-contact Level Transmitter working on NOGS technology based, Level sensor
2	Protection Class	IP-66 or better
3	Housing	Diecast Aluminum
4	Operating Principle	Detects the Gamma Ions/ Radioactivity from Fly Ash to measure continuous Level (Naturally Occurring Gamma Ray Sensor). No Radioactive Source is used. Only Detector is used, and Coal, Fly Ash is the source of Gamma Ions / Radioactivity.
5	Accuracy	+/- 0.5 % to +/- 1%
6	Ambient Temperature	-20º C TO 85º C
7	Operating Pressure	1 Atm
8	Power Supply	24V DC (Charger based supply) / 230 V AC (UPS supply)
9	Output	4 – 20 mA (Continuous Level) / 2 Relay Contacts
10	Mounting & Local Display	To be Mounted with Touch Buttons
11	4-20 mA signal shall be hardwired to corresponding DDCMIS for displaying Average Level	

24.00.00 **DELETED**

25.00.00 **DELETED**

26.00.00 **DELETED**

27.00.00 **DELETED**

28.00.00 **DELETED**

ELECTRICAL POWER SUPPLY SYSTEM

1.00.00 ELECTRICAL POWER SUPPLY

1.01.00 The requirements of Electrical Power Supply system are specified herein on system basis. The Contractor shall be responsible for engineering and furnishing a complete and operational system fully meeting the intent and requirements of this specification including tender drawings and Employer approved drawings during detailed engineering. All equipment and accessories required for completeness of this system shall be furnished by the Contractor whether these are specifically mentioned herein or not. All the equipments and sub systems offered shall be from reputed experienced manufacturers. All system cabinets, enclosures, & distribution boards shall be manufactured, assembled, wired and fully tested as a complete assembly as per the requirements of this specification at the manufacturer's works.

The Contractor shall furnish all required equipment cubicles and wiring required for conversion and/or stabilization of the power sources provided by the Employer to all other levels which may be necessary for meeting the individual requirement of equipment/system furnished by him including the panel/desk mounted equipment.

1.02.00 The power supply system shall be designed to meet the electrical power requirements of various C&I systems including DDCMIS. The Power Supply System shall be designed to give the voltage at approximate mid level of the tolerance band of the power supply modules/packs of Control System, when the charger is feeding the load. This shall also take in consideration the voltage drop in cables from DCDB to the control panels. In case the Power Supply Output of a charger exceeds the voltage band tolerated by the power supply modules/packs of Control System, provision for safe tripping of that charger is to be ensured.

1.02.01 Bidder may specifically note that the KVA rating of UPS system shall be guaranteed at 50 deg.C ambient temperature and load power factor of 0.8 lagging.In case the Bidder's standard UPS KVA ratings are applicable at a lower ambient temperature (say 40 deg.C) than specified 50 deg.C temperature, the Bidder shall consider derating factor of at least 1.5%/deg.C for arriving at the specified UPS capacity at 50 deg.C ambient temperature so that required capacity is ensured at 50°C. The Contractor shall demonstrate the above stated capacity at 50°C during shop testing.

1.02.02 The Bidder may note that for UPS of capacity above 25 KVA, the following should be followed:-

(a) Both the inverters shall not be housed in single cubicle.

(b) Both the chargers shall not be housed in single cubicle.

One inverter and one changer can be housed in one common cubicle i.e. there will be two such cubicles per UPS system if the same is standard and proven practice of the Bidder.

1.02.03 Bidder may note that in case the calculated UPS rating is not same as one of the standard KVA rating of the single UPS system, the next higher standard rating of the manufacturer shall be selected and provided. Bidder may specifically note that UPS of manufacturer's non-standard rating shall not be acceptable. Furthermore, it may be noted that to attain the calculated UPS rating, paralleling of multiple UPS systems of lower ratings will not be accepted.

1.02.04 **DELETED**

CLAUSE NO.	TECHNICAL REQUIREMENTS
1.03.00	The applicable configurations are as indicated in Part-A of contract quantities: - **(A)** NOT USED. **(B1)** **DELETED** **(B2)** DC power supply system for areas other than Unit: DC power supply system shall comprise of two sets. Each set shall consist of 1 x 100% microprocessor controlled, intelligent, modular rectifier banks, Controller –one for each rectifier bank, 1 x 100% Nickel - Cadmium batteries for one (1) hour duty, 1 X 100% DC distribution board. 1x100% Microprocessor controlled Battery Health Monitoring System (BHMS)– common for both the sets. The specifications for this DC Power Supply System shall be as per Cl.No.2.01.00 to 2.03.00 and specifications for Battery shall be as per Cl. No 4.01.00 for Ni-Cd type Batteries **(C)** DC power supply system shall comprise of 2 x100% power supply unit along with 1x100% sealed maintenance free lead Acid batteries for 30 Min back up and DC Distribution Board. DC power supply unit along with batteries shall be housed in a single panel. The power supply unit shall be capable of charging the batteries and feeding the load simultaneously. The DC distribution board shall have redundant feeders for critical loads. The specifications for this configuration shall be as per Cl.No.2.04.00. **(D)** DC power supply system shall consist of one set of 24 VDC redundant power supply system with battery back up as per the process requirement. In case power supply module/power packs with 24 VDC output are used, the input power supply to the same can be either of 24 VDC/110 VAC/230 VAC/220 VDC, to be finalized during detailed engineering. The specifications for this configuration shall be as per manufacturer's standard Bidder shall clearly bring out in the proposal the redundancy features along with configuration diagram, single line diagram & data sheets etc. and this shall be finalized and subject to Employer's approval during detailed engineering.
1.04.00	NOT USED.
1.05.00	The UPS Power Supply for various sub-systems shall consist of one or more of the following configurations. The applicable configurations are as indicated in Part-A of contract quantities. Bidder shall clearly bring out in the proposal the redundancy feature along with configuration diagram, single line diagram and data sheets etc. & this shall be finalized subject to employer's approval during detailed engineering. (A) UPS System shall consist of 2 x 100% parallel redundant chargers and inverters with input isolation transformers, 1 x 100% battery bank for one (1) hour, Bypass line transformers & voltage stabilizer, static switch manual bypass switch, 2 x 100% ACDB, 1x100% Microprocessor controlled Battery Health Monitoring System (BHMS) and other necessary protective devices and accessories. **Contractor has the option of supplying either Nickel Cadmium type batteries or Lead Acid Plante type batteries for this configuration.** The specifications for this UPS configuration shall be as per Cl.No.3.00.00 to 3.05.00 and specifications for Battery shall be as per Cl. No 4.01.00 for Ni-Cd type Batteries &

	4.02.00 for Lead Acid Plante type Batteries. (B) UPS system shall consist of 1 x 100% charger and inverter with input isolation transformer, 1 x 100% Ni Cd Battery Bank for 1 hour, Bypass Line Transformers and Voltage Stabilizer, static switch, manual bypass switch, 2 x 100% ACDB, 1x100% Microprocessor controlled Battery Health Monitoring System (BHMS) and other necessary protective devices and accessories. The specifications for this UPS configuration shall be as per Cl.No. 3.00.00 to 3.05.00 and specifications for Battery shall be as per Cl. No 4.01.00 for Ni-Cd type Batteries. (C) On line UPS with remote monitoring having a battery backup of 30 min. The batteries for UPS System shall be Sealed Maintenance Free type and shall be as per Control System Vendor's standards.
1.06.00	For distribution of UPS Supply Contractor shall provide PDBs. The output feeders from the PDB shall be provided with separate fuse & MCB's. 10% spare feeders (min. 1 no.) with MCB & fuses for each rating shall be provided in Bidder's each PDB. The PDBs provided for distribution of UPS loads shall be as per following guidelines. (a) **DELETED** (b) For offsite Area HMI & other loads which accept redundant inputs shall be fed directly from redundant PDB feeders. The loads which accept only single input feeder shall be divided between the two ACDB's such that even in event of unavailability of one ACDB, half of the devices/peripherals are available. (c) **DELETED**
2.00.00	**DELETED**
2.01.00	**DELETED**
2.01.01	**DELETED**
2.01.02	**DELETED**
2.01.03	**DELETED**
2.01.04	**DELETED**
2.01.05	**DELETED**
2.01.06	**DELETED**
2.01.07	**DELETED**
2.01.08	**DELETED**
2.01.09	**DELETED**
2.01.10	**DELETED**
2.02.00	**DELETED**

2.03.00	**Battery Health Monitoring System (BHMS)** BHMS, wherever applicable, shall include microprocessor-based hardware and software to monitor the condition of each battery cell of 24 V DC systems & UPS battery banks on-line. With BHMS it shall be possible to measure & analyze the minimum and maximum voltage values of each battery-cell so that any damage to battery shall be prevented by pro-active maintenance. BHMS shall communicate with the DDCMIS and provide alarms as finalized by Employer during detailed engineering. Contractor to ensure that the configuration of the BHMS system being supplied along with the batteries of 24 V DC Charger System and UPS System shall meet the technical requirements of the type of batteries supplied along with these power supply systems.
2.04.00	Power Supply shall be sized to meet connected load requirements and keep the connected battery full charged in Float/ Boost mode. The rectifier module output regulation shall be ± 1% or better from no load to full load with an input power supply variation of ± 10% in voltage and ± 5% in frequency. In addition to indications/display on the panel, potential free contacts for alarms like O/P voltage high & low, AC Input supply failure, battery feeding the load etc shall also be provided for use in respective control system i.e., PLC/Remote IO etc . Further isolated 4-20 mA signals shall be provided for important parameters like rectifier module voltage, rectifier bank current, battery voltage etc. The list of alarm output & 4-20 mA signals shall be as approved by Employer during detailed engineering. The exact design, rating & number of feeders of the DCDB shall be as finalised during detailed engineering and as approved by Employer. However, 25% spare feeder (min. 1 no.) with fuses for each rating shall be provided in each DCDB.
3.00.00	**UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEM** The minimum capacity of the UPS at load factor of 0.8 lagging inclusive of 10% design margin at 50 deg c shall be as indicated in Part-A of the specification. The UPS system shall meet the following requirements as a minimum. If UPS KVA rating is applicable at a lower ambient temperature than specified 50 deg.C, the bidder shall consider a derating factor of at least 1.5%/deg.C for arriving at the specified UPS capacity at 50 deg.C ambient. The UPS shall have an overload capacity of 125 % rated capacity for 10 minutes and 150 % rated capacity for 10 seconds. The inverter shall have sufficient capability to clear fault in the maximum rated branch circuit, limited to 8 percent of finally selected ups capacity.
3.01.00	**Chargers**
3.01.01	The chargers shall be self regulating, solid state silicon controlled, full-wave rectifier type designed for single and parallel operation with battery and shall have automatic voltage regulators for close voltage stability even when AC supply voltage fluctuates, effective current limiting features and filters to minimize harmonics. The Battery should be directly connected to the Controlled Rectifier and no intermediate component between Battery and controlled rectifier is allowed. In event of mains failure, Battery should feed the inverter directly without any intermediate component. The charger should be capable to fully charge the required batteries as well as supply the full rated load through inverter. Furthermore, the charger should be able to re-charge the fully discharged battery within 8 hours. The charger output regulation shall be ± 1% from no load to full load with an input power supply variation of ± 10% in voltage and ± 5% in frequency. In addition to indications/display on charger panel, alarms along with relevant analog measurements shall also be provided by employing RS 485 Port Modbus Protocol / Ethernet TCP/IP protocol for use in DDCMIS. The list of alarm output & 4-20 mA signals shall be as approved by Employer during detailed engineering.

CLAUSE NO.	TECHNICAL REQUIREMENTS
3.01.02	The charger shall be current limited for charger circuit protection and protection of battery from overcharge shall also be provided. The current limit shall be continuously adjustable. The chargers shall have a slow walk-in circuit which shall prevent application of full load DC current in less than 10 seconds after AC power is energised.
3.01.03	The chargers shall be fed from 415V AC, 50 HZ, 3 phase, 3 wire system. Charger design shall ensure that there is no component failure due to fluctuations of input supply or loss of supply and restoration.
3.01.04	The minimum full load efficiency at nominal input and output shall be 90%. The ripple content shall be limited to +/- 2 % of Charger output voltage.
3.01.05	The UPS battery shall have sufficient amp-hour capacity to supply the steady state KVA rating of the UPS specified for 60 minute, irrespective of the actual load on UPS.
3.01.06	The UPS system shall be capable of operating without D.C. battery in circuit under all conditions of load and the performance of various components of UPS like inverter, charger, static switch etc. shall be guaranteed without the battery in circuit.
3.01.07	The UPS system design shall ensure that in case of failure of mains input power supply to one of the chargers, the other charger whose mains input power supply is healthy, shall feed to one or both the inverters as the case may be as per manufacturer's standard practice & continue to charge the D.C. battery at all load conditions. The Bidder should note that this situation should not in any way lead to the discharge of the D.C. Battery.
3.02.00	**Static Inverters** The static inverter shall be of continuous duty, solid state type using proven Pulse Width Modulation (PWM)/Quasi square wave/step wave technique. Ferro-resonant types Inverters are not acceptable. The nominal voltage output shall be 230 Volts. single phase ,50 Hz. The inverter equipment shall include all necessary circuitry and devices to conform to requirements like voltage regulation, current limiting, wave shaping, transient recovery, automatic synchronization etc. The steady state voltage regulation shall be +/-2% and transient voltage regulation (on application/removal of 100% load) shall be +/-20%. Time to recover from transient to normal voltage shall not be more than 50 milli-sec. Frequency regulation for all conditions of input supplies, loads and temperature occurring simultaneously or in any combination shall be better than ± 0.5% (automatically controlled). The total harmonic content shall be 5% maximum and content of any single harmonic shall be 3% maximum. The inverter efficiency shall be at least 85% on full load and 80% on 50% load. The synchronization limit for maintenance of synchronization between the inverter and stand by AC source shall be 48-52Hz, field adjustable in steps of 1 Hz.
3.03.00	**Static Switch and Manual Bypass Switch** The static switch shall be provided to perform the function of transferring UPS loads automatically without any break from (i) faulty inverter to healthy inverter in case of failure of one of the two inverters and (ii) from faulty inverter to standby AC source in case of failure of both the inverters. The transfer time shall be ¼ cycle maximum in synchronous mode. Manual bypass switch shall be employed for isolating the UPS during maintenance. Continuous and overload capacity of the switches shall be equal to 100% of the continuous and overload rating of each inverter. Peak Capacity shall be 1000% of continuous rating for 5 cycles.

3.04.00 **Step Down Transformer and Voltage Stabiliser**

One 415V three phase to 230V, single phase transformer along with associated voltage stabilizer shall be furnished with each UPS system. The transformer and stabilizer combination shall convert Employer furnished 415V ± 10% three phase plant auxiliary AC supply to 230 V ± 2%, single phase standby AC Power Supply source.

The transformer shall be of low impedance air-cooled type and its KVA rating and percentage impedance should be selected so that extremely fast fault clearance is achieved.

The overload capacity of the transformer and voltage stabilizer shall not be less than 300% for 200 millisecond durations. The voltage stabilizer shall employ servo-controlled circuitry and shall maintain the specified output voltage for 0-100% load with maximum input voltage variations as indicated above. The efficiency of the stabilizer shall be 95% or better.

The type and other details shall be subject to Employer's approval.

3.05.00 **AC Distribution Board (ACDB)**

The details of the AC distribution board, i.e. exact, rating and number of feeders etc. of the 2x100% ACDB shall be as indicated in Part-A of the specification and as approved by Employer during detailed engineering. ACDB shall be designed to cater to the requirements of both Employer's System and Contractors systems.

4.00.00 **Batteries**

4.01.00 Nickel Cadmium Batteries

4.01.01 The batteries shall be heavy duty Nickel-cadmium type and shall be sized for one hour of full load operation during non-availability of AC supply / chargers. The Ni-Cd batteries shall **strictly** conform to the latest edition of **IS: 10918** including all applicable official amendments and revisions as on date of opening of techno-commercial bid. For sizing calculation, an aging factor of 0.8 and a temperature correction factor as per manufacturer's standard at 4 deg. C electrolyte temperature (Based on temperature characteristics curve to be submitted by the Contractor at a temperature of 4 deg. C), Capacity factor, float correction (if applicable) shall be taken into consideration. The sizing of the battery shall be as approved by Employer during detailed engineering. The Contractor shall typically consider a voltage drop of 2.5V from battery room to DCDB and DCDB to load, while sizing the battery for 24 V DC Charger System and 4V from battery room to the inverter input while sizing the battery for UPS System.

4.01.02 Connectors and Fasteners

Nickel plated copper connectors shall be used for connecting adjacent cells and PVC insulated flexible copper cables shall be used for inter-row / inter-tier / inter-bank connections. Bolts, nuts and washers shall be Stainless Steel / Nickel coated steel to prevent corrosion. All the terminals and cells inter-connectors shall be fully insulated or have insulation shrouds. Necessary supports and lugs for termination of these cables on batteries shall also be supplied by the contractor. All connectors and lugs shall be capable of continuously carrying the 60 minutes discharge current of the respective batteries and fault short circuit current which the battery can produce and withstand for the period declared.

4.02.00 **Lead Acid Plante Batteries**

4.02.01 **Codes & Standards**

4.02.02 All standards, specification and codes of practice, referred to herein, shall be the latest edition including all applicable official amendments and revisions as on date of opening of techno-commercial bid.

In case of conflict between this specification and those (IS Codes Standards etc.) referred to herein, the former shall prevail. All works shall be carried out as per the following standards and codes:

IS : 266	Specification for sulphuric acid
IS : 1069	Specification for water for storage batteries
IS : 1146	Specification for rubber & plastic containers for lead acid storage batteries.
IS : 1652	Specification for stationary cells and batteries, lead acid type (with plante positive plates).
IS : 3116	Specification for sealing compound for lead acid batteries.
IS : 8320	General requirements and methods of tests for lead acid storage batteries.
IS : 6071	Specification for synthetic separators for lead acid batteries.
	Indian Electricity Rules
	Indian Electricity Acts

4.02.03 Equipment complying with other internationally accepted standards such as IEC, BS, VDE etc. will also be considered if they ensure performance and constructional features equivalent or superior to standards listed above. In such a case, the Bidder shall clearly indicate the standard(s) adopted, furnish a copy in English of the latest revision of the standards alongwith copies of all official amendments and revisions in force as on date of opening of techno-commercial bid and shall clearly bring out the salient features for comparison.

4.02.04 **GENERAL TECHNICAL REQUIREMENTS**

4.02.04.01 Equipments

DC Batteries shall be stationary lead acid Plante positive plate type conforming to IS:1652. The battery shall be high discharge performance type shall be sized for one hour of full load operation during non-availability of AC supply / chargers. For the purpose of sizing Temperature Correction Factor as per manufacturer's standard at 4 Deg C electrolyte temperature, relative humidity of 95%, aging factor of 0.8 and Capacity Factor shall be considered. The Contractor shall furnish relevant charts, curves, tables etc. in support of the various factors considered during battery sizing.

DC Batteries shall be suitable for standby duty. The Batteries shall normally be permanently connected to the load in parallel with a charger and shall supply the load during emergency conditions when AC supplies are lost. Batteries shall be suitable for a long life under

	continuous float operations and occasional discharges. The batteries shall be boost charged at about 2.7 volts per cell maximum and float charged at about 2.25 V/cell: The number of cells for the 24 V DC Charger System and UPS System shall be decided during detailed engineering.
4.02.04.02	Connectors and Fasteners Lead or Lead coated copper connectors shall be used for connecting up adjacent cells and rows. Bolts, nuts and washers shall be effectively lead coated to prevent corrosion. All the terminals and cells inter-connectors shall be fully insulated or have insulation shrouds.
4.02.04.03	Contractor to note that DCDB/ACDB for common DC / AC loads shall be located in Unit-1. These DCDB/ACDB shall be powered from the 24 V DC Charger Systems (Diode ORing) & UPS Systems (Static Switch based change-over system) of 2 different Units to ensure their powering in event of unavailability of any one of the units. Scheme for the same shall be finalized during Detailed Engineering.
5.00.00	**AUXILIARY EQUIPMENTS**
5.01.00	All required auxiliary equipment/materials as finalized during detailed engineering shall be furnished with each rectifier bank, UPS & battery bank and shall include as a minimum various meters (AC/DC voltage/current, kVA, power factor, frequency meters etc), circuit breakers, selector switches, push buttons indicating lights, ground detector system, battery accessories like (inter cell connectors, inter step connectors, battery racks etc.) isolated 4-20 mA signals for important parameters and potential free contacts for important alarms shall be provided for use in DDCMIS.
6.00.00	**Battery Racks** The battery racks shall be constructed from high strength good quality mild steel sections. Battery Racks should either be epoxy painted or epoxy powder coated with three (3) coats, with acid resistant grade of pigment as per approved coating process to provide a non-peel able protective coat. The racks shall be of single tier/ two tier construction depending on the final layout based on space availability.
7.00.00	**SITE TESTS** The Contractor shall also carry out the site tests on equipments/systems as decided during detailed engineering.
8.00.00	**TRAINING** Contractor shall provide training on UPS & 24V DC Power Supply system for Employer's personnel. Please also refer Part-C, Section-VI of technical specifications.

CLAUSE NO.	TECHNICAL REQUIREMENTS
1.00.00	**PROCESS CONNECTION AND PIPING** **LOCAL INSTRUMENT ENCLOSURE AND RACKS (LIE & LIR)** All transmitters, solenoid valves and switches shall be suitably grouped together and mounted inside (i) Local Instruments Enclosures (LIE) in case of Open Areas of the Plant like Boiler Area, Coal Handling, Chimney Area, FGD area, ACW Pump House, Ash Handling Plant etc. (ii) **DELETED** (iii) Local Indicators/Gauges shall also be suitably grouped in Local Instrument Racks Integral JB shall be provided with each Enclosure and Rack (except for those having Local Gauges). In case grouping is not possible and these are to be installed individually, a canopy with suitable mounting arrangement shall be provided. All electric actuators, pneumatic control valves, Junction Boxes, Solenoid boxes and Local control panels which are not installed inside building, suitable canopy shall be provided and design of canopy shall be approved by Employer during detailed engineering. Local Instrument Enclosures (LIEs) and Local Instrument Racks (LIRs) complete with all fittings, mountings & accessories, drains and Utility Lighting, Cable & Grounding cable etc. shall be provided by the Contractor on as required basis. The internal layout shall be such that the impulse piping/ blow down lines are accessible from back side of the enclosure / rack and the transmitters etc. are accessible from front as well as rear side for easy maintenance. Bulkheads, especially designed to provide isolation from process line vibration shall be installed on instrument enclosures/racks. Vibration dampeners shall be installed for each enclosure / rack. The Degree of Protection of LIE and JB of LIE/LIR shall be IP-55. The instrument racks shall be constructed from 1.6 mm sheet plate and shall be free standing type constructed of suitable 3 mm thick channel frame of steel and shall be provided with a canopy to protect the equipment mounted in racks from falling objects, water etc. The canopy shall not be less than 3 mm thick steel and extended beyond the ends of the rack.

CLAUSE NO.	TECHNICAL REQUIREMENTS

INSTRUMENTATION CABLE, CONTROL & POWER SUPPLY CABLE, INTERNAL WIRING AND ELECTRICAL FIELD CONSTRUCTION MATERIAL (CABLE SUB-TRAYs ETC

Specification of Instrumentation cable

1.00.00 **Common Requirements**

S. No.	Property	Requirement
1	Operating Voltage	225 V (peak value)
2.	Codes and standard	All instrumentation cables shall comply with VDE 0815, VDE 0207, Part 4, Part 5, Part 6, VDE 0816, VDE 0472, SEN 4241475, ANSI MC 96.1, IS-8784, IS-10810 (latest editions) and their amendments read along with this specification.
3.	Continuous operation suitability	At 205 Deg C for Type-C cables & heat resistant cables (PTFE F & G instrumentation cables) At 70 Deg C for all other type of cables.
4.	Marking :- a.*Progressive automatic on-line sequential marking of length in meters to be provided at every one meter on outer sheath.* *b.*Marking to read 'FRLS' to be provided at every 5 meters on outer sheath except for Type-C cable	
5.	Allowable Tolerance on overall diameter	+/- 2 mm (maximum) over the declared value in data sheet
6.	Variation in diameter	Not more than 1.0 mm throughout the length of cable.
7.	Color	The outer sheath shall be of blue color.
8.	Others	Repaired cables shall not be acceptable.

1.01.00 **Specific Requirements**

Specification Requirements	Type-A cable	Type-B cable	Type F & G cable	Type-C cable	PTFE - F & G instrumentation cable
A. CONDUCTORS					
Cross section area	0.5 sq. mm				
Conductor material	ANSI type KX	ANSI type SX	Annealed bare copper	ANSI type KX	Annealed bare copper
Colour code	Yellow-Red	Black-Red	As per VDE-815	Yellow-Red	As per VDE-815

Specification Requirements	Type-A cable	Type-B cable	Type F & G cable	Type-C cable	PTFE - F & G instrumentation cable
Conductor Grade	As per ANSI MC 96.1		Electrolytic	As per ANSI MC 96.1	Electrolytic
No & dia of strands	7x0.3 mm (nom)				
No. of Pairs	2	2	2/4/8/12/16/24/ 48	2	2/4/8/12/16/24/ 48
Max. conductor loop resistance per Km (in ohm) at 20 deg. C	As per ANSI MC 96.1		73.4	As per ANSI MC 96.1	73.4
Reference Standard	As per ANSI MC 96.1		VDE : 0815	As per ANSI MC 96.1	VDE : 0815
B. INSULATION					
Material	Extruded PVC type YI 3			Teflon	Teflon
Thickness in mm (Min/Max)	0.25/0.35			0.4 / 0.50 (nominal)	0.4 / 0.50 (nominal)
Volume Resistivity (Min) in ohm-cm	1 x 10^{14} at 20 deg. C & 1x10^{11} at 70 deg. C.			2.8x 10^{14} at 20 deg. C & 2x10^{11} at 205 deg. C.	2.8x 10^{14} at 20 deg. C & 2x10^{11} at 205 deg. C.
C. PAIRING & TWISTING					
Max. lay of pairs (mm)	50				
Single layer of binder tape on each pair provided	Each core printed with number or Numbered binder tape to be provided on each pair		Yes	Each core printed with number	Each core printed with number or Numbered binder tape to be provided on each pair
Bunch (Unit Formation) for more than 4P	N.A		To be provided	NA	To be provided
Conductor /pair	N.A.		To be	NA	To be

Specification Requirements	Type-A cable	Type-B cable	Type F & G cable	Type-C cable	PTFE - F & G instrumentation cable
identification as per VDE0815			provided		provided
D. SHIELDING					
Type of shielding	Al-Mylar tape				
Individual pair shielding	No		To be provided for F-type cable	No	To be provided for PTFE F type cable
Minimum thickness of Individual pair shielding	No		0.028mm (28 micron)	No	0.028mm (28 micron)
Overall cable assembly shielding	To be provided				
Minimum thickness of Overall cable assembly shielding	0.055 mm (55 micron)				
Coverage / Overlapping	100% / 20%				
Drain wire provided for individual (F Type)/overall shield	Yes, Size- 0.5 sqmm,No of strands-7,Dia of strands-0.3mm,Annealed Tin coated copper				
E. FILLERS (if applicable)					
Non-hygroscopic, flame retardant	To be provided				
F. OUTER SHEATH					
Material	Extruded PVC compound YM1 with FRLS properties			Teflon (i.e. extruded FRP)	Teflon (i.e. extruded FRP)
Minimum Thickness at any point	1.8 mm			0.4 mm	0.4 mm
Nominal Thickness at any point	>1.8 mm			0.5 mm	0.5 mm
Resistant to water, fungus, termite & rodent attack	Required				

Specification Requirements	Type-A cable	Type-B cable	Type F & G cable	Type-C cable	PTFE - F & G instrumentation cable
Minimum Oxygen index as per ASTMD-2863	29 %			N.A.	N.A.
Minimum Temperature index as per ASTMD-2863	250 deg.C			N.A.	N.A.
Maximum Acid gas generation by weight as per IEC-60754-1	20%			N.A.	N.A.
Maximum Smoke Density Rating as per ASTMD-2843	60% (defined as the average area under the curve when of smoke density test plotted on a curve indicating light absorption vs. time as per ASTMD-2843)			N.A.	N.A.
Reference standard	VDE207 Part 5,VDE-816			VDE207 Part 6 ASTM D2116	VDE207 Part 5,VDE-816
G. Electrical Parameters					
Mutual Capacitance Between Conductors At 0.8 Khz (Max.)	200 nF/km		120 nF/km for F 100 nF/km for G	200 nF/km	120 nF/km for F 100 nF/km for G
Insulation Resistance (Min.)	100 M Ohm/Km				
Cross Talk Figure (Min.) At 0.8 Khz	60 dB		60 dB	60dB	60dB
Characteristic Impedance (Max) At 1 Khz	N.A.		320 OHM FOR F-TYPE 340 OHM FOR G-TYPE	N.A.	320 ohm for F-type 340 ohm for G-type
Attenuation Figure At 1 Khz (Max)	N.A.		1.2 db/km	N.A.	1.2 db/km

Specification Requirements	Type-A cable	Type-B cable	Type F & G cable	Type-C cable	PTFE - F & G instrumentation cable
H. COMPLETE CABLE					
Complete Cable assembly	Shall pass Swedish Chimney test as per SEN-SS 4241475 class F3.			N.A.	N.A.
Flammability	Shall pass flammability as per IEEE-383 read in conjunction to this specification			As per manufacturer's standard subject to employer's approval	As per manufacturer's standard subject to employer's approval
I. CABLE DRUM					
Type	Non-returnable wooden drum or steel drum.				
Length	1000 m $\pm$ 5%				

Note: Heat resistant instrumentation cable shall have specification as per above column **"PTFE - F & G Instrumentation cable"** and cable shall be suitable for continuous operation at 205 Deg. C

2.00.00 **SPECIFICATION OF OPTICAL FIBER CABLES (OFC)**

2.01.00 Optic Fiber cable shall be 4/8/12 core, Electrolytically chrome plated corrugated steel taped (ECCST), fully water blocked with dielectric central member for outdoor/indoor application so as to prevent any physical damage. The cable shall have multiple single-mode or multi mode fibers on as required basis so as to avoid the usage of any repeaters. The outer sheath shall have Flame Retardant, UV resistant properties and are to be identified with the manufacturer's name, year of manufacturer, progressive automatic sequential on-line marking of length in meters at every meter.

2.02.00 The cable core shall have suitable characteristics and strengthening for prevention of damage during pulling viz. Dielectric central member, Loose buffer tube design, 4 fibers per buffer tube (minimum), Interstices and buffer tubes duly filled with Thixotropic jelly etc. The cable shall be suitable for a maximum tensile force of 2000 N during installation, and once installed, a tensile force of 1000 N minimum. The compressive strength of cable shall be 3000 N minimum& crush resistance 4000 N minimum. The operating temperature shall be – 20 deg. C to 70 deg.C

2.03.00 All testing of the fiber optic cable being supplied shall be as per the relevant IEC, EIA and other international standards. Spliced / Repaired cables are not acceptable.

2.04.00 Bidder to ensure that minimum 100% cores are kept as spares in all types of optical fibre cables.

CLAUSE NO.	TECHNICAL REQUIREMENTS
3.00.00	**DELETED**
4.00.00	**INSTRUMENTATION CABLE INSTALLATION AND ROUTING**
4.01.00	Cables shall be segregated as per IEEE Std.-422. In vertically stacked trays, the higher voltage cable shall be in higher position and instrumentation cable shall be in bottom tier of the tray stack. The distance between instrumentation cables and those of other system shall be as follows: From 11 kV/6.6 kV/3.3 kV tray system - 914 mm From 415V tray system - 610 mm From control cable tray system - 305 mm
4.02.00	The cables emanating from redundant equipment/devices shall be routed through different paths. The above segregation of cables & wiring for redundant equipments/devices shall be in accordance with IEEE-Std-422.
4.03.00	Normally 10% spare cores shall be provided when the numbers of pairs of cables are more than four pairs, except for pre-fabricated cables.
4.04.00	Internal panel/cabinet wiring shall be of multi-stranded copper conductor with FRLS PVC insulation without shield and outer sheath meeting the requirements of VDE 0815.
4.05.00	Internal Panels / System cabinets wiring and termination of signal cables shall be as per standard and proven practice of contractor
5.00.00	**CABLE LAYING AND ACCESSORIES** **Laying of Optic Fiber cables (OFCs) :** Outside Building Area – to be laid necessarily inside covered cable tray of 100 mm with support from trestle structure Inside Building area- to be laid on separate cable sub trays While Buried – in separate buried trench approx. 1 meter depth to be laid in 2 “rodent proof HDPE conduits covered with sand, brick, laid breadth -wise and soil along the pipe line. While crossing roads- to be laid in rodent proof HDPE conduits with sand filling at bottom and sand, soil filling at top with cement concrete. While crossing canals/ rivers – to be laid in rodent proof HDPE conduits with hume pipe **Laying of Network Cable (UTP/ STP), Flame Scanner, TSI:** Outside Building Area – to be laid necessarily inside separate covered cable tray of 100 mm with support from trestle structure Inside Building Area- to be laid necessarily inside separate covered cable sub-trays**.**
6.00.00	**FIELD MOUNTED LOCAL JUNCTION BOXES (AS PER STANDARD AND PROVEN**

CLAUSE NO.	TECHNICAL REQUIREMENTS
	Practice of vendor (i) No. of ways: 12/24/36/48/64/72/96/128 with 20% spares terminals. (ii) Material and Thickness: 4mm thick Fiberglass Reinforced Polyester (FRP). (iii) Type of terminal blocks: Rail mounted cage-clamp type suitable for conductor size upto 2.5 mm^2. A M6 earthing stud shall be provided. (iv) Protection Class: IP: 55 min. for indoor & IP-65 min for outdoor applications. (v) Grounding: To be provided. (vi) Color: RAL 7035
7.00.00	**CONDUITS AND CABLE TRAYS TO BE PROVIDED AS PER STANDARD AND PROVEN PRACTISE OF CONTRACTOR.**

CLAUSE NO.	TECHNICAL REQUIREMENTS
	CONTROL VALVES, ACTUATORS & ACCESSORIES
1.00.00	**VALVE ACTUATORS**
	All control valves shall be furnished with pneumatic actuators
2.00.00	**CONTROL VALVE ACCESSORY DEVICES**
2.01.00	All pneumatic actuated control valve accessories such as air locks, hand wheels/hand-jacks, limit switches, microprocessor based electronic Positioner, diffusers, external volume chambers, position transmitters (capacitance or resistance type only), reversible pilot for Positioner, tubing and air sets, solenoid valves and junction boxes etc. shall be provided as per the requirements.

3.00.00 **SPECIFICATIONS FOR MICROPROCESSOR BASED ELECTRONIC POSITIONER**

1	Electrical	a) Input Demand Signal	4-20 mA
		b) Power Supply	Loop Powered from the output card of Control System.
		c) HART Protocol	Compatibility for Remote Calibration & Diagnostics (Super-imposed HART signal on input Signal (4-20 mA)
		d. Valve position sensing	Position sensing, 4-20 mA output signal to be provided for control system.
2	Environment	a) Operating temp.	(-)30 To 80 Deg. C
		b) Humidity	0-95 %
		c) Protection class	IP-65 Minimum
3	Software for Configuration and Diagnostics	Software	Software shall meet the requirements for Configuration, Diagnostics, Calibration and Testing of the actuator.
		Diagnostic/Test features	Advanced diagnostic features like Stroke counter or Travel counter, Leakage in actuators, Valve Signature analysis, Step Response test, Valve friction /Jamming detection etc to be provided.
4	Test reports/Certificates	Factory Valve Signature Tests Reports (Pr Vs Valve travel and Travel Vs I/P signal) are to be provided.	
		Test certificates as per Manufacture Standard/Relevant Standard are to be submitted.	
5	Configuration/Calibration.	Remote & Local Calibration, Auto & Manual Calibration shall be possible.	
6	Operating Range	Full range/ Split range.	
7	Modes	Valve Action	Direct / Reverse Valve Action
		Flow Characterization	Possible to fit Valve Characteristic Curves- Linear , Equal percentage etc.
8	Fail Safe/Fail Freeze	Fail Safe/Fail Freeze feature is to be provided. (In case the fail freeze feature is not intrinsic to the positioner, Bidder shall achieve the same externally through solenoid valve connected in the pneumatic circuit).	
9	Pneumatic	Air capacity	Sufficient to handle the valves & actuators selected/ Boosters to be supplied, if required.
		Air pressure	To suit the air supply pressure/quality available.
		Process connection	¼" NPT
10	Performance	Characteristic deviation	<=0.5 % of span.
		Ambient temp effect	<=0.01 %/ deg C or better.
11	EMC & CE Compliance	Required to International Standard like EN/IEC.	EN50081-2 & EN50082 or equivalent.
12	Accessories	In-built Operator Panel	Display with push buttons for configuration and display on the positioner itself (Password protected/Hardware lock).
		Hand Held Hart Calibrator	Universal Hart Calibrator to be provided (for quantity, refer Part-A: Contract quantities of the specification).
		Press Gauge Block	For supply & output pressures, Air Filter Regulator and other accessories shall be provided on as required basis for making system complete.
		Electrical Cable Entry	1/2"NPT, side or bottom entry to avoid water ingress
		Valves Mounting Assembly	For Sliding Stem/Rotary/Single acting/Double acting actuators on as required basis

ELECTRIC ACTUATORS WITH INTEGRAL STARTERS

1.00.00 CODES AND STANDARDS:

1.01.00 All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions. In case of conflict between this specification and codes, standards, etc, the former shall prevail.

2.00.00 ELECTRIC ACTUATORS WITH INTEGRAL STARTERS

2.01.00 TYPE:

2.01.01 The actuators shall have integral starters along with over load relays with built in SPP (Single Phasing Preventer). Alternatively, Smart non-intrusive actuators are also acceptable. A 415, 3 phase 3 wire power supply shall be given to the actuator from switch board as applicable through a switch fuse unit. Control voltage of the motor starter shall be 110 V AC / 24 V DC, derived suitably from 415V power supply.

2.01.02 In case supplier's standard control voltage for Open/Close contactors is 110V AC, the same is acceptable if suitable Opto Isolation circuit is provided with coupling relays for 24 V DC command inputs.

2.02.00 INTERFACES:

2.02.01 Open/Close command termination logic with position & torque Limit Switches, positioner circuit shall be suitably built in the PCB inside the actuator.

(a) For Binary Drive (both ON-OFF and INCHING type) :- Open/Close command & status thereof and disturbance monitoring signal (common contact for Overload, Thermostat, control supply failure, L/R selector switch at local & other protections operated) shall be provided. Interface with the control system shall be through hardware signal only. Inter posing relays provided (with coil burden 2.5 VA) in the actuator shall be energized to initiate opening and closing, by 24V DC signal from the external control system.

(b) For Modulating Drive: - the command to actuator shall be in form of 4-20mA signal. The necessary positioning circuit and motor protection shall be provided

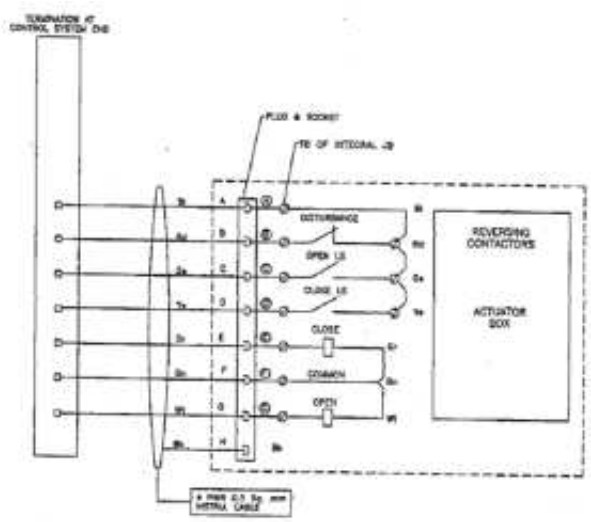
(c) Open/close command termination logic shall be suitably built inside actuator.

2.03.00 RATING:

(a) Supply Voltage & frequency: 415V +/- 10%, 3 Phase, 3 Wire 50HZ +/-5%.

(b) Sizing: -Open/Close at rated speed against designed differential pressure at 90% of rated voltage. For isolating service: - Three successive open-close operations or 15 mins, whichever is higher. For regulating service 150 starts per hour or required cycles, whichever is higher.

CLAUSE NO.	TECHNICAL REQUIREMENTS
2.04.00	**CONSTRUCTION:** (a) Enclosure: Totally enclosed weatherproof minimum IP-55 degree of protection. (b) Gear Train: Metal (Fibre gears are not acceptable)) self-locking to prevent drift under torque switch (where ever applicable) spring pressure when motor is de-energized. (c) Manual Wheel: Shall disengage automatically during motor operation.
2.05.00	**MOTOR** a) Type: Squirrel cage induction motor suitable for Direct on Line (DOL) starting. (b) Enclosure: Totally enclosed, self-ventilated IP-55 degree of protection. (c) Insulation: Class B or better. Temperature rise 70 Deg C. over 50 Deg C ambient (d) Bearings: Double shielded, grease lubricated antifriction. (e) Earth Terminals: Two (f) Protection: Single Phasing Protection, over heating protection through Thermostat (as applicable) and wrong phase sequence protection shall be provided over and above other protection features standard to bidder's design Suitable means shall be provided to diagnose the type of fault locally.
2.06.00	**POSITION/TORQUE SWITCHES:** 2.06.01: Four nos. (2 each in open and close position) position limit switches/contacts and two nos. (one in open and other in close direction) torque switches/contacts each having two nos. NO and two nos. NC contacts shall be provided. Torque switches/contacts shall be bypassed in both the end positions with the other end Limit switches/contacts. **Limit switches/contacts** Limit switches shall be Silver plated with high conductivity and non –corrosive type. Contact rating shall be sufficient to meet the requirement of Control System subject to a minimum of 60 V, 6 VA rating. Protection class shall be IP-55. Limit switch/contacts and disturbance signals shall be available to DCS even when the power supply to the actuators is not available.
2.07.00	**LOCAL OPERATION:** It shall be possible to operate the actuator locally also. Lockable local/remote selection shall be provided on the actuator.
2.08.00	**POSITION INDICATOR:** To be provided for 0 to 100% travel.
2.09.00	**POSITION TRANSMITTER (FOR MODULATING/INCHING TYPE):** As required. Suitable for stabilized 4-20 mA signal, 2 wire inductive type, External 24 volts DC operated.

CLAUSE NO.	TECHNICAL REQUIREMENTS
2.10.00	**WIRING:** Suitable voltage grade copper wire.
2.11.00	**TERMINAL BOX:** (i) 9 pin plug and socket (1 no. per actuator to suit 4 pair 0.5 sq.mm. copper overall shielded (16 mm OD), instrumentation cable) suitably mounted in the starter box itself to terminate open/close command and status feedback signals with external control systems. (ii) Additional one number 9 pin plug and socket (to suit 4 pair 0.5 sq.mm copper (16 mm OD) individual and overall shielded instrumentation cable) suitably mounted in the starter box itself for actuators with 4-20 mA position transmitters. (iii) Necessary glands for power cables shall be provided.
2.12.00	**TERMINAL BLOCK:** 650V grade. For power cables.
2.13.00	**SPACE HEATER:** Space heater of suitable rating. The supply shall be derived from the main power supply available in the actuator.
2.14.00	**TYPICAL WIRING DIAGRAM: as below**  FOR TENDER PURPOSE ONLY

CLAUSE NO.	TECHNICAL REQUIREMENTS
	PROGRAMMABLE LOGIC CONTROLLER FOR AUXILIARY SYSTEMS
1.00.00	**General Requirements** 1. Contractor shall provide complete Control and Instrumentation system with all accessories, auxiliaries and associated equipment's and cables for the safe, efficient and reliable operation of the plant auxiliary systems as indicated under Scope of Supply & Services at Sub-section IIC, Part-A, Section VI. 2. For certain systems where PLC is integrally mounted on the equipment, Contractor's standard and proven practice shall also be taken into consideration. This shall be finalized during detailed engineering. 3. All electrical devices like switches/ transmitters/ controller/ analyzer/ solenoid valves which are located in the hydrogen generation plant shall be made intrinsically safe by providing suitable type of transformer isolated barrier/ Zener barrier of standard make in case it is a standard and proven practice of the bidder. Otherwise such instruments shall be provided with explosion proof enclosure suitable for hazardous areas described in National Electric Code (USA), Article 500, Class-I, Division-I or EN60079-14or shall comply with the essential requirements of ATEX directives. All fittings, cable glands etc. for the above requirement shall be strictly as per NEC recommendation article, 500 to 503
2.00.00	**Standards for Compliance** • Requirement specific to programmable controllers: Functional characteristics, Immunity, Resistance, Safety etc.: IEC / EN 61131-2 and IEC / EN 61010-2-201 • IEC-61131-3 [Programming Language Standard] / IEC-61804 [Standard for EDDL] / IEC-61499 • ISA S 71.01 [Environmental Conditions for Process Measurement and Control Systems: Temperature and Humidity] • ISA S 71.01 [Environmental Conditions for Process Measurement and Control Systems: Temperature and Humidity]
3.00.00	**System Requirements** 1. Control system shall provide safe operation under all plant disturbances and on component failure so that under no condition the safety of plant, personnel or equipment is jeopardized. 2. It shall be possible to remove / replace online, various modules (like Controller, I/O module, interface module, etc.) from its slot for maintenance purpose without switching off power supply to the corresponding rack. 3. All Electronic modules of PLC shall have conformal protective coating as per G3 / GX classification in accordance with ISA S-71.04 standard. The conformal coating version shall be a standard product from the manufacturer's factory. The hardware that is being conformal coated locally shall not be acceptable. 4. The system design shall be modular and scalable to facilitate easy system expansion. Further it shall ensure that no single failure in the system results in loss of system operation.
4.00.00	**Processor** 1. Two (2) numbers, one as primary and another as hot standby. It shall be based on dual core multi-function microprocessor technology as a minimum and shall carry the latest error correction (ECC) technology. 2. Controllers shall be fully redundant operating in Hot-standby mode. Either controller can serve as primary or backup. The primary and standby CPU sections should be connected over a dedicated redundant link (with extremely high transmission speed (in GBPS)) to ensure true redundancy.
5.00.00	**Memory** Integrated flash memory based on Maintenance free battery-less design on its mother board. Internal Memory shall be non-volatile, based on

CLAUSE NO.	TECHNICAL REQUIREMENTS	
		latest semiconductor (NAND flash) storage technology and scalable (min. 8 MB) for programming, process application and data storage. In case of non-scalable memory based design, minimum 32 MB shall be provided. In case of a battery based design, Lithium or Ni-Cd battery for 360 hours backup to be provided. CPU memory shall have minimum 30% spare capacity for future use.
6.00.00	**I/O racks and modules**	Modular design. All input/output cards shall have quick disconnect terminations allowing for card replacement without disconnection of external wiring and without switching of power supply. In general, all Output cards shall be sourcing type and Input cards shall be sinking type.
7.00.00	**Analog Signal Conditioning**	1. Galvanic isolation of input and output signals for which power supply source is derived from source external to the control system power supply. 2. Transmitter power supply with per point current limiting or fuse protection for loop powered transmitters. 3. Monitor sensor wire break/open circuit/short circuit and take suitable actions in logic/loop. (This will include blocking of trip signals in case of RTD failure). 4. All analog outputs shall be short circuit proof.
8.00.00	**Isolation between I/P, O/P and controller**	1.5 KV with opto couplers.
9.00.00	**Diagnostics & Indication**	1. Channel Level Diagnostics (with reverse polarity, wire break, short circuit & optical /galvanic isolation) for DI / DO, AI & AO shall be provided. Each individual Channel healthiness shall be monitored at workstation / GUI level. 2. Individual signal status of each Input / Output, power supply status shall be indicated on the module faceplates.
10.00.00	**Fail safe mode**	1. On power supply failure / both PLCs failure / communication failure etc. the output shall be automatically switched over to fail safe mode. 2. In case of such failures, operating drives / equipment shall be tripped or kept running as per a pre-determined programmable requirement finalized during detailed engineering.
11.00.00	**Fusing philosophy**	Individual fuses with blown fuse indicator for each output. Individual fuses for each input/ group of inputs, keeping in view of system availability.
12.00.00	**Switching Capacity**	Output modules shall be rated to switch on/off coupling relays of 3VA at 24V DC. Coupling relays shall be provided in HT/LT Switchgears.
14.01.00	**Data Communicatio n Sub-System**	The communication sub-system shall be a digital communication bus, based on standard Ethernet technology as its infrastructure backbone that provides a high speed data transfer rapidly and reliably between the operator station, process I/O devices and other devices connected to it. Based on existing IEEE 802.3 Ethernet standards, the network system shall be compatible with commercial off-the-shelf Ethernet products. HMI network between controllers and HMI devices shall be a minimum 100 Mbps redundant Ethernet control network (based on TCP/IP) to ensure high availability. Similarly, the redundant I/O bus / ring network

CLAUSE NO.	TECHNICAL REQUIREMENTS	
		shall be based on Ethernet technology (TCP/IP) with minimum 100 Mbps data transmission speed using suitable protocols to ensure 50 ms or better recovery time.
14.02.00	**Integration with Station LAN**	1. The PLC system shall be OPC compliant and shall be provided with necessary hardware and software for successfully establishing dual redundant fiber optic connectivity with DDCMIS Station wide LAN using bidirectional OPC communication through OPC DA / UA protocol. 2. Suitable OPC server and client software and sufficient no. of licenses shall be procured by the contractor for fully meeting the intent as stated above. 3. Redundant Ethernet switches to be supplied for output to Station wide LAN shall be 24V DC operated, managed switches. 4. The PLC system shall have interface and be able to communicate with several Open Industrial standard communications viz. HART, Profibus / Foundation Fieldbus, Modbus Serial / TCP-IP, ASI, OPC DA / OPC UA.
14.03.00	**Power Supply**	1. Two (2) nos. 415V AC feeders shall be provided for each PLC control panel / desk and remotely located I/O panels. 2. 24 V DC power supply system for PLC shall comprise of 2 x 100% power supply unit (power pack) along with 1 x 100% sealed maintenance free lead acid batteries for 30 minutes back up and DC distribution board, the whole assembly housed in a single panel. Power supply unit shall be capable of charging the batteries and feeding the load simultaneously. The DC distribution board shall have redundant feeders for critical loads. This can be through UPS by 2x100% parallel redundant and same shall be decided by customer during DE. 3. Redundant power supply system for CPU, I/O system, interposing relays shall be provided. Power distribution shall be performed in such a way that any single power supply failure shall not cause loss of operation of any module. Power conditioning and isolation shall be performed to eliminate ground loops. The redundant power supply arrangement for Interposing relays shall be separate from the power supply arrangement for CPU / I/O modules. 4. PLC internal power supply modules shall be capable of accepting input voltage in the range of 18 to 32 V DC and give a stable 24V DC output. 5. Single phase 230V AC power supply for PC / monitor & printer units shall be derived from the incoming feeders provided, preferably from within the 24V DC power supply cabinet to be fed through mini-UPS. Surge protected power sockets shall be considered for powering the PC, monitor and printer units.
14.04.00	**Command Hierarchy**	Protection commands shall have priority over manual commands and manual commands shall prevail over auto commands.
15.00.00	**Time Synchronization system**	The PLC processor should be capable of receiving clock signals from Master Slave Clock system of the Owner in either NTP, DCF77 or IRIG-B format.
16.00.00	**System Reaction time**	Less than 100 msec. from input signal to output signal including logic processing. Display response of maximum 1 sec for control related displays. 2 to 3 secs for other displays.
17.00.00	**Programming functionalities**	1. PLC shall be function block based besides ladder logic complying with IEC 61131-3 standard for programming languages. The programming language shall be based on object model approach, it should be user friendly with graphical user interface and shall not require knowledge of

CLAUSE NO.	TECHNICAL REQUIREMENTS	
		any specialized language. Further along with IEC 61131-3, programming language confirming to IEC 61804 / IEC 61499 shall also be acceptable. All standard libraries of FBs as per IEC 61131-3 shall be provided. 2. Adequate testing procedure shall be available to verify new logic prior to activating it in the on-line program. Further facility to simulate and test logic before on-line loading shall be available in the programming / configuration software.
19.00.00	**HMIS (Human Machine Interface System)**	1. Operator shall be able to access all control / information related data under all operating conditions including a single processor / computer failure in the HMIS. 2. The operator functions for each OWS shall as a minimum include Control System operation (A/M selection, raise/lower, set point/bias change, on/off, open/close operation, mode/device selection, bypassing criteria, sequence auto, start/stop selection, drive auto selection, local-remote/other multi-position selection etc.); alarm acknowledge; call all kind of displays, logs, summaries, calculation results, etc.; printing of logs & reports; retrieval of historical data; and any other functions required for smooth operation, control & management of information as finalized during detailed engineering. 3. The system design shall provide for non-disruptive repairs of faulty equipment and on-line, non-disruptive system expansion in the field. 4. The system shall support notification of a service disruption and recovery including computer name of failed server. 5. Normal / Test/Program / Off facility shall be provided. In test mode all outputs shall be blocked. Manual intervention shall be possible at any stage of operation
20.00.00	**Long time storage and retrieval**	Minimum 1 year's long term historical data shall be available.
21.00.00	**Software**	1. Industry standard operating system like UNIX/WINDOWS (latest version) etc. to ensure openness and connectivity with other system in industry standard protocols (TCP-IP/ OPC etc.) shall be provided. 2. Contractor shall provide all system / application soft wares with locks and passwords for PLC functioning like Real Time Operating System, File management software, screen editor, database management software, input/output scanning, acquisitions, condition processing, control and communication, operator interface of monitors, display trends, curves, bar charts, historical storage/ retrieval and alarm functions for meeting the intent, functional and parametric requirements of the specification. Complete set of documents for modifications / editing / additions/ deletions of features in software. Comprehensive list of all application/ system software.
22.00.00	**Accessories**	Industrial grade furniture shall be provided along with Control desk / OWS / printer which shall be aesthetically designed and finalized during detailed engineering.
23.00.00	**Software license & Upgrades**	1. The Contractor shall provide software license for all software being used in PLC based control system including HMI. The software licenses shall be provided for the project and shall not be hardware/machine specific. All licenses shall be valid for the continuous service life of the plant. 2. As a customer support the Contractor shall periodically inform the designated officer of the Employer about the software upgrades / new

releases that would be taking place after the system is commissioned and in service, so that, if required, same can be procured and installed at site.

24.00.00 **OWS / EWS & printers**

1. Operator workstations (OWS) shall perform control, monitoring and operation of all auxiliaries / drives interacting with PLC based control system. It shall be possible to use the same system as EWS. The quantity of PCs, its associated peripherals and printers shall be finalized during detailed engineering. ~~GIU shall be provided for CSU.~~
2. All cables/links for connecting system described above shall be provided by the Contractor on as required basis within quoted price.

25.00.00 **Remote I/O panels**

Contractor shall provide Remote Input /Output modules housed in free-standing cabinets / racks (with suitable redundant datalink to the central PLC system) as finalized during detailed engineering. These Input / Output modules of the RIOs shall be designed to continuously work under the environment expected to be encountered in assigned areas without any air-conditioning support.

26.00.00 **PLC system security and Cyber security**

The PLC system shall comply with IEC-62443 standards for Industrial Automation and Control System security. The system may preferably be Achilles level 2 / ISA Secure EDSA / Equivalent certified.

27.00.00 **Spare Requirement**

1.	Spare channels in input / output modules fully wired up to cabinets' TBs	10% of as Engineered
2.	Wired-in "usable" space in each of the system cabinets for mounting electronic modules wired up to corresponding spare terminals in system cabinets. (Empty slots between individual modules / group of modules, kept for ease in maintenance or for heat dissipation requirement as per standard practice of Contractor shall not be considered as wired-in "usable" space for I/O modules.)	For 20% of as Engineered modules
3	Wired-in "usable" space for modules Terminal assemblies (if any in the offered system), corresponding to the I/O modules shall be provided	20% for above mentioned 20 % blank space
4	Spare capacity in Processor / Controller to handle additional inputs / outputs of each type over and above implemented capacity.	30% spare functional capacity
5	Communication Controllers & Data communication system each	30% spare functional capacity of as Engineered
6	Spare relays & isolators of each type and rating mounted and wired in cabinets' TBs	20% of as Engineered

28.00.00 **Type Test Requirement - PLC**

PLC type test shall be provided as specified in the Type Test Requirements chapter of technical specifications.

CLAUSE NO.	TECHNICAL REQUIREMENTS
29.00.00	Applicability PLC for CHP systems

S no	System	PLC system
1	LSU/CSU	Applicable
2	Stacker	Applicable

CLAUSE NO.	TECHNICAL REQUIREMENTS
1.00.00	**TYPE TEST REQUIREMENTS**
1.01.00	General Requirements
1.01.01	The Contractor shall furnish the type test reports of all type tests as per relevant standards and codes as well as other specific tests indicated in this specification. If the bidder proposes a different standard/code from that indicated at clause no 2.01.00 and at table 3.00.00, same is acceptable provided the equivalence of the proposed standard is established by the bidder. A list of such tests are given for various equipment in table titled 'TYPE TEST REQUIREMENT FOR OTHER C&I SYSTEMS' at the end of this chapter and under the item “Special Requirement for Solid State Equipments/Systems”. (a) Out of the tests listed, the Bidder/ sub-vendor/ manufacturer is required to conduct certain type tests specifically for this contract (and witnessed by Employer or his authorized representative) even if the same had been conducted earlier, as clearly indicated subsequently against such tests. (b) For the rest, submission of type test results and certificate shall be acceptable provided. i. The same has been carried out by the Bidder/ sub-vendor on exactly the same model /rating of equipment. ii. There has been no change in the components from the offered equipment & tested equipment. iii. The test has been carried out as per the latest standards amendments as on the date of Bid opening and carried out within last ten years from the date of bid opening (c) In case the approved equipment is different from the one on which the type test had been conducted earlier or any of the above grounds, then the tests have to be repeated and the cost of such tests shall be borne by the Bidder/ sub-vendor within the quoted price and no extra cost will be payable by the Employer on this account.
~~1.01.02~~	**DELETED**
1.01.03	For the type tests to be conducted, Contractor shall submit detailed test procedure for approval by Employer. This shall clearly specify test setup, instruments to be used, procedure, acceptance norms (wherever applicable), recording of different parameters, interval of recording precautions to be taken etc. for the tests to be carried out.
1.01.04	**DELETED**
2.00.00	**SPECIAL REQUIREMENT FOR SOLID STATE EQUIPMENTS/ SYSTEMS**
2.01.00	The type test reports which are to be submitted for each of the C&I systems (indicated in clause 2.01.01) shall be as indicated below: i) Surge Withstand Capability (SWC) for Solid State Equipments/ Systems All solid-state systems/ equipment’s shall be able to withstand the electrical noise and surges as encountered in actual service conditions and inherent in a power plant. All the solid-state systems/ equipment’s shall be provided with all required

protections that needs the surge withstand capability as defined in ANSI / IEEE C37.90. 1.. Hence, all front-end cards/ devices which receive external signals like Analog input & output modules, Binary input & output modules etc. including power supply, data highway, data links shall be provided with protections that meets the surge withstand capability as defined in ANSI / IEEE C37.90.1. Complete details of the features incorporated in electronics systems to meet this requirement, the relevant tests carried out, the test certificates etc. shall be submitted along with the proposal. As an alternative to compliance to ANSI / IEEE C37.90.1, the system shall comply to IEC-61000-4-4, IEC-61000-4-5 and IEC-61000-4-18.

ii) Dry Heat test as per IEC-60068-2-2 or equivalent.

iii) Damp Heat test as per IEC-60068-2-30 or IEC-60068-2-78 or equivalent.

iv) Vibration test as per IEC-60068-2-6 or equivalent.

v) Electrostatic discharge tests as per IEC 61000-4-2 or equivalent.

vi) Radio frequency immunity test as per IEC 61000-4-6 or equivalent.

vii) Electromagnetic Field immunity as per IEC 61000-4-3 or equivalent.

2.01.01 **C&I Systems-**

Sl. No	Item	Remark	Test to Be Specifically Conducted	CUSTM's Approval Req. On Test Certificate
1	PLC, excluding its HMI	Not applicable for integral PLCs and PLCs which are governed by standard practice of OEM	No	Yes

3.00.00 **TYPE TEST REQUIREMENT FOR OTHER C&I SYSTEMS**

Sl. No	Item	Test Requirement	Standard	Test To Be Specifically Conducted	CUSTM's Approval Req. On Test Certificate
1	Electronic transmitter	As per standard (col 4)	BS-6447 / IEC-60770	No	Yes
2	Instrumentation Cables Twisted & Shielded*				
	-Conductor	Resistance test	VDE-0815	No	Yes
		Diameter test	IS-10810	No	Yes
		Tin Coating test (Persul-phate test)	IS-8130	No	Yes
	-Insulation	Loss of mass	VDE 0472	No	Yes
		Ageing in air ovens**	VDE 0472	No	Yes
		Tensile strength and elongation test before and after ageing**	VDE 0472	No	Yes
		Heat shock	VDE 0472	No	Yes
		Hot deformation	VDE 0472	No	Yes
		Shrinkage	VDE 0472	No	Yes
		Bleeding & blooming	IS-10810	No	Yes
	-Inner sheath***	Loss of mass	VDE 0472	No	Yes
		Heat shock	VDE 0472	No	Yes
		Cold bend/ cold impact test	VDE 0472	No	Yes
		Hot deformation	VDE 0472	No	Yes
		Shrinkage	VDE 0472	No	Yes
	-Outer sheath	Loss of mass	VDE 0472	No	Yes
		Ageing in air ovens**	VDE 0472	No	Yes

		Tensile strength and elongation test before and after ageing**	VDE 0472	No	Yes
		Heat shock	VDE 0472	No	Yes
		Hot deformation	VDE 0472	No	Yes
		Shrinkage	VDE 0472	No	Yes
		Bleeding & blooming	IS-10810	No	Yes
		Colour fastness to water	IS-5831	No	Yes
		Cold bend/ cold impact test	VDE-0472	No	Yes
		Oxygen index test	ASTMD-2863	No	Yes
		Smoke Density Test	ASTMD-2843	No	Yes
		Acid gas generation test	IEC-60754-1	No	Yes
	-fillers	Oxygen index test	ASTMD-2863	No	Yes
		Acid gas generation test	IEC-60754-1	No	Yes
	-AL-MYLAR shield	Continuity test		No	Yes
		Shield thickness		No	Yes
		Overlap test		No	Yes
	-Over all cable	Flammability Test	IEEE 383	No	Yes
		Swedish Chimney Test	SEN 4241475	No	Yes
		Noise interference	IEEE Trans-actions	No	Yes
		Dimensional checks	IS 10810	No	Yes
		Cross talk	VDE-0472	No	Yes
		Mutual capacitance	VDE-0472	No	Yes
		HV test	VDE-0815	No	Yes
		Drain wire continuity		No	Yes

* 1.0 All cables to be supplied shall be of type tested quality. The Contractor shall submit for Owner's approval the reports of all the type tests as listed in this specification and carried out within last Ten years from the date of bid opening. These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.

2.0 In case the Contractor is not able to submit report of the type test(s) conducted within last Ten years from the date of bid opening, or in case the type test report(s) are not found to be meeting the specification requirements, the Contractor shall conduct all such tests either in an independent laboratory or at manufacturer's works in presence of Owner's representative under this contract free of cost to the Owner and submit the reports for approval.

**These tests shall be carried out as per VDE0207 Part 6 & ASTMD-2116 for TEFLON insulated & outer sheathed cables

***Applicable for armoured cables only

3 DC Power Supply System (Applicable for each model and rating)

1)The Type Test reports for offered rectifier module and the controller module irrespective of the rectifier bank shall be acceptable

	Surge Withstand Capability(SWC)	(ANSI / IEEE C37.90.1)or (IEC-61000-4-4, IEC-61000-4-5 and IEC-61000-4-18).	No	Yes
	Dry Heat Test	IEC-60068-2-2 or equivalent	No	Yes
	Damp Heat test	IEC-60068-2-30 or IEC-60068-2-78 o equivalent	No	Yes
	Vibration test	IEC-60068-2-6 or equivalent	No	Yes
	Electrostatic discharge test	IEC 61000-4-2 or equivalent	No	Yes
	Radio frequency immunity test	IEC-61000-4-6 or equivalent	No	Yes
	Electromagnetic field immunity	IEC 61000-4-3 or equivalent	No	Yes

		Degree of Protection	IS-13947 or equivalent	No	Yes
4	Battery ##	As per standard (col 4)	IS-10918 (Ni-Cd Batteries) IS-1652 (Lead Acid Plante Batteries)	No No	Yes

5 UPS (Applicable for each model and rating)

1) Type Test reports of same series of UPS with similar PCB's cards and controllers as the target UPS system shall be acceptable.

2) For Dry heat, Damp heat and vibration, the tests conducted on individual PCB's shall be acceptable.

		Surge Withstand Capability(SWC)	(ANSI / IEEE C37.90.1)or (IEC-61000-4-4, IEC-61000-4-5 and IEC-61000-4-18).	No	Yes
		Dry Heat Test	IEC-60068-2-2 or equivalent	No	Yes
		Damp Heat test	IEC-60068-2-30 or IEC-60068-2-78 or equivalent	No	Yes
		Vibration test	IEC-60068-2-6 or equivalent	No	Yes
		Electrostatic discharge test	IEC 61000-4-2 or equivalent	No	Yes
		Radio frequency immunity test	IEC-61000-4-6 or equivalent	No	Yes
		Electromagnetic field immunity	IEC 61000-4-3 or equivalent	No	Yes
		Degree of protection test	IS-13947	No	Yes
		Fuse Clearing Capability	Approved	No	Yes

			procedure		
		Short Circuit current capability	IEC 60146-2	No	Yes
6	Public Address System				
	IP based PA system components	As per Standard	IEC 60268-16	No	Yes
7	Control Valves	CV test	ISA 75.02& 75.11	No	Yes
8	Flow Nozzle Orifice plates	Calibration	ASME PTC BS 1042	No	Yes

The contractor shall submit for Employers approval the reports of all the type test as per latest IS-10918 carried out within last ten years from the date of Bid opening and the test(s) should have been either conducted at an independent laboratory or in presence of owner's representative. The complete type test reports shall be for any rating of Battery in a particular group based on plate dimensions being manufactured by supplier.

CLAUSE NO.	TECHNICAL REQUIREMENTS

1.01.00 **Furniture**

1.01.01 Bidder shall provide following industrial grade furniture items as a minimum from reputed manufacturers/suppliers meeting International Standards. The furniture shall be modular and latest with ease of operational features. The furniture shall be modern, aesthetically designed, modular, flexible, space saving and future safe. Each module shall have transparent cover and adjustable partition. It shall have locking provision for security. The components shall be suitable for integration/fabrication without any welding technology.

1.	**Work Station furniture**	
	Modular work station furniture, suitable for mounting servers & historians, programmer stations, PC based systems, printers (inkjet or A4 laser) etc. is to be provided.	
2.	**Server Rack**	
	Server rack shall be provided to mount programmer stations, PC based systems (of rack type and tower type), Matrix KVM switcher, Mini UPS etc. in Programmer room. Suitable arrangement for Ventilation and cooling shall be built in.	
3.	**PC rack**	
	PC rack shall be provided to mount CPUs of work stations/PCs of OWS/LVS etc in Control Room.	
4.	**Chairs**	
	Industry standard Ergonomic revolving chairs with wheels, with provision for breathable mesh design backrest with adjustable lumbar support, adjustable armrests, adjustable headrest, adjustment of height (hydraulically/gas lift) shall be provided for the operators, unit-in-charge & other personnel in control room area. These shall be designed for sitting for long duration such that these are comfortable for the back. Chair shall have Steel-strengthened cushion seat and twin wheel castor of glass filled nylon. The exact details shall be finalized & approved by Employer during detailed engineering.	
5.	Tables	
	a	Industry standard computer tables shall be provided & shall be as approved by Employer during detailed Engineering.
	b	Conference Room standard tables shall be provided with acrylic coat for good finish. Details shall be finalized & approved by Employer during detailed engg.
6.	Almirahs	
	Steel Almirahs shall be provided for keeping documents in the documentation room.	
7.	Keypad	
	Keypads shall be provided for the storing of keys of relevant areas in the respective control rooms	
8.	Lockers	
	Suitable lockers shall be provided in the room adjacent to the control room for storing of personal articles of control room personnel & also for documents.	

CLAUSE NO.	TECHNICAL REQUIREMENTS
1.00.00	**WIRELESS FIELD INSTRUMENTS & SYSTEM**
1.01.00	This section provides the basic specification for the design, engineering, manufacture, inspection, testing, supply, installation, commissioning and implementation of Wireless network along with wireless field transmitters and devices in 2.4 to 2.4835Ghz (ISM Band). The requirements given herein are minimum to be considered by Contractor, if wireless instruments are required for the process.
1.02.00	Codes and Standards: All wireless transmitters, wireless devices and its accessories in the network shall comply with Wi- HART as per IEC62591 or ISA100.11a as per IEC62734.
1.03.00	The total wireless network design, engineering, installation, field testing and commissioning and in coordination with Control system contractor shall be in Contractor's scope. Any statutory requirements and coordination with statutory authorities required for wireless frequencies / system shall be in Contractors scope. All licenses, software and networking items required for establishing this connectivity will be in the scope of the contractor.
1.04.00	Wireless Network Instrumentation shall be considered for monitoring purpose only. The contractor will carry out site survey for more clarity of geographical area, topology, structure. All the instruments supplied and the Wireless gateway components shall be suitable as per area classification. Any special tool required for configuration/calibration to be supplied by contractor. The exact applications for wireless devices shall be indicated in PART-A of Specification.
1.05.00	Contractor to submit end user certificate for six months successful operation of offered wireless field instruments in any industrial application on the date of bid opening. For this purpose experience of family/series of wireless field instruments will be considered in place of exact model.
2.00.00	**DESIGN REQUIREMENTS:**
2.01.00	WIRELESS NETWORK SHALL BE A SECURE AND ROBUST NETWORKING TECHNOLOGY OPERATING IN THE 2.4GHZ INDUSTRIAL, SCIENTIFIC, AND MEDICAL (ISM) RADIO BAND. THE TOPOLOGY TO BE FOLLOWED FOR CONFIGURING THE WIRELESS PATH SHOULD BE SUCH THAT COMMUNICATION SHOULD SUSTAIN EVEN AFTER FAILURE OF ONE.
2.02.00	device/transmitters/router/repeater. That is, no single failure in the offered system shall lead to loss of communication from any wireless field transmitter to DDCMIS, except that process information of failed transmitter would not be available. For achieving same redundant Gateway/Manager with redundant access point/remote antenna with best available switch over time as per protocol followed (ISA or WiHART) shall be provided. Wireless instrument shall be connected to network in such manner that failure of any individual device/instrument/router/repeater should not affect functionality and communication of any other instrument/device. Network Security shall follow standard IEEE 802.15.4. The contractor shall take all necessary actions to ensure security of wireless network installed at site. The update rate/scan time for the field transmitter shall be 5 seconds or better.
2.03.00	Gateways/Manger will be cabinet mounted inside RIO/System cabinet. Remote antenna / access points (as applicable) with surge protection facility shall be suitable for mounting

	outside the RIO/Control room building. Contractor shall consider and supply interconnection cable on as required basis for this purpose.
2.04.00	Gateway/Manager shall be provided with complete hardware/software enabling full functionality such as configuration of the network, enabling/scheduling communication between host application and wireless field devices, peer to peer communication, device communication routing, network diagnostics to monitor and report the health of the Wireless Network .Wireless Gateway/Manager shall be provided by the Contractor with Modbus over Ethernet/RS-485 serial link for establishing connection with Control system.2.09.00Wireless Gateway/Manager shall be provided connectivity with Network PC to be supplied by Contractor, where gateway/manager's software will be installed/accessed for purposes such as configuration/monitoring/diagnostics. When more then 10 nos. of wireless instruments are being supplied, Wireless Field Calibrator with necessary Hardware/Software including laptop/adapter shall be provided for the configuration/ diagnostics of wireless instrument in field. If more than one set of gateways is required for catering to the number of wireless instruments, then gateways should be multi-dropped for further interfacing with DDCMIS as finalized during detailed engineering. Diagnostic data shall be available on Network PC which shall include status, configuration, calibration, path reliability and stability, battery health and signal strength etc. for each device and network.
2.05.00	The Wireless devices network shall be designed in such a way that continuous communication with gateway is established. It shall be Contractor's responsibility to supply adequate amount of repeaters/routers in field based on Contractor's recommendations for wireless network design ensuring network reliability and continuous communication. Such devices (repeaters/routers) shall be provided on as required basis and no additional cost will be payable for these.
2.06.00	Contractor to note that wireless networks of Wireless HART and ISA 100.11a may coexist in the same area. Therefore, network design shall be such that there is no interference or compromise in performance of the network of one type because of the presence of the other. The interchangeability and interoperability of wireless instruments of different vendors within respective protocol (Wi HART or ISA100.11.a) shall be ensured.
2..07.00	Contractor shall consider additional 2 Nos. of router/repeaters over and above the wireless network design requirements for addition of wireless instruments at new location during detail engineering / future expansion. Each wireless network shall be designed considering 20% future expandability. Contractor to carry out field visit after 06 month of successful commissioning of the complete wireless system to evaluate the performance and take corrective actions, if require, at site.2.17.00
3.00.00	**WIRELESS FIELD INSTRUMENTS INCLUDING ROUTER/ REPEATERS**
3.01.00	For Pressure Transmitters/Differential Pressure Transmitter/Level Transmitter (DPT type)/Flow Transmitter (DPT type)/Temperature transmitter, in place of requirement of 2-wire HART protocol output, following shall be considered: Protocol shall be Wi-HART or ISA100.11a, Battery Powered Native wireless device without Integral display with Battery conservation feature. For multi input temperature transmitter display is no transmitter display is not applicable. Update rate/Scan rate of 5 seconds or better. Integrally mounted antenna /Internal within Sensor Housing antenna/ Extended antenna. Antenna type shall be finalized during detailed engineering as per actual requirement as per frequency 2.4Ghz ISM Band adapter. Security as per IEEE 802.15.4. Replaceable Battery. Field configurable. Self Diagnostics at local display.

CLAUSE NO.	TECHNICAL REQUIREMENTS
	All other requirements and features shall be as per respective instruments chapter, of Technical specification. In future wireless requirement may be extended for other field instruments depending on availability and other technical consideration.
4.00.00	**BATTERY**
4.01.00	Field Wireless devices shall be power sourced by low power battery. The shelf life of the battery shall be minimum 5 years. In addition to one battery supplied with each wireless instrument/ device, 2 nos. of additional batteries for each wireless instrument/ device shall also be provided. For multi- input transmitters (with 4 or more nos. of inputs), 4 nos. of additional batteries for each device shall be provided. The supply of battery to site shall be in two phases so that shelf-life of batteries is maintained. Battery status/remaining life /drain indication / alarm shall be available in system as part of diagnostics / maintenance data.
5.00.00	**UTILITIES**
5.01.00	Gateway shall be fed from 24VDC power supply available in RIO/Cabinets.
5.02.00	If any additional 24VDC/230VAC power supply is required, it shall be provided through feeder from available 24VDC/230VAC system.
6.00.00	**ENGINEERING, INSTALLATION, TESTING AND COMMISIONING**
6.01.00	Contractor shall provide services of his technical team well versed, trained and experienced wireless technology design, engineering, implementation and documentation for large industrial applications. Necessary site survey shall be done to finalize all network devices.
6.02.00	Contractor's responsibility at site shall include all activities necessary to be performed to complete the job including:
6.02.01	Receipt of all items and related hardware and checking of completeness of supply. In case of installation of gateway/manger in cabinet of control system in RIO/CER cabinets, verification of all components and accessories duly installed & wired.
6.02.02	Installation of all repeaters / routers, antennas, configuration and loop checking of all wireless transmitters etc, Termination of all cables to control room, ferruling/tagging of interconnecting cables in RIO/ Control room. All civil works like grouting, fixing etc. and patch up work where Contractor is likely to remove the plaster and shall make holes in the walls, floor or ceiling for the installation of Contractor supplied items like antennas, repeater / routers etc, .
6.02.03	Checking of interconnections, hardware configuration, overall system functioning. Liaison with Contractor's remote support, as required. Liaison with Contractor's remote support, as required. Laison with contractor remote support as required, field testing, Integration of wireless system with DDCMIS, FAT, Commissioning of complete wireless system, SAT.
7.00.00	**FACTORY ACCEPTANCE TEST (FAT)**
	In addition to visual test and BOM check, the following functional tests shall be carried out by the Contractor at their works during FAT. Performance test including reliability, stability and path redundancy of the Wireless system considering routers / repeaters and minimum nos. of wireless transmitters as finalized during detailed engineering. (The transmitters shall be arranged by the Contractor at their works for demonstrating this performance test). Update rate verification in the system considering above transmitters. Redundancy, synchronization and seamless switchover of the Gateways/Managers and access points for redundant application. Capabilities of network manager/gateway software.

8.00.00 **SITE ACCEPTANCE TEST (SAT)**

The Employer will take over the system from the Contractor after the final acceptance test, which is defined as successful uninterrupted operation of the integrated system for four weeks with desired performance. Contractor's personnel shall be present during the test. Any malfunctioning of the system components shall be replaced/repaired by Contractor as required. Once the system failure (loss of two or more devices leading to loss of communication in whole system) is detected, the acceptance test shall start all over again from the beginning.

9.00.00 **DOCUMENTATION**

Datasheets for all devices like sensors, transmitters, repeaters/routers, gateway/access point, cables. Features of software to be installed in Network PC; redundancy feature
User guide and User manuals. Certification for Explosion proof/ intrinsically safe (where required) Certification for use of wireless system/signals.

10.00.00 **ANNUAL MAINTENANCE SERVICES**

10.01.00 The requirements specified below are applicable for warranty (defect liability period.

10.01.01 In the event of any malfunction of the system hardware/system software, experienced service engineer shall be made available at site within 48 hours on the receipt of such information from Employer.
Employer personnel will work on system day-to-day basis and wherever possible, Employer shall inform the type of failure of hardware/ software to Contractor based on diagnostic available with the system. However, Contractor shall be fully responsible to attend and rectify the root cause and the failure within 48 hrs. Contractor may utilize the spares available with Employer, if necessary and available with Employer at site, which are part of mandatory spares supplied with system as per this specification. However, the consumed spares shall be replenished to Employer within 2 months' time.

PART D
VENDOR LIST

ELECTRICAL

D – 00	GENERAL INSTRUCTIONS
D – 01	VENDOR LIST-ELECTRICAL
D – 02	VENDOR LIST-C&I

CHAPTER D – 00
GENERAL GUIDELINES

1.1 The make and inspection categorisation of all equipment/instruments covered under this specification shall be subject to approval by BHEL/End Customer after award of contract. The successful bidder shall submit, during detailed engineering, a comprehensive list of proposed makes, sub-vendors, and sub-contractors along with the corresponding inspection categorisation for approval.

BHEL/End Customer reserves the right to accept, reject, or require modification of any proposed make, sub-vendor, or inspection categorisation. BHEL/End Customer may also suggest inclusion of additional makes/sub-vendors, subject to technical suitability and project requirements.

Any change in makes, sub-vendors, or inspection categorisation proposed by the contractor shall be carried out without any cost or time implication to BHEL/End Customer.

1.2 The list of indicative vendors enclosed for reference. For any items which are not listed in the indicative vendor list, bidder may propose list of vendors. BHEL/End Customer reserves the right to accept, reject, or require modification of any proposed make, sub-vendor, or inspection categorisation.

1.3 In case the successful bidder proposes additional sub-vendors after award of contract, such proposals shall be submitted in advance without effecting the project schedule. BHEL/End Customer reserves the right to accept, reject, or require modification of any additional proposed make, sub-vendor, or inspection categorisation.

1.4 The contractor shall remain fully responsible for the performance, quality, and timely delivery of all equipment and services covered under the contract, including those supplied by approved sub-vendors and sub-contractors. Any deficiency, delay, or non-performance attributable to sub-vendors shall not relieve the contractor of its contractual obligations.

1.5 During detailed engineering and prior to placement of orders, the contractor shall ensure that all approval conditions stipulated by BHEL/End Customer for makes, sub-vendors, and inspection categorisation are fully complied with. The contractor shall submit all necessary documents, drawings, quality plans, and credentials required for obtaining approvals in a timely manner.

No purchase order shall be placed on any sub-vendor without obtaining prior approval from BHEL/End Customer, unless explicitly waived in writing.

Any delay arising out of failure by the contractor to comply with approval requirements or submission timelines shall be to the contractor’s account

CHAPTER D – 01
VENDOR LIST-ELECTRICAL

MASTER VENDORS LIST

FOR

PROJECTS

ELECTRICAL ITEMS

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810101 : CIRCUIT BREAKERS,66KV & ABOVE.

CODE	NAME
INDIA	
1 . P0066	ASEA BROWN BOVERI LTD.
2 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
3 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
4 . P0869	VOLTAS LTD. (PUMPS & PROJECTS BUSINESS DIV)

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810102 : HIGH VOLTAGE CIRCUIT BREAKERS.

CODE	NAME
INDIA	
1 . P0036	ALSTOM LIMITED (AREVA T & D)
2 . P0066	ASEA BROWN BOVERI LTD.
3 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
4 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
5 . P8173	CG POWER AND INDUSTRIAL SOLUTIONS LIMITED
6 . P8104	JYOTI LIMITED
7 . P0736	SIEMENS LTD.
8 . P0802	THE MYSORE ELECTRICAL INDUSTRIES LTD.

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810103 : MV ACB.

CODE	NAME
INDIA	
1 . P0173	C&S ELECTRIC LTD. (Upto 6300A)
2 . P0573	GE POWER CONTROLS INDIA PVT. LTD.
3 . P0485	LARSEN & TOUBRO LTD.(EL.PRODUCTS DIVN)
4 . P0736	SIEMENS LTD.
5 . P8051	SPACEAGE SWITCHGEARS LIMITED

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810104 : MOULDED CASE CIRCUIT BREAKERS (MCCB)

CODE	NAME
INDIA	
1 . P0173	C&S ELECTRIC LTD. (Upto 400A)
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P0573	GE POWER CONTROLS INDIA PVT. LTD.
4 . P0337	HAVELLS INDIA LTD.
5 . P8060	HPL ELECTRIC & POWER PVT. LTD. (10A to 800A)
6 . P0485	LARSEN & TOUBRO LTD.(EL.PRODUCTS DIVN)
7 . P0736	SIEMENS LTD.
8 . P8051	SPACEAGE SWITCHGEARS LIMITED
9 . P8070	STANDARD ELECTRICALS LIMITED (MCCB)

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810105 : MINIATURE CIRCUIT BREAKERS(MCB)

CODE	NAME
INDIA	
1 . P8068	ADHUNIK SWITCHGEARS (P) LTD.
2 . P0173	C&S ELECTRIC LTD.
3 . P0337	HAVELLS INDIA LTD.
4 . P8060	HPL ELECTRIC & POWER PVT. LTD.
5 . P0384	INDIANA CURRENT CONTROL LTD.
6 . P0413	INDO ASIAN FUSEGEAR LTD
7 . P0523	LEGRAND INDIA LTD
8 . P0693	S & S POWER SWITCHGEAR LTD
9 . P8070	STANDARD ELECTRICALS LIMITED

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810106 : MV ELCB

CODE	NAME
INDIA	
1 . P0173	C&S ELECTRIC LTD.
2 . P0573	GE POWER CONTROLS INDIA PVT. LTD.
3 . P0337	HAVELLS INDIA LTD.
4 . P0413	INDO ASIAN FUSEGEAR LTD
5 . P0523	LEGRAND INDIA LTD
6 . P0693	S & S POWER SWITCHGEAR LTD
7 . P0736	SIEMENS LTD.
8 . P8070	STANDARD ELECTRICALS LIMITED

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810201 : EHV SWITCHES/ISOLATORS

CODE	NAME
INDIA	
1 . P0780	ELPRO INTERNATIONAL LIMITED
2 . P0693	S & S POWER SWITCHGEAR LTD
3 . P0824	TRANSLECT

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810202 : HV SWITCHES/ISOLATORS

CODE	NAME
INDIA	
1 . P0066	ASEA BROWN BOVERI LTD.
2 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
3 . P8190	ELEKTROLITES (POWER) PRIVATE LIMITED
4 . P0780	ELPRO INTERNATIONAL LIMITED
5 . P0736	SIEMENS LTD.
6 . P0824	TRANSLECT

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810203 : LOW VOLTAGE INDUSTRIAL SWITCHES/ISOLATORS

CODE	NAME
INDIA	
1 . P0066	ASEA BROWN BOVERI LTD.
2 . P0173	C&S ELECTRIC LTD.
3 . P0573	GE POWER CONTROLS INDIA PVT. LTD.
4 . P0337	HAVELLS INDIA LTD.
5 . P8060	HPL ELECTRIC & POWER PVT. LTD.
6 . P0440	KAYCEE INDUSTRIES LTD
7 . P0485	LARSEN & TOUBRO LTD.(EL.PRODUCTS DIVN)
8 . P0736	SIEMENS LTD.

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810301 : POWER TRANSFORMER, 66 KV & ABOVE (OIL FILLED)

CODE	NAME
INDIA	
1 . P0036	ALSTOM LIMITED (AREVA T & D)
2 . P0066	ASEA BROWN BOVERI LTD.
3 . P8162	ATLANTA ELECTRICALS PVT. LTD
4 . P0104	BHARAT BIJLEE LTD
5 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
6 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
7 . P0236	EMCO LIMITED (upto 100 MVA)
8 . P0392	IMP POWER LTD.
9 . P0453	KIRLOSKAR ELECTRIC COMPANY LTD.
10 . P0868	VOLTAMP TRANSFORMERS LTD. (upto 132KV , 50MVA)

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810302 : POWER TRANSFORMER,33KV & BELOW

CODE	NAME
INDIA	
1 . P0036	ALSTOM LIMITED (AREVA T & D)
2 . P8162	ATLANTA ELECTRICALS PVT. LTD
3 . P0104	BHARAT BIJLEE LTD
4 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
5 . P0236	EMCO LIMITED
6 . P8124	ESENNAR TRANSFORMERS (P) LTD.
7 . P0378	INDCOIL TRANSFORMERS PVT. LTD.
8 . P0432	KANOHAR ELECTRICALS LTD. (upto 10 MVA)
9 . P0453	KIRLOSKAR ELECTRIC COMPANY LTD.
10 . P8157	RAYCHEM RPG PRIVATE LIMITED
11 . P8136	VARDHMAN ELECTRO-MECH PVT. LTD. (Upto 8 MVA)
12 . P0868	VOLTAMP TRANSFORMERS LTD. (upto 132KV,50MVA)
13 . P0869	VOLTAS LTD. (PUMPS & PROJECTS BUSINESS DIV)

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810303 : AUXILIARY SUPPLY TRANSFORMER

CODE	NAME
INDIA	
1 . P8124	ESENNAR TRANSFORMERS (P) LTD.
2 . P8111	GUJARAT PLUG-IN DEVICES PVT. LTD. (Upto 300 KVA)
3 . P0392	IMP POWER LTD.
4 . P0378	INDCOIL TRANSFORMERS PVT. LTD.
5 . P8052	KALPA ELECTRICAL PRIVATE LIMITED (DRY TYPE UPTO 100 KVA)
6 . P0079	MEHRU ELECTRICALS (FORMERLY AUTOMATIC ELECTRIC LIMITED)
7 . P8157	RAYCHEM RPG PRIVATE LIMITED
8 . P0723	SHEPHARD TRANSFORMERS LTD
9 . P8136	VARDHMAN ELECTRO-MECH PVT. LTD.

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810304 : AUTO TRANSFORMER

CODE	NAME
INDIA	
1 . P0036	ALSTOM LIMITED (AREVA T & D)
2 . P0104	BHARAT BIJLEE LTD
3 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
4 . P0236	EMCO LIMITED
5 . P0329	HACKBRIDGE - HEWITTIC & EASUN LTD
6 . P0378	INDCOIL TRANSFORMERS PVT. LTD.
7 . P0453	KIRLOSKAR ELECTRIC COMPANY LTD.
8 . P0823	TRANSFORMERS & ELECTRICALS KERALA LTD

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810305 : REACTOR

CODE	NAME
INDIA	
1 . P0036	ALSTOM LIMITED (AREVA T & D)
2 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
3 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
4 . P0329	HACKBRIDGE - HEWITTIC & EASUN LTD

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810306 : EARTHING TRANSFORMER

CODE	NAME
INDIA	
1 . P0036	ALSTOM LIMITED (AREVA T & D)
2 . P0104	BHARAT BIJLEE LTD
3 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
4 . P0236	EMCO LIMITED
5 . P0329	HACKBRIDGE - HEWITTIC & EASUN LTD
6 . P0453	KIRLOSKAR ELECTRIC COMPANY LTD.
7 . P0823	TRANSFORMERS & ELECTRICALS KERALA LTD

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810307 : CURRENT TRANSFORMERS, 66KV & ABOVE

CODE	NAME
INDIA	
1 . P0066	ASEA BROWN BOVERI LTD.
2 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
3 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
4 . P0079	MEHRU ELECTRICALS (FORMERLY AUTOMATIC ELECTRIC LIMITED)
5 . P0560	NAGPUR TRANSFORMERS LTD
6 . P0823	TRANSFORMERS & ELECTRICALS KERALA LTD

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810308 : POTENTIAL TRANSFORMER, 66KV & ABOVE

CODE	NAME
INDIA	
1 . P0066	ASEA BROWN BOVERI LTD.
2 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
3 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
4 . P0079	MEHRU ELECTRICALS (FORMERLY AUTOMATIC ELECTRIC LIMITED)
5 . P0560	NAGPUR TRANSFORMERS LTD
6 . P0823	TRANSFORMERS & ELECTRICALS KERALA LTD

All rights reserved

810309 : HV CURRENT TRANSFORMERS

CODE	NAME
INDIA	
1 . P8128	ANANT POWERTECH ((11 KV to 33 KV))
2 . P0066	ASEA BROWN BOVERI LTD.
3 . P8052	KALPA ELECTRICAL PRIVATE LIMITED
4 . P0079	MEHRU ELECTRICALS (FORMERLY AUTOMATIC ELECTRIC LIMITED)
5 . P8053	PERFECT SALES CORPORATION

All rights reserved

810310 : HV POTENTIAL TRANSFORMER

CODE	NAME
INDIA	
1 . P8128	ANANT POWERTECH ((11 KV to 33 KV))
2 . P0066	ASEA BROWN BOVERI LTD.
3 . P8052	KALPA ELECTRICAL PRIVATE LIMITED
4 . P0079	MEHRU ELECTRICALS (FORMERLY AUTOMATIC ELECTRIC LIMITED)
5 . P8053	PERFECT SALES CORPORATION

All rights reserved

810311 : MV CURRENT TRANSFORMERS

CODE	NAME
INDIA	
1 . P0036	ALSTOM LIMITED (AREVA T & D)
2 . P8128	ANANT POWERTECH
3 . P0378	INDCOIL TRANSFORMERS PVT. LTD.
4 . P0434	KAPPA ELECTRICALS
5 . P0079	MEHRU ELECTRICALS (FORMERLY AUTOMATIC ELECTRIC LIMITED)
6 . P8155	NEWTEK ELECTRICALS
7 . P8053	PERFECT SALES CORPORATION
8 . P0736	SIEMENS LTD.

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810312 : MV POTENTIAL TRANSFORMERS

CODE	NAME
INDIA	
1 . P0036	ALSTOM LIMITED (AREVA T & D)
2 . P0378	INDCOIL TRANSFORMERS PVT. LTD.
3 . P8052	KALPA ELECTRICAL PRIVATE LIMITED
4 . P0434	KAPPA ELECTRICALS
5 . P0485	LARSEN & TOUBRO LTD.(EL.PRODUCTS DIVN)
6 . P0079	MEHRU ELECTRICALS (FORMERLY AUTOMATIC ELECTRIC LIMITED)
7 . P8155	NEWTEK ELECTRICALS
8 . P8053	PERFECT SALES CORPORATION
9 . P0736	SIEMENS LTD.

All rights reserved

810401 : HIGH VOLTAGE SWITCH BOARD

CODE	NAME
INDIA	
1 . P0036	ALSTOM LIMITED (AREVA T & D)
2 . P8191	APPLICATION CONTROL PANELS PVT. LTD.
3 . P0066	ASEA BROWN BOVERI LTD.
4 . P8197	ASTEK ELECTRICAL INDIA PRIVATE LIMITED
5 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
6 . P0116	BIECCO LAWRIE LIMITED
7 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
8 . P8104	JYOTI LIMITED
9 . P8101	LARSEN &TOUBRO LIMITED
10 . P8041	LOTUS POWERGEAR PVT LTD
11 . P0736	SIEMENS LTD.
12 . P8176	STELMEC LIMITED
13 . P8183	TENCO SYSTEMS & SWITCH GEARS PVT. LTD.

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810402 : MEDIUM VOLTAGE SWITCH BOARD(PCC/MCC)

CODE	NAME
INDIA	
1 . P0036	ALSTOM LIMITED (AREVA T & D)
2 . P8191	APPLICATION CONTROL PANELS PVT. LTD.
3 . P8197	ASTEK ELECTRICAL INDIA PRIVATE LIMITED
4 . P0113	BHARTIA INDUSTRIES LTD. (DIVN. BCH)
5 . P0173	C&S ELECTRIC LTD.
6 . P8069	COSMIC POWER SYSTEMS PVT. LTD.
7 . P0231	ELECMECH CORPORATION
8 . P0573	GE POWER CONTROLS INDIA PVT. LTD.
9 . P0405	INTRELEC
10 . P8008	JAKSON ENGINEERS LTD
11 . P0485	LARSEN & TOUBRO LTD.(EL.PRODUCTS DIVN)
12 . P8041	LOTUS POWERGEAR PVT LTD
13 . P8210	RASHMI ELECTRICALS
14 . P0736	SIEMENS LTD.
15 . P8051	SPACEAGE SWITCHGEARS LIMITED
16 . P8183	TENCO SYSTEMS & SWITCH GEARS PVT. LTD.
17 . P8106	VENUS CONTROLS & SWITCHGEAR (P) LTD.

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810403 : DRAW-OUT MCC

CODE	NAME
INDIA	
1 . P8129	ADVANCE PANELS & SWITCHGEARS (P) LTD.
2 . P8191	APPLICATION CONTROL PANELS PVT. LTD.
3 . P8197	ASTEK ELECTRICAL INDIA PRIVATE LIMITED
4 . P0173	C&S ELECTRIC LTD.
5 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
6 . P0172	CONTROLS & SCHEMATICS PVT LTD.
7 . P8069	COSMIC POWER SYSTEMS PVT. LTD.
8 . P0231	ELECMECH CORPORATION
9 . P0573	GE POWER CONTROLS INDIA PVT. LTD.
10 . P0405	INTRELEC
11 . P8054	JASPER SWITCHGEARS LIMITED
12 . P0485	LARSEN & TOUBRO LTD.(EL.PRODUCTS DIVN)
13 . P8041	LOTUS POWERGEAR PVT LTD
14 . P8126	POWERTECH SWITCHGEARS (INDIA) PVT. LTD.
15 . P8210	RASHMI ELECTRICALS
16 . P0736	SIEMENS LTD.
17 . P8051	SPACEAGE SWITCHGEARS LIMITED

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810403 : DRAW-OUT MCC

CODE	NAME
18 . P8183	TENCO SYSTEMS & SWITCH GEARS PVT. LTD.
19 . P8106	VENUS CONTROLS & SWITCHGEAR (P) LTD.
20 . P8046	VIDHYUT CONTROL(INDIA) PVT LTD

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810404 : NON-DRAWOUT M.C.C.

CODE	NAME
INDIA	
1 . P0045	ANAND POWER LIMITED (upto 1800 Amp.)
2 . P0071	ASSOCIATED SWITCHGEARS & PROJECTS LTD.
3 . P8105	AVONE SYSTEM & CONTROLS
4 . P0173	C&S ELECTRIC LTD.
5 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
6 . P0172	CONTROLS & SCHEMATICS PVT LTD.
7 . P8069	COSMIC POWER SYSTEMS PVT. LTD.
8 . P0231	ELECMECH CORPORATION
9 . P0226	ELECTRIC SUPPLY & SERVICES (P) LTD
10 . P0352	HINDUSTAN CONTROL & EQPT PV. LTD.
11 . P0405	INTRELEC
12 . P8054	JASPER SWITCHGEARS LIMITED
13 . P8041	LOTUS POWERGEAR PVT LTD
14 . P0670	REUNION ELECTRICAL MANUFACTURERS (P) LTD
15 . P8107	SHIVALIC POWER CONTROL (P) LTD.
16 . P8051	SPACEAGE SWITCHGEARS LIMITED
17 . P0828	TRICOLITE ELECTRICAL INDUSTRIES PVT.LTD.

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810404 : NON-DRAWOUT M.C.C.

CODE	NAME
18 . P8106	VENUS CONTROLS & SWITCHGEAR (P) LTD.
19 . P8046	VIDHYUT CONTROL(INDIA) PVT LTD

All rights reserved

810405 : ELECTROMAGNATIC TYPE CONTROL PANEL/DESKS

CODE	NAME
INDIA	
1 . P8129	ADVANCE PANELS & SWITCHGEARS (P) LTD.
2 . P0078	AUTOMATIC CONTROLS CORPORATION
3 . P0231	ELECMECH CORPORATION
4 . P0226	ELECTRIC SUPPLY & SERVICES (P) LTD
5 . P0352	HINDUSTAN CONTROL & EQPT PV. LTD.
6 . P0405	INTRELEC
7 . P8008	JAKSON ENGINEERS LTD
8 . P8041	LOTUS POWERGEAR PVT LTD
9 . P8126	POWERTECH SWITCHGEARS (INDIA) PVT. LTD.

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810406 : PROGRAMMABLE LOGIC CONTROLLER.

CODE	NAME
INDIA	
1 . P0066	ASEA BROWN BOVERI LTD.
2 . P8076	HONEYWELL AUTOMATION INDIA LIMITED
3 . P0399	INSTRUMENTATION LTD
4 . P8008	JAKSON ENGINEERS LTD
5 . P0444	KERALA STATE ELECTRONICS DEV. CORPN. LTD.
6 . P0485	LARSEN & TOUBRO LTD.(EL.PRODUCTS DIVN)
7 . P0033	ROCKWELL AUTOMATION INDIA PVT. LTD.
8 . P0736	SIEMENS LTD.
GERMANY	
9 . P0348	HIMA PAUL HILDEBRANDT GMBH + CO KG
SINGAPORE	
10 . P0362	HONEYWELL HIPACK ASIA PACIFIC

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810407 : STATIC TYPE CONTROL PANEL/DESKS.

CODE	NAME
INDIA	
1 . P8129	ADVANCE PANELS & SWITCHGEARS (P) LTD.
2 . P0036	ALSTOM LIMITED (AREVA T & D)
3 . P0066	ASEA BROWN BOVERI LTD.
4 . P0172	CONTROLS & SCHEMATICS PVT LTD.
5 . P0231	ELECMECH CORPORATION
6 . P0391	INDUSTRIAL INSTRUMENTS & CONTROLS
7 . P8054	JASPER SWITCHGEARS LIMITED
8 . P0485	LARSEN & TOUBRO LTD.(EL.PRODUCTS DIVN)
9 . P8041	LOTUS POWERGEAR PVT LTD
10 . P8126	POWERTECH SWITCHGEARS (INDIA) PVT. LTD.
11 . P0736	SIEMENS LTD.
12 . P0737	SILKAANS ELECTRICAL MFG. CO. PVT.LTD.

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810408 : FLOOR MOUNTING TYPE DISTRIBUTION BOARDS.

CODE	NAME
INDIA	
1 . P0045	ANAND POWER LIMITED
2 . P8191	APPLICATION CONTROL PANELS PVT. LTD.
3 . P0071	ASSOCIATED SWITCHGEARS & PROJECTS LTD.
4 . P8197	ASTEK ELECTRICAL INDIA PRIVATE LIMITED
5 . P0078	AUTOMATIC CONTROLS CORPORATION
6 . P8105	AVONE SYSTEM & CONTROLS
7 . P0173	C&S ELECTRIC LTD.
8 . P0172	CONTROLS & SCHEMATICS PVT LTD.
9 . P8069	COSMIC POWER SYSTEMS PVT. LTD.
10 . P8203	DURGA TECHNO INDUSTRIES
11 . P0231	ELECMECH CORPORATION
12 . P0226	ELECTRIC SUPPLY & SERVICES (P) LTD
13 . P8200	EX-PROTECTA
14 . P0573	GE POWER CONTROLS INDIA PVT. LTD.
15 . P0312	GLOBE ELECTRICAL INDUSTRIES
16 . P8114	HI-TECH ENGINEERS
17 . P0352	HINDUSTAN CONTROL & EQPT PV. LTD.

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810408 : FLOOR MOUNTING TYPE DISTRIBUTION BOARDS.

CODE	NAME
18 . P0405	INTRELEC
19 . P8008	JAKSON ENGINEERS LTD
20 . P8054	JASPER SWITCHGEARS LIMITED
21 . P0485	LARSEN & TOUBRO LTD.(EL.PRODUCTS DIVN)
22 . P8041	LOTUS POWERGEAR PVT LTD
23 . P8210	RASHMI ELECTRICALS
24 . P0670	REUNION ELECTRICAL MANUFACTURERS (P) LTD
25 . P8107	SHIVALIC POWER CONTROL (P) LTD.
26 . P0736	SIEMENS LTD.
27 . P8051	SPACEAGE SWITCHGEARS LIMITED
28 . P0828	TRICOLITE ELECTRICAL INDUSTRIES PVT.LTD.
29 . P0831	TRIDENT SWITCHGEARS PVT. LTD. (upto 3200 A)
30 . P0841	UNITED ELECTRIC CO. (DELHI) PVT. LTD.
31 . P0845	UNIVERSAL INDUSTRIAL PRODUCTS
32 . P8106	VENUS CONTROLS & SWITCHGEAR (P) LTD.
33 . P8046	VIDHYUT CONTROL(INDIA) PVT LTD

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810409 : WALL MOUNTING TYPE DISTRIBUTION BOARDS.

CODE	NAME
INDIA	
1 . P8068	ADHUNIK SWITCHGEARS (P) LTD.
2 . P0045	ANAND POWER LIMITED
3 . P8191	APPLICATION CONTROL PANELS PVT. LTD.
4 . P0071	ASSOCIATED SWITCHGEARS & PROJECTS LTD.
5 . P8197	ASTEK ELECTRICAL INDIA PRIVATE LIMITED
6 . P0078	AUTOMATIC CONTROLS CORPORATION
7 . P8105	AVONE SYSTEM & CONTROLS
8 . P0173	C&S ELECTRIC LTD.
9 . P0172	CONTROLS & SCHEMATICS PVT LTD.
10 . P8203	DURGA TECHNO INDUSTRIES
11 . P0231	ELECMECH CORPORATION
12 . P8200	EX-PROTECTA
13 . P0312	GLOBE ELECTRICAL INDUSTRIES
14 . P0337	HAVELLS INDIA LTD.
15 . P8114	HI-TECH ENGINEERS
16 . P0352	HINDUSTAN CONTROL & EQPT PV. LTD.
17 . P0384	INDIANA CURRENT CONTROL LTD.

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810409 : WALL MOUNTING TYPE DISTRIBUTION BOARDS.

CODE	NAME
18 . P0413	INDO ASIAN FUSEGEAR LTD
19 . P0405	INTRELEC
20 . P8008	JAKSON ENGINEERS LTD
21 . P0523	LEGRAND INDIA LTD
22 . P8041	LOTUS POWERGEAR PVT LTD
23 . P8210	RASHMI ELECTRICALS
24 . P0670	REUNION ELECTRICAL MANUFACTURERS (P) LTD
25 . P8107	SHIVALIC POWER CONTROL (P) LTD.
26 . P8070	STANDARD ELECTRICALS LIMITED
27 . P0828	TRICOLITE ELECTRICAL INDUSTRIES PVT.LTD.
28 . P0831	TRIDENT SWITCHGEARS PVT. LTD.
29 . P8106	VENUS CONTROLS & SWITCHGEAR (P) LTD.

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810410 : VARIABLE SPEED MOTOR PACKAGE

CODE	NAME
INDIA	
1 . P8082	AMTECH ELECTRONICS (INDIA) LTD. (LT)
2 . P0066	ASEA BROWN BOVERI LTD.
3 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
4 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
5 . P8098	DANFOSS INDUSTRIES PVT. LTD. (Upto 1400 KW)
6 . P8152	DELTA ELECTRONICS INDIA PVT.LTD. (VARIABLE FREQUENCY DRIVE SYSTEM UP TO 75 KW)
7 . P8178	HITACHI HI-REL POWER ELECTRONICS PRIVATE LIMITED
8 . P0453	KIRLOSKAR ELECTRIC COMPANY LTD.
9 . P0485	LARSEN & TOUBRO LTD.(EL.PRODUCTS DIVN)
10 . P0033	ROCKWELL AUTOMATION INDIA PVT. LTD.
11 . P0736	SIEMENS LTD.
12 . P8142	TMEIC INDUSTRIAL SYSTEMS INDIA PRIVATE LIMITED
13 . P8120	VACON DRIVES & CONTROL PVT. LTD. (Variable Frequency Drive System)
14 . P8164	YASKAWA INDIA PRIVATE LIMITED (UPTO 355 KW)
FRANCE	
15 . P0034	ALSTHOM ATLANTIQUE
GERMANY	
16 . P0735	SIEMENS AG, GERMANY

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810410 : VARIABLE SPEED MOTOR PACKAGE

CODE	NAME
ITALY	
17 . P0052	ANSALDO ROBICON
JAPAN	
18 . P0287	FUJI ELECTRIC SYSTEMS CO. LTD.
19 . P8127	TOSHIBA MITSUBISHI ELECTRIC INDUSTRIAL SYSTEMS CORPORATION
SWITZERLAND	
20 . P0130	BROWN BOVERI CORPORATION
U.K.	
21 . P0300	GEC INDUSTRIAL CONTROL LTD.

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810411 : SOFT STARTER

CODE	NAME
INDIA	
1 . P8082	AMTECH ELECTRONICS (INDIA) LTD.
2 . P8098	DANFOSS INDUSTRIES PVT. LTD. (Upto 800 KW)
3 . P8178	HITACHI HI-REL POWER ELECTRONICS PRIVATE LIMITED
4 . P8071	INNOVATIVE TECHNOMATICS PVT. LTD.
5 . P8122	JAYASHREE ELECTRON PVT. LTD.
6 . P8066	KIMO ELECTRONICS PVT. LTD.
7 . P0485	LARSEN & TOUBRO LTD.(EL.PRODUCTS DIVN)
8 . P0033	ROCKWELL AUTOMATION INDIA PVT. LTD.
9 . P0736	SIEMENS LTD.
10 . P8142	TMEIC INDUSTRIAL SYSTEMS INDIA PRIVATE LIMITED

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810501 : HT POWER CABLE

CODE	NAME
INDIA	
1 . P8151	CMI LIMITED
2 . P8121	ADVANCE CABLE TECHNOLOGIES PRIVATE LIMITED
3 . P8087	APAR INDUSTRIES LTD. (UNIT: UNIFLEX CABLES)
4 . P0142	CABLE CORPN. OF INDIA LIMITED
5 . P8103	DIAMOND POWER INFRASTRUCTURE LTD.
6 . P8184	DYNAMIC CABLES LIMITED
7 . P8159	GEMSCAB INDUSTRIES LTD (Upto 33 KV (Single core upto 500 sq.mm & Three core upto 300 sq.mm.))
8 . P8195	GLOSTER CABLES LIMITED
9 . P8171	GRANDLAY ELECTRICALS INDIA
10 . P8117	GUPTA POWER INFRASTRUCTURE LTD. ((Up to 33 KV & size up to 3CX400 sq.mm and 1CX1000 sq.mm))
11 . P0337	HAVELLS INDIA LTD.
12 . P0388	INDUSTRIAL CABLES (I) LIMITED (3.3 KV PVC/XLPE & 11 KV XLPV Insulated)
13 . P8209	KEC INTERNATIONAL LIMITED
14 . P0687	KEC INTERNATIONAL LTD. (FORMERLY RPG CABLES LIMITED-
15 . P0442	KEI INDUSTRIES LIMITED (Upto 33 KV)
16 . P0574	NICCO CORPORATION LTD
17 . P8116	PARAMOUNT COMMUNICATIONS LTD. ((Up to 33 KV & size up to 3CX400 sq.mm and 1CX630 sq.mm))

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810501 : HT POWER CABLE

CODE	NAME
18 . P8199	PARAMOUNT COMMUNICATIONS LTD.
19 . P8055	PLAZA CABLE INDUSTRIES LIMITED
20 . P8001	POLYCAB INDIA LIMITED (FORMERLY POLYCAB WIRES PRIVATE LTD.)
21 . P8043	RAVIN CABLES LIMITED
22 . P8130	STERLITE TECHNOLOGIES LTD., (6.6 kV to 33 kV)
23 . P0818	TORRENT CABLES LTD.
24 . P0843	UNIVERSAL CABLES LTD.
25 . P8177	V-MARC INDIA LIMITED

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810502 : LT POWER CABLES

CODE	NAME
INDIA	
1 . P8151	CMI LIMITED
2 . P8056	ALPHA COMMUNICATION LIMITED
3 . P8087	APAR INDUSTRIES LTD. (UNIT: UNIFLEX CABLES)
4 . P8182	AXELON INDUSTRIES
5 . P0142	CABLE CORPN. OF INDIA LIMITED
6 . P8166	CHANDRESH CABLES LIMITED
7 . P8149	CORDS CABLE INDUSTRIES LTD.
8 . P0200	DELTON CABLES LTD
9 . P8103	DIAMOND POWER INFRASTRUCTURE LTD.
10 . P8184	DYNAMIC CABLES LIMITED
11 . P0260	FINOLEX CABLES LTD
12 . P8204	GEEP POLYMERS INDIA PRIVATE LIMITED
13 . P8159	GEMSCAB INDUSTRIES LTD
14 . P8112	GENUS ELECTROTECH LTD.
15 . P8195	GLOSTER CABLES LIMITED
16 . P0319	GRANDLAY ELECTRICALS (INDIA) (1.1 KV PVC/XLPE Insulated)
17 . P8171	GRANDLAY ELECTRICALS INDIA

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810502 : LT POWER CABLES

CODE	NAME
18 . P8113	GRID INDIA POWER CABLES PVT. LTD.
19 . P0327	GUPTA ELECTRIC & MACHINERY STORES (GEMSCAB) (3-1/2 core 400 mm2)
20 . P8117	GUPTA POWER INFRASTRUCTURE LTD.
21 . P0337	HAVELLS INDIA LTD.
22 . P8180	HPL ELECTRIC & POWER LIMITED
23 . P0388	INDUSTRIAL CABLES (I) LIMITED (1.1 KV PVC/XLPE Insulated)
24 . P0416	J K CABLES LIMITED
25 . P8209	KEC INTERNATIONAL LIMITED
26 . P0687	KEC INTERNATIONAL LTD. (FORMERLY RPG CABLES LIMITED-
27 . P0442	KEI INDUSTRIES LIMITED
28 . P8175	KLJ PARAFLEX INDIA LIMITED
29 . P0466	KRISHNA ELECTRICAL INDUSTRIES LTD.
30 . P8193	LUMINO INDUSTRIES LIMITED
31 . P8093	MANSFIELD CABLE CO.
32 . P8187	NEC WIRE & CABLES PRIVATE LIMITED
33 . P0569	NETCO CABLE INDUSTRIES (PVT.) LTD. (Upto 3-½ core 400 mm2)
34 . P0574	NICCO CORPORATION LTD

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810502 : LT POWER CABLES

CODE	NAME
35 . P0604	OMEGA CABLES LTD.
36 . P8057	PARAGON CABLES
37 . P8199	PARAMOUNT COMMUNICATIONS LTD.
38 . P8055	PLAZA CABLE INDUSTRIES LIMITED
39 . P8001	POLYCAB INDIA LIMITED (FORMERLY POLYCAB WIRES PRIVATE LTD.)
40 . P8207	POLYVION CABLES PVT. LTD
41 . P8090	PRESTIGE CABLE INDUSTRIES
42 . P0647	PREW INDUSTRIES LTD.
43 . P8147	R R KABEL LIMITED
44 . P0658	RADIANT CABLES PVT. LIMITED
45 . P8167	RAVI INDUSTRIES
46 . P8043	RAVIN CABLES LIMITED
47 . P0702	SATELLITE CABLES PVT. LTD. (3-1/2 core 400 mm2)
48 . P8078	SHYAM CABLES INDUSTRIES
49 . P0739	SKYTONE ELECTRICALS (I) LTD. (3-1/2 core 400 mm2)
50 . P0744	SPECIAL CABLES PVT. LTD.
51 . P0777	SUYOG ELECTRICALS LTD.

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810502 : LT POWER CABLES

CODE	NAME
52 . P8086	T C COMMUNICATION PVT LTD
53 . P8109	TCL CABLES LTD.
54 . P8094	TERACOM LIMITED
55 . P0818	TORRENT CABLES LTD.
56 . P8165	TORTEK INDIA PRIVATE LIMITED
57 . P0843	UNIVERSAL CABLES LTD.
58 . P8177	V-MARC INDIA LIMITED
59 . P8206	ZENIUM CABLES LIMITED

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810503 : CONTROL CABLE

CODE	NAME
INDIA	
1 . P8151	CMI LIMITED
2 . P8056	ALPHA COMMUNICATION LIMITED
3 . P8087	APAR INDUSTRIES LTD. (UNIT: UNIFLEX CABLES)
4 . P8182	AXELON INDUSTRIES
5 . P8058	BHANSALI CABLES & CONDUCTORS PVT. LTD
6 . P0142	CABLE CORPN. OF INDIA LIMITED
7 . P8166	CHANDRESH CABLES LIMITED
8 . P8149	CORDS CABLE INDUSTRIES LTD.
9 . P0200	DELTON CABLES LTD
10 . P8103	DIAMOND POWER INFRASTRUCTURE LTD.
11 . P8184	DYNAMIC CABLES LIMITED
12 . P0260	FINOLEX CABLES LTD
13 . P8204	GEEP POLYMERS INDIA PRIVATE LIMITED
14 . P8159	GEMSCAB INDUSTRIES LTD
15 . P8112	GENUS ELECTROTECH LTD.
16 . P8195	GLOSTER CABLES LIMITED
17 . P0319	GRANDLAY ELECTRICALS (INDIA) (PVC/XLPE Insulated)

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810503 : CONTROL CABLE

CODE	NAME
18 . P8171	GRANDLAY ELECTRICALS INDIA
19 . P8113	GRID INDIA POWER CABLES PVT. LTD.
20 . P0327	GUPTA ELECTRIC & MACHINERY STORES (GEMSCAB) (19 core 2.5 mm2)
21 . P8117	GUPTA POWER INFRASTRUCTURE LTD.
22 . P0337	HAVELLS INDIA LTD.
23 . P8180	HPL ELECTRIC & POWER LIMITED
24 . P0416	J K CABLES LIMITED
25 . P8209	KEC INTERNATIONAL LIMITED
26 . P0687	KEC INTERNATIONAL LTD. (FORMERLY RPG CABLES LIMITED-
27 . P0442	KEI INDUSTRIES LIMITED
28 . P8175	KLJ PARAFLEX INDIA LIMITED
29 . P0466	KRISHNA ELECTRICAL INDUSTRIES LTD.
30 . P8193	LUMINO INDUSTRIES LIMITED
31 . P8093	MANSFIELD CABLE CO.
32 . P8059	N.C. CABLES LIMITED (FORMERLY NATIONAL CABLES)
33 . P8187	NEC WIRE & CABLES PRIVATE LIMITED
34 . P0569	NETCO CABLE INDUSTRIES (PVT.) LTD. (Upto 19 core 2.5 mm2)

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810503 : CONTROL CABLE

CODE	NAME
35 . P0574	NICCO CORPORATION LTD
36 . P0604	OMEGA CABLES LTD.
37 . P8057	PARAGON CABLES
38 . P8199	PARAMOUNT COMMUNICATIONS LTD.
39 . P8055	PLAZA CABLE INDUSTRIES LIMITED
40 . P8001	POLYCAB INDIA LIMITED (FORMERLY POLYCAB WIRES PRIVATE LTD.)
41 . P8207	POLYVION CABLES PVT. LTD
42 . P8090	PRESTIGE CABLE INDUSTRIES
43 . P0647	PREW INDUSTRIES LTD.
44 . P8147	R R KABEL LIMITED
45 . P0658	RADIANT CABLES PVT. LIMITED
46 . P8167	RAVI INDUSTRIES
47 . P8043	RAVIN CABLES LIMITED
48 . P0702	SATELLITE CABLES PVT. LTD. (19 core 2.5 mm2)
49 . P8078	SHYAM CABLES INDUSTRIES
50 . P0739	SKYTONE ELECTRICALS (I) LTD. (19 core 2.5 mm2, 1.1 KV)
51 . P0744	SPECIAL CABLES PVT. LTD.

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810503 : CONTROL CABLE

CODE	NAME
52 . P0777	SUYOG ELECTRICALS LTD.
53 . P8168	SVARN INFRATEL PRIVATE LIMITED
54 . P8086	T C COMMUNICATION PVT LTD
55 . P8109	TCL CABLES LTD.
56 . P8094	TERACOM LIMITED
57 . P0818	TORRENT CABLES LTD.
58 . P8165	TORTEK INDIA PRIVATE LIMITED
59 . P0843	UNIVERSAL CABLES LTD.
60 . P8177	V-MARC INDIA LIMITED
61 . P8206	ZENIUM CABLES LIMITED

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810504 : FLEXIBLE CABLE.

CODE	NAME
INDIA	
1 . P8002	ANCHOR ELECTRICALS PVT. LTD.
2 . P8182	AXELON INDUSTRIES
3 . P8058	BHANSALI CABLES & CONDUCTORS PVT. LTD
4 . P8166	CHANDRESH CABLES LIMITED
5 . P0200	DELTON CABLES LTD
6 . P0260	FINOLEX CABLES LTD
7 . P8204	GEEP POLYMERS INDIA PRIVATE LIMITED
8 . P8195	GLOSTER CABLES LIMITED
9 . P8171	GRANDLAY ELECTRICALS INDIA
10 . P8117	GUPTA POWER INFRASTRUCTURE LTD.
11 . P0337	HAVELLS INDIA LTD.
12 . P8180	HPL ELECTRIC & POWER LIMITED
13 . P8075	KALINGA CABLES & CONDUIT CO.
14 . P8175	KLJ PARAFLEX INDIA LIMITED
15 . P8059	N.C. CABLES LIMITED (FORMERLY NATIONAL CABLES)
16 . P8187	NEC WIRE & CABLES PRIVATE LIMITED
17 . P0574	NICCO CORPORATION LTD

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810504 : FLEXIBLE CABLE.

CODE	NAME
18 . P8199	PARAMOUNT COMMUNICATIONS LTD.
19 . P8055	PLAZA CABLE INDUSTRIES LIMITED
20 . P8001	POLYCAB INDIA LIMITED (FORMERLY POLYCAB WIRES PRIVATE LTD.)
21 . P8207	POLYVION CABLES PVT. LTD
22 . P8090	PRESTIGE CABLE INDUSTRIES
23 . P0647	PREW INDUSTRIES LTD.
24 . P8147	R R KABEL LIMITED
25 . P8167	RAVI INDUSTRIES
26 . P8078	SHYAM CABLES INDUSTRIES
27 . P0739	SKYTONE ELECTRICALS (I) LTD. (3-1/2 core, 185 mm2)
28 . P0744	SPECIAL CABLES PVT. LTD.
29 . P0777	SUYOG ELECTRICALS LTD.
30 . P8168	SVARN INFRATEL PRIVATE LIMITED
31 . P8086	T C COMMUNICATION PVT LTD
32 . P8094	TERACOM LIMITED
33 . P0818	TORRENT CABLES LTD.
34 . P8165	TORTEK INDIA PRIVATE LIMITED

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810504 : FLEXIBLE CABLE.

CODE	NAME
35 . P8177	V-MARC INDIA LIMITED
36 . P8206	ZENIUM CABLES LIMITED

All rights reserved

810505 : TELEPHONE CABLE

CODE	NAME
INDIA	
1 . P8056	ALPHA COMMUNICATION LIMITED
2 . P8058	BHANSALI CABLES & CONDUCTORS PVT. LTD
3 . P0163	CMI LIMITED
4 . P8149	CORDS CABLE INDUSTRIES LTD.
5 . P0200	DELTON CABLES LTD
6 . P0260	FINOLEX CABLES LTD
7 . P0351	HINDUSTAN CABLES LTD
8 . P0574	NICCO CORPORATION LTD
9 . P8057	PARAGON CABLES
10 . P8055	PLAZA CABLE INDUSTRIES LIMITED
11 . P8001	POLYCAB INDIA LIMITED (FORMERLY POLYCAB WIRES PRIVATE LTD.)
12 . P8090	PRESTIGE CABLE INDUSTRIES
13 . P0647	PREW INDUSTRIES LTD.
14 . P0665	RELIANCE ENGINEERS LTD.
15 . P0688	RPG TELECOM LTD
16 . P8078	SHYAM CABLES INDUSTRIES
17 . P0744	SPECIAL CABLES PVT. LTD.

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810505 : TELEPHONE CABLE

CODE	NAME
18 . P8168	SVARN INFRATEL PRIVATE LIMITED
19 . P0850	USHA BELTRON LIMITED,
20 . P0863	VINDHYA TELELINK LTD

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810506 : CABLES FOR EARTHING

CODE	NAME
INDIA	
1 . P8121	ADVANCE CABLE TECHNOLOGIES PRIVATE LIMITED
2 . P0200	DELTON CABLES LTD
3 . P0260	FINOLEX CABLES LTD
4 . P0327	GUPTA ELECTRIC & MACHINERY STORES (GEMSCAB)
5 . P0416	J K CABLES LIMITED
6 . P0569	NETCO CABLE INDUSTRIES (PVT.) LTD.
7 . P0574	NICCO CORPORATION LTD
8 . P8001	POLYCAB INDIA LIMITED (FORMERLY POLYCAB WIRES PRIVATE LTD.)
9 . P8090	PRESTIGE CABLE INDUSTRIES
10 . P8078	SHYAM CABLES INDUSTRIES
11 . P0744	SPECIAL CABLES PVT. LTD.
12 . P0777	SUYOG ELECTRICALS LTD.
13 . P8168	SVARN INFRATEL PRIVATE LIMITED
14 . P8086	T C COMMUNICATION PVT LTD
15 . P0843	UNIVERSAL CABLES LTD.

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810507 : SPECIAL CABLES

CODE	NAME
INDIA	
1 . P8121	ADVANCE CABLE TECHNOLOGIES PRIVATE LIMITED
2 . P8056	ALPHA COMMUNICATION LIMITED
3 . P8058	BHANSALI CABLES & CONDUCTORS PVT. LTD
4 . P8057	PARAGON CABLES
5 . P8055	PLAZA CABLE INDUSTRIES LIMITED
6 . P8090	PRESTIGE CABLE INDUSTRIES
7 . P8078	SHYAM CABLES INDUSTRIES

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810601 : HIGH VOLTAGE INDUCTION MOTORS

CODE	NAME
INDIA	
1 . P8158	ABB INDIA LIMITED
2 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
3 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
4 . P8140	JEUMONT ELECTRIC INDIA PVT. LTD. (Excluding Flame Proof (Exd) type Motors but Pressurised (Exp) Type Motors - upto 1300 KW; Increased Safety (Exe) Type Motors - Upto 770 KW; Non-Sparking (Exn) Typep Motors - Upto 860 KW and Safe Area Motors - Upto
5 . P8104	JYOTI LIMITED
6 . P0453	KIRLOSKAR ELECTRIC COMPANY LTD.
7 . P8163	MARATHON ELECTRIC MOTORS (INDIA) LTD. (UP TO 2800KW)
8 . P8142	TMEIC INDUSTRIAL SYSTEMS INDIA PRIVATE LIMITED
9 . P8137	WEG INDUSTRIES (INDIA) PVT. LTD (Up to Frame Size 1600 and rating up to 16 MW)
FRANCE	
10 . P0034	ALSTHOM ATLANTIQUE
11 . P0426	JEUMONT INDUSTRIE
GERMANY	
12 . P0016	AEG TELEFUNKEN AG
ITALY	
13 . P0052	ANSALDO ROBICON
JAPAN	
14 . P0287	FUJI ELECTRIC SYSTEMS CO. LTD.
15 . P0539	MITSUBISHI CORPORATION

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810601 : HIGH VOLTAGE INDUCTION MOTORS

CODE	NAME
16 . P0726	SHINKO ELECTRICALS CO. LTD.
17 . P0819	TOSHIBA CORPORATION
18 . P8127	TOSHIBA MITSUBISHI ELECTRIC INDUSTRIAL SYSTEMS CORPORATION ((Excludin g Flame-proof motors of frame size more than 900))
SWEDEN	
19 . P0064	ASEA BROWN BOVERI
U.K.	
20 . P0486	LAURENCE, SCOTT & ELECTROMOTORS LTD.
21 . P0621	PEEBLES ELECTRICAL MACHINES
U.S.A.	
22 . P0303	GENERAL ELECTRIC CO.
23 . P0877	WESTINGHOUSE ELECTRIC CORPORATION

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810602 : MEDIUM VOLTAGE INDUCTION MOTORS

CODE	NAME
INDIA	
1 . P0036	ALSTOM LIMITED (AREVA T & D)
2 . P0066	ASEA BROWN BOVERI LTD.
3 . P0104	BHARAT BIJLEE LTD
4 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
5 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
6 . P8042	ELGI ELECTRIC INDUSTRIES LTD
7 . P8102	HEM INDUSTRIES
8 . P0453	KIRLOSKAR ELECTRIC COMPANY LTD.
9 . P8081	LAXMI HYDRAULICS PVT. LTD. (Upto 355L Frame Size)
10 . P8202	ROTOMOTIVE POWERDRIVES INDIA LTD.
11 . P0736	SIEMENS LTD.
FRANCE	
12 . P0034	ALSTHOM ATLANTIQUE
13 . P0426	JEUMONT INDUSTRIE
GERMANY	
14 . P0016	AEG TELEFUNKEN AG
15 . P0735	SIEMENS AG, GERMANY
ITALY	

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810602 : MEDIUM VOLTAGE INDUCTION MOTORS

CODE	NAME
16 . P0052	ANSALDO ROBICON
	JAPAN
17 . P0287	FUJI ELECTRIC SYSTEMS CO. LTD.
18 . P0539	MITSUBISHI CORPORATION
19 . P0726	SHINKO ELECTRICALS CO. LTD.
20 . P0819	TOSHIBA CORPORATION
	SWEDEN
21 . P0064	ASEA BROWN BOVERI
	U.K.
22 . P0486	LAURENCE, SCOTT & ELECTROMOTORS LTD.
23 . P0621	PEEBLES ELECTRICAL MACHINES
	U.S.A.
24 . P0303	GENERAL ELECTRIC CO.
25 . P0877	WESTINGHOUSE ELECTRIC CORPORATION

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810603 : MEDIUM VOLTAGE FLAME PROOF/ INCREASED SAFETY MOTORS

CODE	NAME
INDIA	
1 . P0066	ASEA BROWN BOVERI LTD.
2 . P0104	BHARAT BIJLEE LTD
3 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
4 . P8102	HEM INDUSTRIES (0.18 KW TO 200 KW)
5 . P0453	KIRLOSKAR ELECTRIC COMPANY LTD.
6 . P8081	LAXMI HYDRAULICS PVT. LTD. (Upto 315L Frame Size)
7 . P8202	ROTOMOTIVE POWERDRIVES INDIA LTD.
FRANCE	
8 . P0426	JEUMONT INDUSTRIE
GERMANY	
9 . P0735	SIEMENS AG, GERMANY
ITALY	
10 . P0052	ANSALDO ROBICON
JAPAN	
11 . P0287	FUJI ELECTRIC SYSTEMS CO. LTD.
12 . P0539	MITSUBISHI CORPORATION
13 . P0819	TOSHIBA CORPORATION
SWEDEN	
14 . P0064	ASEA BROWN BOVERI
U.K.	

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810603 : MEDIUM VOLTAGE FLAME PROOF/ INCREASED SAFETY MOTORS

CODE	NAME
15 . P0486	LAURENCE, SCOTT & ELECTROMOTORS LTD.
16 . P0621	PEEBLES ELECTRICAL MACHINES
U.S.A.	
17 . P0303	GENERAL ELECTRIC CO.
18 . P0877	WESTINGHOUSE ELECTRIC CORPORATION

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810604 : SYNCHRONOUS MOTORS

CODE	NAME
INDIA	
1 . P0066	ASEA BROWN BOVERI LTD.
2 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
3 . P8202	ROTOMOTIVE POWERDRIVES INDIA LTD.
4 . P8137	WEG INDUSTRIES (INDIA) PVT. LTD (Up to Frame Size 1600 and rating up to 16 MW)
FRANCE	
5 . P0034	ALSTHOM ATLANTIQUE
6 . P0426	JEUMONT INDUSTRIE
GERMANY	
7 . P0016	AEG TELEFUNKEN AG
8 . P0735	SIEMENS AG, GERMANY
ITALY	
9 . P0052	ANSALDO ROBICON
JAPAN	
10 . P0287	FUJI ELECTRIC SYSTEMS CO. LTD.
11 . P0539	MITSUBISHI CORPORATION
12 . P0726	SHINKO ELECTRICALS CO. LTD.
13 . P0819	TOSHIBA CORPORATION
14 . P8127	TOSHIBA MITSUBISHI ELECTRIC INDUSTRIAL SYSTEMS CORPORATION
SWEDEN	

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810604 : SYNCHRONOUS MOTORS

CODE	NAME
15 . P0064	ASEA BROWN BOVERI
U.K.	
16 . P0486	LAURENCE, SCOTT & ELECTROMOTORS LTD.
17 . P0621	PEEBLES ELECTRICAL MACHINES
U.S.A.	
18 . P0303	GENERAL ELECTRIC CO.
19 . P0877	WESTINGHOUSE ELECTRIC CORPORATION

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810605 : CANNED MOTORS

CODE	NAME
INDIA	
1 . P0453	KIRLOSKAR ELECTRIC COMPANY LTD.
2 . P0736	SIEMENS LTD.

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810606 : GEARED MOTORS

CODE	NAME
INDIA	
1 . P0321	GREAVES COTTON & CO. LTD.
2 . P0453	KIRLOSKAR ELECTRIC COMPANY LTD.
3 . P0571	NEW ALLENBERRY WORKS
4 . P8084	NORD DRIVESYSTEMS PVT. LTD.
5 . P0638	POWER BUILD LTD
6 . P8202	ROTOMOTIVE POWERDRIVES INDIA LTD.
7 . P8091	SEW EURODRIVE INDIA PRIVATE LIMITED

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810701 : BATTERY CHARGER

CODE	NAME
INDIA	
1 . P0040	AMCO POWER SYSTEMS LIMITED
2 . P0154	CHHABI ELECTRICALS PVT. LTD.
3 . P0144	CHLORIDE POWER SYSTEMS AND SOLUTIONS LTD. (formerly CALDYNE
4 . P8092	DUBAS ENGINEERING PVT. LTD.
5 . P0694	HBL NIFE POWER SYSTEMS LTD.
6 . P0444	KERALA STATE ELECTRONICS DEV. CORPN. LTD.
7 . P0079	MEHRU ELECTRICALS (FORMERLY AUTOMATIC ELECTRIC LIMITED)
8 . P8131	SERVILINK ENGINEERS PVT. LTD.
9 . P0845	UNIVERSAL INDUSTRIAL PRODUCTS

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810703 : STATIC TYPE UPS SYSTEM

CODE	NAME
INDIA	
1 . P0195	DB POWER ELECTRONICS PVT. LTD.
2 . P8092	DUBAS ENGINEERING PVT. LTD.
3 . P8003	EMERSON NETWORK POWER (INDIA) PVT. LTD.
4 . P0573	GE POWER CONTROLS INDIA PVT. LTD.
5 . P0360	HITACHI HI-REL POWER ELECTRONICS PVT. LTD.
6 . P0399	INSTRUMENTATION LTD
7 . P0444	KERALA STATE ELECTRONICS DEV. CORPN. LTD.
8 . P0453	KIRLOSKAR ELECTRIC COMPANY LTD.
GERMANY	
9 . P0016	AEG TELEFUNKEN AG
JAPAN	
10 . P0287	FUJI ELECTRIC SYSTEMS CO. LTD.
11 . P0819	TOSHIBA CORPORATION
SWEDEN	
12 . P0064	ASEA BROWN BOVERI
U.S.A.	
13 . P0303	GENERAL ELECTRIC CO.
14 . P0742	SOLIDSTATE CONTROL INC.
15 . P0877	WESTINGHOUSE ELECTRIC CORPORATION

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810705: ELECTROSTATIC TYPE VOLTAGE STABILIZERS

CODE	NAME
INDIA	
1 . P0055	APLAB LIMITED

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810801 : NEUTRAL EARTHING RESISTOR

CODE	NAME
INDIA	
1 . P0113	BHARTIA INDUSTRIES LTD. (DIVN. BCH)
2 . P0231	ELECMECH CORPORATION
3 . P8041	LOTUS POWERGEAR PVT LTD
4 . P8004	PEFCO FOUNDRY & CHEM LTD
5 . P0669	RESITECH ELECTRICALS PRIVATE LIMITED
6 . P0689	RSI SWITCHGEAR PRIVATE LTD.
7 . P0692	S R NARKHEDE ENGINEERING PVT. LTD.

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810802 : EARTHING & LIGHTNING PROTECTION MATERIAL, AL WIRE/STRIP

CODE	NAME
INDIA	
1 . P0046	ANAND ELECTRIC TRADING CO.
2 . P8135	INDMARK FORMTECH PVT. LTD.
3 . P8085	JAMNA METAL COMPANY
4 . P0423	JAYANT METAL MFG CO
5 . P0504	MAHAVIR INDUSTRIAL CORPORATION
6 . P0533	METROPOLITAN INDUSTRIES
7 . P8072	PREMIER POWER PRODUCTS (CALCUTTA) PVT. LTD.
8 . P0696	SAI GALVANISERS & FABRICATORS PVT LTD

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810803 : EARTHING & LIGHTNING PROTECTION MATERIAL,G.I.WIRE/STRIP

CODE	NAME
INDIA	
1 . P0046	ANAND ELECTRIC TRADING CO.
2 . P0112	BHARTI EXPORTS
3 . P8203	DURGA TECHNO INDUSTRIES
4 . P8205	INDIANA GRATINGS PRIVATE LIMITED
5 . P8135	INDMARK FORMTECH PVT. LTD.
6 . P8085	JAMNA METAL COMPANY
7 . P0423	JAYANT METAL MFG CO
8 . P0504	MAHAVIR INDUSTRIAL CORPORATION
9 . P0529	METALITE INDUSTRIES
10 . P0533	METROPOLITAN INDUSTRIES
11 . P8189	PINAX STEEL INDUSTRIES PRIVATE LIMITED
12 . P8072	PREMIER POWER PRODUCTS (CALCUTTA) PVT. LTD.
13 . P8174	R.K. Engineering Works
14 . P8179	RATAN PROJECTS AND ENGINEERING CO. PVT. LTD.
15 . P8044	RUKMANI ELECTRICALS & COMPONENTS PVT LTD
16 . P0695	SADHANA ENGINEERING CORPORATION
17 . P0696	SAI GALVANISERS & FABRICATORS PVT LTD

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810803 : EARTHING & LIGHTNING PROTECTION MATERIAL,G.I.WIRE/STRIP

CODE	NAME
18 . P0753	STEALITE ENGG CO
19 . P8154	TELECOM NETWORK SOLUTIONS PVT.LTD.

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810901 : MV Ex. Proof Items(Switches/Switch Skt./Plugs/Isolators/J.Box/LCS/DB)

CODE	NAME
INDIA	
1 . P0089	BALIGA LIGHTING EQUIPMENTS LIMITED
2 . P8138	EX-PROTECTA
3 . P0147	FCG FLAMEPROOF CONTROL GEARS PVT. LTD. (FORMERLY CEAG FLAME
4 . P8007	FCG POWER INDUSTRIES PVT.LTD.
5 . P0268	FLAMEPROOF EQUIPMENTS PVT. LTD.
6 . P0272	FLEXPRO ELECTRICALS PVT. LTD.
7 . P8134	INDUSTRIAL PRODUCTS EQUIPMENT
8 . P8132	KAYSONS TECHNO EQUIPMENTS PVT. LTD.
9 . P8045	PETROLEUM SAFETY PRODUCTS INDUSTRIES PRIVATE LTD.
10 . P8088	PROMPT ENGINEERING WORKS
11 . P8194	Phoenix Mecano (India) Pvt.Ltd.
12 . P8156	SHREYA EX-TECH PRIVATE LIMITED
13 . P0763	SUDHIR SWITCHGEARS PVT. LTD.
FRANCE	
14 . P0491	LEGRAND S.A.
GERMANY	
15 . P0016	AEG TELEFUNKEN AG
16 . P0092	BBC-BROWN BOVERI & CIE AG

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810901 : MV Ex. Proof Items(Switches/Switch Skt./Plugs/Isolators/J.Box/LCS/DB)

CODE	NAME
17 . P0657	R STAHL SCHALTGERATE GMBH
18 . P0735	SIEMENS AG, GERMANY
19 . P0875	WEIDMULLER LTD.
ITALY	
20 . P0178	CORTEM S.p.A.
JAPAN	
21 . P0287	FUJI ELECTRIC SYSTEMS CO. LTD.
22 . P0815	TOGAMI ELECTRIC MFG. COMPANY
23 . P0819	TOSHIBA CORPORATION
SWEDEN	
24 . P0064	ASEA BROWN BOVERI
U.K.	
25 . P0187	CROUSE-HINDS (EUROPE) LTD.
26 . P0300	GEC INDUSTRIAL CONTROL LTD.
27 . P0555	M&C SWITCHGEAR

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810903 : EXPLOSION PROOF LIGHTING FIXTURES

CODE	NAME
INDIA	
1 . P0089	BALIGA LIGHTING EQUIPMENTS LIMITED
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P8138	EX-PROTECTA
4 . P0147	FCG FLAMEPROOF CONTROL GEARS PVT. LTD. (FORMERLY CEAG FLAME
5 . P8007	FCG POWER INDUSTRIES PVT.LTD.
6 . P0268	FLAMEPROOF EQUIPMENTS PVT. LTD.
7 . P0272	FLEXPRO ELECTRICALS PVT. LTD.
8 . P8132	KAYSONS TECHNO EQUIPMENTS PVT. LTD.
9 . P8045	PETROLEUM SAFETY PRODUCTS INDUSTRIES PRIVATE LTD.
10 . P8148	SAIEX FLAMEPROOF EQUIPMENTS PVT LTD
11 . P8156	SHREYA EX-TECH PRIVATE LIMITED
12 . P0763	SUDHIR SWITCHGEARS PVT. LTD.

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810904 : EXPLOSION PROOF PANIC LIGHTS

CODE	NAME
INDIA	
1 . P0089	BALIGA LIGHTING EQUIPMENTS LIMITED
2 . P0147	FCG FLAMEPROOF CONTROL GEARS PVT. LTD. (FORMERLY CEAG FLAME
3 . P8007	FCG POWER INDUSTRIES PVT.LTD.
4 . P0268	FLAMEPROOF EQUIPMENTS PVT. LTD.
5 . P0272	FLEXPRO ELECTRICALS PVT. LTD.
6 . P8132	KAYSONS TECHNO EQUIPMENTS PVT. LTD.
FRANCE	
7 . P0513	MAPELEC SA
GERMANY	
8 . P0148	CEAG LIGHT-UDN STROMVERSORGUNGS TECHNIK

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810906 : FLAMEPROOF CABLE GLAND

CODE	NAME
INDIA	
1 . P0089	BALIGA LIGHTING EQUIPMENTS LIMITED
2 . P0165	COMET BRASS PRODUCTS
3 . P8100	COMET INDUSTRIES
4 . P0211	DOWELL'S ELECTRICALS
5 . P0228	ELECTROMAC INDUSTRIES
6 . P8138	EX-PROTECTA
7 . P0147	FCG FLAMEPROOF CONTROL GEARS PVT. LTD. (FORMERLY CEAG FLAME
8 . P8007	FCG POWER INDUSTRIES PVT.LTD.
9 . P0268	FLAMEPROOF EQUIPMENTS PVT. LTD.
10 . P0272	FLEXPRO ELECTRICALS PVT. LTD.
11 . P8134	INDUSTRIAL PRODUCTS EQUIPMENT
12 . P8132	KAYSONS TECHNO EQUIPMENTS PVT. LTD.
13 . P0639	POWER ENGG CO
14 . P8088	PROMPT ENGINEERING WORKS
15 . P8194	Phoenix Mecano (India) Pvt.Ltd.
16 . P8148	SAIEX FLAMEPROOF EQUIPMENTS PVT LTD
17 . P8156	SHREYA EX-TECH PRIVATE LIMITED

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810906: FLAMEPROOF CABLE GLAND

	CODE	NAME
18.	P0763	SUDHIR SWITCHGEARS PVT. LTD.

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810909 : EXPLOSION PROOF EXHAUST FAN

CODE	NAME
INDIA	
1 . P0036	ALSTOM LIMITED (AREVA T & D)
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P0147	FCG FLAMEPROOF CONTROL GEARS PVT. LTD. (FORMERLY CEAG FLAME
4 . P0268	FLAMEPROOF EQUIPMENTS PVT. LTD.
5 . P8134	INDUSTRIAL PRODUCTS EQUIPMENT
6 . P8156	SHREYA EX-TECH PRIVATE LIMITED

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811001 : COMMERCIAL LTG FIXTURES

CODE	NAME
INDIA	
1 . P0085	BAJAJ ELECTRICALS LIMITED
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P0337	HAVELLS INDIA LTD.
4 . P8099	KESELEC SCHREDER PRIVATE LIMITED
5 . P8170	LIGHTING TECHNOLOGIES INDIA PRIVATE LIMITED (-)
6 . P8208	ORIENT ELECTRIC LIMITED
7 . P0623	PHILIPS INDIA LTD.
8 . P8186	PYROTECH ELECTRONICS PVT. LTD.
9 . P8096	SURYA ROSHNI LTD.
10 . P0881	WIPRO LIGHTING

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811002 : CORROSION PROOF INDUSTRIAL LTG.FIXTURES

CODE	NAME
INDIA	
1 . P0085	BAJAJ ELECTRICALS LIMITED
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P0337	HAVELLS INDIA LTD.
4 . P8099	KESELEC SCHREDER PRIVATE LIMITED
5 . P0623	PHILIPS INDIA LTD.
6 . P8186	PYROTECH ELECTRONICS PVT. LTD.

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811003 : HOSE PROOF INDUSTRIAL LTG.FIXTURES

CODE	NAME
INDIA	
1 . P0085	BAJAJ ELECTRICALS LIMITED
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P8099	KESELEC SCHREDER PRIVATE LIMITED
4 . P0623	PHILIPS INDIA LTD.
5 . P8186	PYROTECH ELECTRONICS PVT. LTD.
6 . P8051	SPACEAGE SWITCHGEARS LIMITED
7 . P8096	SURYA ROSHNI LTD.
8 . P0881	WIPRO LIGHTING

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811004 : STREET/FLOOD LTG.FIXTURES

CODE	NAME
INDIA	
1 . P0085	BAJAJ ELECTRICALS LIMITED
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P0337	HAVELLS INDIA LTD.
4 . P8099	KESELEC SCHREDER PRIVATE LIMITED
5 . P8170	LIGHTING TECHNOLOGIES INDIA PRIVATE LIMITED (-)
6 . P8208	ORIENT ELECTRIC LIMITED
7 . P0623	PHILIPS INDIA LTD.
8 . P8186	PYROTECH ELECTRONICS PVT. LTD.
9 . P8051	SPACEAGE SWITCHGEARS LIMITED
10 . P8096	SURYA ROSHNI LTD.
11 . P0881	WIPRO LIGHTING

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811005 : AIR OBSTRUCTION LIGHTS (NEON TYPE)

CODE	NAME
INDIA	
1 . P0085	BAJAJ ELECTRICALS LIMITED
2 . P0686	ELECAB POYSHA
3 . P0881	WIPRO LIGHTING

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811006 : LAMPS & TUBES

CODE	NAME
INDIA	
1 . P8002	ANCHOR ELECTRICALS PVT. LTD.
2 . P0085	BAJAJ ELECTRICALS LIMITED
3 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
4 . P8006	ECE BULBS & TUBES
5 . P0337	HAVELLS INDIA LTD.
6 . P8170	LIGHTING TECHNOLOGIES INDIA PRIVATE LIMITED (-)
7 . P8208	ORIENT ELECTRIC LIMITED
8 . P8005	OSRAM INDIA LTD.
9 . P0623	PHILIPS INDIA LTD.
10 . P8096	SURYA ROSHNI LTD.
11 . P0881	WIPRO LIGHTING

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811007 : COMPACT FLUORESCENT LAMPS

CODE	NAME
INDIA	
1 . P0085	BAJAJ ELECTRICALS LIMITED
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P0337	HAVELLS INDIA LTD.
4 . P0413	INDO ASIAN FUSEGEAR LTD (Ecolite make)
5 . P8005	OSRAM INDIA LTD.
6 . P0623	PHILIPS INDIA LTD.
7 . P8070	STANDARD ELECTRICALS LIMITED
8 . P8096	SURYA ROSHNI LTD.

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811101 : ALKALINE BATTERY

CODE	NAME
INDIA	
1 . P0040	AMCO POWER SYSTEMS LIMITED
2 . P0694	HBL NIFE POWER SYSTEMS LTD.
3 . P0346	HIGH ENERGY BATTERIES (INDIA) LTD.
JAPAN	
4 . P0287	FUJI ELECTRIC SYSTEMS CO. LTD.
5 . P0357	HITACHI LTD.

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811102 : LEAD ACID BATTERY

CODE	NAME
INDIA	
1 . P0151	ABB INDIA LIMITED
2 . P0038	AMARA RAJA BATTERIES LTD
3 . P0249	EXIDE INDUSTRIES LIMITED
4 . P8108	MICROTEX ENERGY P LTD.

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811201 : LIFT

CODE	NAME
INDIA	
1 . P0609	OTIS ELEVATOR CO (I) LTD
JAPAN	
2 . P0190	DAIICHI JITSUGYO CO., LTD.
3 . P0287	FUJI ELECTRIC SYSTEMS CO. LTD.
4 . P0581	NIPPON ELEVATOR IND.CO. LIMITED
SWITZERLAND	
5 . P0705	SCHINDLER AG

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811301 : DIESEL GENERATOR SET.

CODE	NAME
INDIA	
1 . P0091	BATLIBOI & CO. LTD.
2 . P8009	BHASKAR POWER PROJECTS LTD.
3 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
4 . P8014	CATERPILLAR
5 . P0188	CUMMINS INDIA LIMITED
6 . P0292	GARDEN REACH SHIPBUILDERS & ENGINEERS LTD.
7 . P0321	GREAVES COTTON & CO. LTD.
8 . P8114	HI-TECH ENGINEERS (Upto 625 KVA)
9 . P8008	JAKSON ENGINEERS LTD
10 . P8015	JEEVAN DIESEL & ELECTRICALS LTD.
11 . P8013	KIRLOSKAR OIL ENGINES
12 . P8188	STERLING GENERATORS PRIVATE LIMITED
13 . P8010	SUDHIR GENSETS LTD.
14 . P8012	TOYO DENKI POWER SYSTEMS PVT. LTD.
15 . P8011	WARTSILLA INDIA LTD.
JAPAN	
16 . P0539	MITSUBISHI CORPORATION

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811301 : DIESEL GENERATOR SET.

CODE	NAME
17 . P0821	TOYO ELECT. MFG. CO. LTD.

SWEDEN

18 . P0064	ASEA BROWN BOVERI

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811401 : HIGH VOLTAGE BUS DUCT.

CODE	NAME
INDIA	
1 . P0102	BEST & CROMPTON ENGG. CO.
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P0405	INTRELEC
4 . P0435	KARAMCHAND THAPAR
5 . P8041	LOTUS POWERGEAR PVT LTD
6 . P0640	POWERGEAR LIMITED
7 . P8051	SPACEAGE SWITCHGEARS LIMITED

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811402 : MEDIUM VOLTAGE BUS DUCT

CODE	NAME
INDIA	
1 . P0045	ANAND POWER LIMITED
2 . P0071	ASSOCIATED SWITCHGEARS & PROJECTS LTD.
3 . P8197	ASTEK ELECTRICAL INDIA PRIVATE LIMITED
4 . P8105	AVONE SYSTEM & CONTROLS
5 . P0102	BEST & CROMPTON ENGG. CO.
6 . P0173	C&S ELECTRIC LTD.
7 . P0172	CONTROLS & SCHEMATICS PVT LTD.
8 . P8069	COSMIC POWER SYSTEMS PVT. LTD.
9 . P0195	DB POWER ELECTRONICS PVT. LTD.
10 . P0312	GLOBE ELECTRICAL INDUSTRIES
11 . P0352	HINDUSTAN CONTROL & EQPT PV. LTD.
12 . P0405	INTRELEC
13 . P8041	LOTUS POWERGEAR PVT LTD
14 . P8074	MAHESHWARI ELECTRICAL MFRS. (P) LTD.
15 . P0640	POWERGEAR LIMITED
16 . P0670	REUNION ELECTRICAL MANUFACTURERS (P) LTD
17 . P8107	SHIVALIC POWER CONTROL (P) LTD.

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811402 : MEDIUM VOLTAGE BUS DUCT

CODE	NAME
18 . P8051	SPACEAGE SWITCHGEARS LIMITED
19 . P0841	UNITED ELECTRIC CO. (DELHI) PVT. LTD.
20 . P8106	VENUS CONTROLS & SWITCHGEAR (P) LTD.

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811501 : SWITCHYARD PACKAGE

CODE	NAME
INDIA	
1 . P0036	ALSTOM LIMITED (AREVA T & D)
2 . P0066	ASEA BROWN BOVERI LTD.
3 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
4 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
5 . P8104	JYOTI LIMITED (upto 33KV only)
6 . P0453	KIRLOSKAR ELECTRIC COMPANY LTD.
7 . P8016	L&T (ECE DIVISION)
8 . P0079	MEHRU ELECTRICALS (FORMERLY AUTOMATIC ELECTRIC LIMITED)
9 . P0132	RELIANCE POWER
10 . P0670	REUNION ELECTRICAL MANUFACTURERS (P) LTD
11 . P0736	SIEMENS LTD.
12 . P0798	THE AHMEDABAD ELECTRICITY CO LTD
13 . P0869	VOLTAS LTD. (PUMPS & PROJECTS BUSINESS DIV)

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811502 : SUB-STATION PACKAGE

CODE	NAME
INDIA	
1 . P0036	ALSTOM LIMITED (AREVA T & D)
2 . P0102	BEST & CROMPTON ENGG. CO.
3 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
4 . P0453	KIRLOSKAR ELECTRIC COMPANY LTD.
5 . P8016	L&T (ECE DIVISION)
6 . P0132	RELIANCE POWER
7 . P0670	REUNION ELECTRICAL MANUFACTURERS (P) LTD
8 . P0736	SIEMENS LTD.
9 . P0798	THE AHMEDABAD ELECTRICITY CO LTD

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811503 : PLANT ELECTRIFICATION PACKAGE(Major Projects)

CODE	NAME
INDIA	
1 . P0036	ALSTOM LIMITED (AREVA T & D)
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P0453	KIRLOSKAR ELECTRIC COMPANY LTD.
4 . P8077	KMG ATOZ SYSTEMS PVT. LTD.
5 . P0132	RELIANCE POWER
6 . P0736	SIEMENS LTD.
7 . P8145	STERLING ELECTRO ENTERPRISES PVT.LTD.
8 . P0798	THE AHMEDABAD ELECTRICITY CO LTD
9 . P0860	VIDUIT AND COMPANY (I) PVT. LTD.
U.K.	
10 . P0481	LA BOUR PUMP CO. LTD.

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811504 : PLANT ELECTRIFICATION PACKAGE(MINOR PROJECTS)

CODE	NAME
INDIA	
1 . P0045	ANAND POWER LIMITED
2 . P8169	ARYAN ELECTRICALS PRIVATE LIMITED (-)
3 . P8017	CHASMITA ENGRS PVT LTD
4 . P8192	GENICS ELECTROTECH PVT. LTD.
5 . P8077	KMG ATOZ SYSTEMS PVT. LTD.
6 . P8118	MEC ENGINEERS
7 . P8020	PACE PROCESS CONTROLS
8 . P8021	POWERMAX ELECTRICALS PVT LTD
9 . P0670	REUNION ELECTRICAL MANUFACTURERS (P) LTD
10 . P8018	ROHINI ELECTRIC
11 . P8145	STERLING ELECTRO ENTERPRISES PVT.LTD.
12 . P0860	VIDUIT AND COMPANY (I) PVT. LTD.
13 . P8019	ZODIAC POWER PROJECTS

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811505 : AIR PRESSURISATION / VENTILLATION SYSTEM

CODE	NAME
INDIA	
1 . P0267	ABB FLAKT INDIA LTD.
2 . P0024	AIR CONDITIONING CORPN LTD
3 . P0041	AMERCIAN REFRIGERATION CO LTD.
4 . P0119	BLUE STAR LTD.
5 . P0869	VOLTAS LTD. (PUMPS & PROJECTS BUSINESS DIV)

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811506: FIRE DETECTION AND ALARM SYSTEM

CODE	NAME
INDIA	
1 . P8201	ZAP FIRE

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811601 : PRE-FABRICATED AL-CABLE TRAYS

CODE	NAME
INDIA	
1 . P8203	DURGA TECHNO INDUSTRIES
2 . P0312	GLOBE ELECTRICAL INDUSTRIES
3 . P0355	HINUSTAN VIDYUT PRODUCTS
4 . P0385	INDIANA ENGG WORKS PVT LTD
5 . P8205	INDIANA GRATINGS PRIVATE LIMITED
6 . P8135	INDMARK FORMTECH PVT. LTD.
7 . P8085	JAMNA METAL COMPANY
8 . P8089	KANADE ANAND UDYOG PVT. LTD.
9 . P8074	MAHESHWARI ELECTRICAL MFRS. (P) LTD.
10 . P0529	METALITE INDUSTRIES
11 . P0619	PAREKH ENGINEERING COMPANY
12 . P8189	PINAX STEEL INDUSTRIES PRIVATE LIMITED
13 . P8072	PREMIER POWER PRODUCTS (CALCUTTA) PVT. LTD.
14 . P8174	R.K. Engineering Works
15 . P8179	RATAN PROJECTS AND ENGINEERING CO. PVT. LTD.
16 . P8044	RUKMANI ELECTRICALS & COMPONENTS PVT LTD
17 . P0695	SADHANA ENGINEERING CORPORATION

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811601 : PRE-FABRICATED AL-CABLE TRAYS

CODE	NAME
18 . P0748	SREE ATREYA ENTERPRISES
19 . P0753	STEALITE ENGG CO

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811602 : PRE-FABRICATED G.I. CABLE TRAYS

CODE	NAME
INDIA	
1 . P8203	DURGA TECHNO INDUSTRIES
2 . P0312	GLOBE ELECTRICAL INDUSTRIES
3 . P0385	INDIANA ENGG WORKS PVT LTD
4 . P8205	INDIANA GRATINGS PRIVATE LIMITED
5 . P8135	INDMARK FORMTECH PVT. LTD.
6 . P8085	JAMNA METAL COMPANY
7 . P8089	KANADE ANAND UDYOG PVT. LTD.
8 . P8074	MAHESHWARI ELECTRICAL MFRS. (P) LTD.
9 . P0529	METALITE INDUSTRIES
10 . P0619	PAREKH ENGINEERING COMPANY
11 . P8189	PINAX STEEL INDUSTRIES PRIVATE LIMITED
12 . P8072	PREMIER POWER PRODUCTS (CALCUTTA) PVT. LTD.
13 . P8174	R.K. Engineering Works
14 . P8179	RATAN PROJECTS AND ENGINEERING CO. PVT. LTD.
15 . P8044	RUKMANI ELECTRICALS & COMPONENTS PVT LTD
16 . P0695	SADHANA ENGINEERING CORPORATION
17 . P8067	SLOTCO STEEL PRODUCTS PVT. LTD.

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811602 : PRE-FABRICATED G.I. CABLE TRAYS

CODE	NAME
18 . P0748	SREE ATREYA ENTERPRISES
19 . P0753	STEALITE ENGG CO

All rights reserved

811603 : FRP CABLE TRAYS

CODE	NAME
INDIA	
1 . P8022	ENERCON
2 . P8146	EPP COMPOSITES PVT.LTD.
3 . P8079	ERCON COMPOSITES (upto 600 mm wide)
4 . P8205	INDIANA GRATINGS PRIVATE LIMITED
5 . P8024	KEMROCK
6 . P8125	KEMROCK INDUSTRIES & EXPORTS LTD.
7 . P8119	SATYAM COMPOSITES PVT. LTD.
8 . P8023	SINTEX INDUSTRIES LTD.
9 . P8083	SUMIP COMPOSITES PVT. LTD.

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811604 : GI PIPES & CONDUITS

CODE	NAME
INDIA	
1 . P0112	BHARTI EXPORTS
2 . P0814	INDIAN TUBE CO. (TATA DIV. OF TUBES & PIPES)
3 . P0427	JINDAL PIPES LTD.
4 . P0527	MEGHJYOT ENTERPRISES
5 . P8044	RUKMANI ELECTRICALS & COMPONENTS PVT LTD
6 . P0755	STEELCRAFT

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811605 : PVC PIPES & CONDUITS

CODE	NAME
INDIA	
1 . P8037	A.K.G.
2 . P8039	FINOLEX INDUSTRIES LTD. (PIPES & PVC DIVN.)
3 . P8075	KALINGA CABLES & CONDUIT CO.
4 . P8055	PLAZA CABLE INDUSTRIES LIMITED
5 . P8040	POLYPACK
6 . P8038	PRAKASH INDUSTRIES LTD.

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811606 : INDUSTRIAL CABLE GLAND

CODE	NAME
INDIA	
1 . P0089	BALIGA LIGHTING EQUIPMENTS LIMITED
2 . P0165	COMET BRASS PRODUCTS
3 . P8100	COMET INDUSTRIES
4 . P0211	DOWELL'S ELECTRICALS
5 . P0228	ELECTROMAC INDUSTRIES
6 . P8200	EX-PROTECTA
7 . P0147	FCG FLAMEPROOF CONTROL GEARS PVT. LTD. (FORMERLY CEAG FLAME
8 . P0310	GLAND-MECH. INDUSTRIES
9 . P8134	INDUSTRIAL PRODUCTS EQUIPMENT
10 . P0639	POWER ENGG CO
11 . P0655	QUALITY & PRECISION INDL. EQUIPMENT
12 . P8025	S J METAL INDUSTRIES (JAINSON)

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811607 : CABLE LUGS

CODE	NAME
INDIA	
1 . P0211	DOWELL'S ELECTRICALS
2 . P0279	FORWARD ENGG INDUSTRIES
3 . P0474	KSE ELECTRICAL PVT. LTD.
4 . P8133	MG ELECTRICA
5 . P0639	POWER ENGG CO
6 . P8025	S J METAL INDUSTRIES (JAINSON)
7 . P0851	USHA MARTIN INDUSTRIES LTD. (ISMAL DIVN)

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811608 : BITUMENOUS BASED CABLE TERMINATION/STRAIGHT THROUGH JOINTING KITS.

CODE	NAME
INDIA	
1 . P0118	BIRLA 3M LTD.
2 . P0142	CABLE CORPN. OF INDIA LIMITED
3 . P0505	MAHINDRA ENGG. & CHEMICAL PRODUCTS LTD.
4 . P8026	RAYCHEM RPG LTD.
5 . P0900	YAMUNA POWER & INFRASTRUCTURE LIMITED

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811609 : EPOXY BASED TERMINATION/STRAIGHT THROUGH JOINTING KITS.

CODE	NAME
INDIA	
1 . P0118	BIRLA 3M LTD.
2 . P0142	CABLE CORPN. OF INDIA LIMITED
3 . P8198	GALA SHRINK FIT (Epoxy/Cross linked Polyolefine)
4 . P8027	HARI CONSOLIDATED PVT LTD.
5 . P0505	MAHINDRA ENGG. & CHEMICAL PRODUCTS LTD.
6 . P8026	RAYCHEM RPG LTD.
7 . P0900	YAMUNA POWER & INFRASTRUCTURE LIMITED
8 . P0890	YASHWANT INDUSTRIAL WORKS PVT. LTD.

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811610 : SI RUBBER BASED CABLE TERM./STRAIGHT THRU JOINTING KITS.

CODE	NAME
INDIA	
1 . P0142	CABLE CORPN. OF INDIA LIMITED
2 . P8027	HARI CONSOLIDATED PVT LTD.
3 . P0505	MAHINDRA ENGG. & CHEMICAL PRODUCTS LTD.
4 . P8026	RAYCHEM RPG LTD.
5 . P0900	YAMUNA POWER & INFRASTRUCTURE LIMITED

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811611 : LIGHTING POLES

CODE	NAME
INDIA	
1 . P0112	BHARTI EXPORTS
2 . P8146	EPP COMPOSITES PVT.LTD.
3 . P8125	KEMROCK INDUSTRIES & EXPORTS LTD. (For FRP Type only)
4 . P8170	LIGHTING TECHNOLOGIES INDIA PRIVATE LIMITED (-)
5 . P0529	METALITE INDUSTRIES
6 . P8208	ORIENT ELECTRIC LIMITED
7 . P8072	PREMIER POWER PRODUCTS (CALCUTTA) PVT. LTD.
8 . P0695	SADHANA ENGINEERING CORPORATION
9 . P8119	SATYAM COMPOSITES PVT. LTD.
10 . P8096	SURYA ROSHNI LTD.
11 . P8181	UTKARSH INDIA LIMITED

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811612 : TRANSFORMER OIL

CODE	NAME
INDIA	
1 . P0053	APAR INUSTRIES LTD.
2 . P0381	INDIAN OIL CORPORATION LTD

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811613 : INDUSTRIAL EXHAUST FAN

CODE	NAME
INDIA	
1 . P0024	AIR CONDITIONING CORPN LTD
2 . P0036	ALSTOM LIMITED (AREVA T & D)
3 . P0041	AMERCIAN REFRIGERATION CO LTD.
4 . P0085	BAJAJ ELECTRICALS LIMITED
5 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
6 . P0337	HAVELLS INDIA LTD.
7 . P0782	S.F. INDIA LTD
8 . P8028	TLT ENGINEERING INDIA PVT LTD

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811701 : ELECTRO-MECHANICAL RELAYS

CODE	NAME
INDIA	
1 . P0036	ALSTOM LIMITED (AREVA T & D)
2 . P0066	ASEA BROWN BOVERI LTD.
3 . P0219	EASUN REYROLLE LIMITED
4 . P8104	JYOTI LIMITED

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811702 : MICROPROCESSOR / NUMERICAL RELAYS

CODE	NAME
INDIA	
1 . P0036	ALSTOM LIMITED (AREVA T & D)
2 . P0066	ASEA BROWN BOVERI LTD.
3 . P8173	CG POWER AND INDUSTRIAL SOLUTIONS LIMITED
4 . P0219	EASUN REYROLLE LIMITED
5 . P0485	LARSEN & TOUBRO LTD.(EL.PRODUCTS DIVN)
6 . P8123	PROK DEVICES PRIVATE LIMITED ((Over Current and Earth Fault Relay, Earth Fault Relay, Earth Leakage Relay with CBCT))
7 . P0736	SIEMENS LTD.

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811703 : METERS

CODE	NAME
INDIA	
1 . P0036	ALSTOM LIMITED (AREVA T & D)
2 . P8047	HOTLINE SWITCHGEAR & CONTROLS
3 . P0392	IMP POWER LTD.
4 . P0420	JAIPUR METALS & ELECTRICAL LTD
5 . P8095	M.B. CONTROL & SYTSTEMS PVT. LTD. ((Only for Multifunctional Meter))
6 . P0526	MECO INSUTRUMENTS
7 . P0079	MEHRU ELECTRICALS (FORMERLY AUTOMATIC ELECTRIC LIMITED)
8 . P8155	NEWTEK ELECTRICALS
9 . P8123	PROK DEVICES PRIVATE LIMITED
10 . P8029	RISHABH INSTRUMENTS PVT. LTD.
11 . P0710	SEAHORSE INDUSTRIES LTD.
12 . P8196	THE MOTWANE MANUFACTURING COMPANY PVT. LTD. (ELETRICAL TESTING & MEASURING EQUIPMENTS)

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811704 : RECORDERS

CODE	NAME
INDIA	
1 . P8030	ALACRITY ELECTRONICS LTD.
2 . P8022	ENERCON
3 . P0479	L & G SWITZERLAND

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811801 : HIGH VOLTAGE SHUNT CAPACITORS

CODE	NAME
INDIA	
1 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P0449	KAPSALES ELECTRICALS LTD.
4 . P0730	SHREEM CAPACITORS PVT. LTD.
5 . P0843	UNIVERSAL CABLES LTD.

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811802 : MEDIUM VOLTAGE SHUNT CAPACITORS

CODE	NAME
INDIA	
1 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P0449	KAPSALES ELECTRICALS LTD.
4 . P0730	SHREEM CAPACITORS PVT. LTD.
5 . P0843	UNIVERSAL CABLES LTD.

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811803 : LOW VOLTAGE SHUNT CAPACITORS

CODE	NAME
INDIA	
1 . P0114	BHEL (ELECTRICAL MACHINES DIVN.)
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P0449	KAPSALES ELECTRICALS LTD.
4 . P0730	SHREEM CAPACITORS PVT. LTD.
5 . P0843	UNIVERSAL CABLES LTD.

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811901 : OVERHEAD CONDUCTORS-AL /ACSR

CODE	NAME
INDIA	
1 . P0037	ALUMINIUM INDUSTRIES LTD
2 . P8184	DYNAMIC CABLES LIMITED
3 . P8171	GRANDLAY ELECTRICALS INDIA
4 . P8193	LUMINO INDUSTRIES LIMITED
5 . P0574	NICCO CORPORATION LTD
6 . P8167	RAVI INDUSTRIES
7 . P8177	V-MARC INDIA LIMITED

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811902 : EHV/HV INSULATORS

CODE	NAME
INDIA	
1 . P0036	ALSTOM LIMITED (AREVA T & D)
2 . P0109	BHARAT HEAVY ELECTRICALS LTD.
3 . P0717	SESHASAYEE INDUSTRIES LTD

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811903 : M.V.INSULATORS

CODE	NAME
INDIA	
1 . P0036	ALSTOM LIMITED (AREVA T & D)
2 . P0347	HIGH TENSION INSULATORS FACTORY
3 . P0717	SESHASAYEE INDUSTRIES LTD

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811904 : LIGHTNING ARRESTOR

CODE	NAME
INDIA	
1 . P0036	ALSTOM LIMITED (AREVA T & D)
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P8190	ELEKTROLITES (POWER) PRIVATE LIMITED
4 . P0234	ELPRO INTERNATIONAL LTD
5 . P0595	OBLUM ELEC. INDUSTRIES PVT LTD

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812001 : TELEPHONE EXCHANGE EQUIPMENTS

CODE	NAME
INDIA	
1 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
2 . P0330	HAKOTRONICS PRIVATE LIMITED
3 . P0383	INDIAN TELEPHONE INDUSTRIES LTD.
4 . P0623	PHILIPS INDIA LTD.
5 . P0736	SIEMENS LTD.
6 . P0788	TATA TELECOM LIMITED
GERMANY	
7 . P0570	NEUMANN GMBH ELEKTRONIK
SINGAPORE	
8 . P0546	MOTOROLA SINGAPORE PTE LTD.

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812002 : PAGING EQUIPMENTS / PUBLIC ADDRESS SYTEM

CODE	NAME
GERMANY	
1 . P8161	INDUSTRONIC INDUSTRIE-ELECTRONIC GMBH & CO. KG
INDIA	
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P0330	HAKOTRONICS PRIVATE LIMITED
4 . P0383	INDIAN TELEPHONE INDUSTRIES LTD.
5 . P0623	PHILIPS INDIA LTD.
6 . P0788	TATA TELECOM LIMITED
7 . P0795	TELEMAX CORPROATION
SINGAPORE	
8 . P8144	COMTROL PTE.LTD.
RUSSIA	
9 . P8150	ARMTEL LLC
GERMANY	
10 . P0570	NEUMANN GMBH ELEKTRONIK
INDIA	
11 . P8185	LARAON ENGINEERS AND CONSULTANTS PVT. LTD.
SINGAPORE	
12 . P0546	MOTOROLA SINGAPORE PTE LTD.
U.K.	
13 . P0289	GAI TRONICS SRL

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812101 : INDUSTRIAL HEATER

CODE	NAME
France	
1 . P8153	Chromalox Etirex SAS
INDIA	
2 . P0030	ALCO HEATING CO.
3 . P0091	BATLIBOI & CO. LTD.
4 . P0234	ELPRO INTERNATIONAL LTD
5 . P0242	ESCORTS LTD
6 . P8139	FATI GENERAL EQUIPMENTS PVT.LTD.
7 . P8031	KANTILAL CHUNNILAL & SONS APPLIANCES PVT. LTD.
8 . P8032	MACNEIL & MAGOR (KILNBURN)
9 . P0535	MIDDLETON ENGG CO
10 . P8033	RAYCOLD LTD.
11 . P8034	T.M.I (TRANSFORMERS MFG. INDUSTRIES)
GERMANY	
12 . P8080	KLOPPER-THERM GmbH & Co. KG

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812201 : HOSE PROOF LOCAL CONTROL STATION

CODE	NAME
INDIA	
1 . P0089	BALIGA LIGHTING EQUIPMENTS LIMITED
2 . P0113	BHARTIA INDUSTRIES LTD. (DIVN. BCH)
3 . P8138	EX-PROTECTA
4 . P0147	FCG FLAMEPROOF CONTROL GEARS PVT. LTD. (FORMERLY CEAG FLAME
5 . P8007	FCG POWER INDUSTRIES PVT.LTD.
6 . P0268	FLAMEPROOF EQUIPMENTS PVT. LTD.
7 . P8047	HOTLINE SWITCHGEAR & CONTROLS
8 . P0639	POWER ENGG CO
9 . P8160	SHRENIK & COMPANY

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812202 : INDUSTRIAL TYPE SW. SOCKET & PLUG

CODE	NAME
INDIA	
1 . P0089	BALIGA LIGHTING EQUIPMENTS LIMITED
2 . P0185	CG POWER AND INDUSTRIAL SOLUTION LIMITED
3 . P0144	CHLORIDE POWER SYSTEMS AND SOLUTIONS LTD. (formerly CALDYNE
4 . P0902	CYCLO ELECTRIC DEVICES & SERVICES CO.
5 . P8138	EX-PROTECTA
6 . P0147	FCG FLAMEPROOF CONTROL GEARS PVT. LTD. (FORMERLY CEAG FLAME
7 . P8007	FCG POWER INDUSTRIES PVT.LTD.
8 . P0268	FLAMEPROOF EQUIPMENTS PVT. LTD.
9 . P0523	LEGRAND INDIA LTD
10 . P8160	SHRENIK & COMPANY
FRANCE	
11 . P0491	LEGRAND S.A.
GERMANY	
12 . P0092	BBC-BROWN BOVERI & CIE AG
13 . P0657	R STAHL SCHALTGERATE GMBH
14 . P0875	WEIDMULLER LTD.
ITALY	
15 . P0178	CORTEM S.p.A.

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812203 : HOSEPROOF JUNCTION BOXES

CODE	NAME
INDIA	
1 . P0089	BALIGA LIGHTING EQUIPMENTS LIMITED
2 . P0113	BHARTIA INDUSTRIES LTD. (DIVN. BCH)
3 . P8138	EX-PROTECTA
4 . P0147	FCG FLAMEPROOF CONTROL GEARS PVT. LTD. (FORMERLY CEAG FLAME
5 . P8007	FCG POWER INDUSTRIES PVT.LTD.
6 . P0268	FLAMEPROOF EQUIPMENTS PVT. LTD.
7 . P8194	Phoenix Mecano (India) Pvt.Ltd.
8 . P8160	SHRENIK & COMPANY

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812204 : ELECTROMAGNETIC EQUIPMENT

CODE	NAME
INDIA	
1 . P0229	ELEKTROMAG DEVICES PVT. LTD
2 . P0638	POWER BUILD LTD
3 . P0757	STERLING CONTROLS PVT. LTD.
4 . P0760	STORM KRAFT CONTROLS

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812205 : LIMIT SWITCHES / BELT MONITORING SWITCHES

CODE	NAME
INDIA	
1 . P0002	A G SYSTEM CONTROLS
2 . P0022	AG MECHANICAL ENTERPRISES (P) LTD.
3 . P8036	BALAJI ELECTRICALS
4 . P0113	BHARTIA INDUSTRIES LTD. (DIVN. BCH)
5 . P0424	JAYASHREE ELECTRODEVICES PVT. LTD.
6 . P8097	PROTOCONTROL INSTRUMENTS (I) PVT. LTD.
7 . P0691	R.K. ELECTRICAL ENGG. WORKS

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812206 : LIMIT SWITCHES (FLAMEPROOF TYPE)

CODE	NAME
INDIA	
1 . P0089	BALIGA LIGHTING EQUIPMENTS LIMITED
2 . P8138	EX-PROTECTA
3 . P0147	FCG FLAMEPROOF CONTROL GEARS PVT. LTD. (FORMERLY CEAG FLAME
4 . P8007	FCG POWER INDUSTRIES PVT.LTD.
5 . P0268	FLAMEPROOF EQUIPMENTS PVT. LTD.
6 . P8097	PROTOCONTROL INSTRUMENTS (I) PVT. LTD.
7 . P8148	SAIEX FLAMEPROOF EQUIPMENTS PVT LTD

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812207 : HORN/HOOTER/KLAXON

CODE	NAME
INDIA	
1 . P0089	BALIGA LIGHTING EQUIPMENTS LIMITED
2 . P8138	EX-PROTECTA
3 . P0268	FLAMEPROOF EQUIPMENTS PVT. LTD.
4 . P0883	WORTHMAX ENGINEERS

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812301 : CATHODIC PROTECTION SYSTEM

CODE	NAME
INDIA	
1 . P8073	CONSTRUCTION GUILD PVT. LTD.
2 . P8110	ELECTRO PROTECTION SERVICES INDIA PVT. LTD. ((Also manufacturer of Anodes for CP System))
3 . P8141	SARK EPC PROJECTS PVT.LTD.
4 . P8143	UNDERGROUND PIPELINE & NDT SERVICES PRIVATE LIMITED
5 .	UNDERGROUND PIPELINE & NDT SERVICES PRIVATE LIMITED
6 . P8172	UNIVERSAL CORROSION PREVENTION INDIA

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CHAPTER D – 02
VENDOR LIST-C&I

MASTER VENDORS LIST

FOR

PROJECTS

INSTRUMENT ITEMS

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310101 : GAS ANALYSERS(IR,Thermal Conductivity, Paramagnetic)

CODE	NAME
INDIA	
1 . P0151	ABB INDIA LIMITED
2 . P0153	CHEMTROLS INDUSTRIES LTD.
3 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
4 . P3427	ENDRESS+HAUSER (INDIA) PVT. LTD. (TDL type)
5 . P0891	YOKOGAWA INDIA LIMITED ((IR/UV, Thermal, UV, TDLS, Gas Density))
GERMANY	
6 . P0506	MAIHAK AKTIENGESELLSCHRAFT
7 . P0735	SIEMENS AG, GERMANY
SINGAPORE	
8 . P0262	EMERSON PROCESS MGT SINGAPORE LTD
U.S.A.	
9 . P0043	AMETEK, INC.
10 . P0552	M.S.A. INTERNATIONAL

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310102 : pH , CONDUCTIVITY& ORP ANALYSER

CODE	NAME
INDIA	
1 . P0151	ABB INDIA LIMITED
2 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
3 . P3427	ENDRESS+HAUSER (INDIA) PVT. LTD. (Liquid Analysers)
4 . P0277	FORBES POLYMETRON PVT. LTD.
5 . P0891	YOKOGAWA INDIA LIMITED ((pH, conductivity, turbidity, chlorine))
FRANCE	
6 . P0893	ZELLWEGER SA
JAPAN	
7 . P0892	YOKOGAWA ELECTRIC CORPORATION
SINGAPORE	
8 . P0262	EMERSON PROCESS MGT SINGAPORE LTD
9 . P0283	FOXBORO FAR EAST PTE LTD
U.S.A.	
10 . P0328	HACH COMPANY

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310103 : TRACE ANALYSER / ION SELECTIVE

CODE	NAME
INDIA	
1 . P0151	ABB INDIA LIMITED
2 . P0277	FORBES POLYMETRON PVT. LTD.
FRANCE	
3 . P0893	ZELLWEGER SA
U.K.	
4 . P0125	BRAN & LUEBBE LTD.
U.S.A.	
5 . P0328	HACH COMPANY

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310104 : SOx / NOx ANALYSER

CODE	NAME
INDIA	
1 . P0151	ABB INDIA LIMITED
2 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
3 . P0891	YOKOGAWA INDIA LIMITED ((CEMS, O2 -Zirconia))
GERMANY	
4 . P0732	SICK AG
5 . P0735	SIEMENS AG, GERMANY
JAPAN	
6 . P0367	HORIBA LTD.
7 . P0892	YOKOGAWA ELECTRIC CORPORATION
SINGAPORE	
8 . P0262	EMERSON PROCESS MGT SINGAPORE LTD
U.S.A.	
9 . P0488	LEAR SIEGLER MEAS. CTRLS. CORP.
10 . P0552	M.S.A. INTERNATIONAL
11 . P0808	THERMO ENVIRONMENT INSTRUMENTS INC.

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310105 : MASS SPECTROMETER

CODE	NAME
INDIA	
1 . P0151	ABB INDIA LIMITED
U.K.	
2 . P0858	VG GAS ANALYSIS SYSTEMS
U.S.A.	
3 . P0607	ORBITAL SCIENCE CORPORATION

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310106 : GAS CHROMATOGRAPH

CODE	NAME
INDIA	
1 . P0151	ABB INDIA LIMITED
2 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
3 . P0891	YOKOGAWA INDIA LIMITED
SINGAPORE	
4 . P0054	APPLIED AUTOMATION INC
5 . P0283	FOXBORO FAR EAST PTE LTD

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310107 : FLUE GAS ANALYSER (ZrO2 Type)

CODE	NAME
INDIA	
1 . P0151	ABB INDIA LIMITED
2 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
3 . P0891	YOKOGAWA INDIA LIMITED
IRELAND	
4 . P0616	GE PANAMETRICS
U.S.A.	
5 . P0043	AMETEK, INC.

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310108 : H2S / TOTAL SULPHUR ANALYSERS

CODE	NAME
INDIA	
1 . P0151	ABB INDIA LIMITED
U.K.	
2 . P0090	BARTON INSTRUMENT SYSTEMS LIMITED

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310109 : SYSTEM HOUSE ANALYSERS

CODE	NAME
INDIA	
1 . P0151	ABB INDIA LIMITED
2 . P3431	ADAGE AUTOMATION PVT. LIMITED
3 . P3457	ANALYSER INSTRUMENT CO. PVT. LTD.
4 . P3492	AXIS SOLUTIONS PVT.LTD.
5 . P0153	CHEMTROLS INDUSTRIES LTD.
6 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
7 . P0891	YOKOGAWA INDIA LIMITED
ITALY	
8 . P0402	INTECH

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310110 : DENSITY ANALYSERS

CODE	NAME
INDIA	
1 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD. (coriolis type)
GERMANY	
2 . P0121	BOPP & REUTHER MESSTECHNIK GMBH (coriolis type)
U.K.	
3 . P0741	SOLARTRON MOBREY

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310111 : MOISTURE ANALYSERS

CODE	NAME
IRELAND	
1 . P0616	GE PANAMETRICS
U.S.A.	
2 . P0043	AMETEK, INC.

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310113 : GAS & FIRE DETECTION SYSTEM

CODE	NAME
INDIA	
1 . P0050	ANDREW YULE & COMPANY LTD. (FIRE)
2 . P0787	HONEYWELL AUTOMATION INDIA LIMITED (GAS)
3 . P0415	J B BODA AND BROTHERS PVT. LTD. (GAS,Make-International Sensor Technology)
4 . P3101	POLLUTION PROTECTION SYSTEM MUMBAI PVT LTD (GAS)
5 . P3473	UNIPHOS ENVIROTRONIC PVT.LTD. (FOR GAS DETECTION SYSTEM ONLY)
RUSSIA	
6 . P3498	JSC "ELECTRONSTANDART-PRIBOR" (-)
THAILAND	
7 . P0794	TELEDYNE FLUID SYSTEMS (GAS)
U.K.	
8 . P0306	GENERAL MONITORS (GAS)

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310114: AIR QUALITY MONITORING SYSTEM

CODE	NAME
INDIA	
1 . P0153	CHEMTROLS INDUSTRIES LTD.

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310115: SAMPLE HANDLING SYSTEM

CODE	NAME
INDIA	
1 . P3457	ANALYSER INSTRUMENT CO. PVT. LTD.

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310201 : FLOW ELEMENT:ORIFICE/VENTURI/ FLOW NOZZLE

CODE	NAME
INDIA	
1 . P3481	DYNAFLUID VALVES AND FLOW CONTROLS PVT.LTD
2 . P3482	MINCO (INDIA) PVT. LTD
3 . P0089	BALIGA LIGHTING EQUIPMENTS LIMITED (Only Orifice)
4 . P0153	CHEMTROLS INDUSTRIES LTD.
5 . P3476	COMFIT & VALVES PVT.LTD. (ONLY ORIFICE)
6 . P3199	EUREKA INDUSTRIAL EQUIPMENTS PRIVATE LIMITED (Upto 12" size & upto 600 #)
7 . P3510	EUREKA INDUSTRIAL EQUIPMENTS PVT. LTD.
8 . P3433	FLOWTECH INSTRUMENTS SERVICES (Orifice Plate /Venturi)
9 . P0304	GENERAL INSTRUMENTS CONSORTIUM,
10 . P3490	HYDROPNEUMATICS PVT.LTD
11 . P0400	INSTRUMENTATION LTD. (PALAKKAD)
12 . P0534	MICRO PRECISION PRODUCTS PRIVATE LTD.
13 . P3520	MINCO (INDIA) FLOW ELEMENTS PVT. LTD.
14 . P3453	MINCO (INDIA) FLOW ELEMENTS PVT.LTD. (All range)
15 . P3416	UNICONTROLS INSTRUMENTS PVT. LTD.
GERMANY	
16 . P0121	BOPP & REUTHER MESSTECHNIK GMBH
ITALY	

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310201 : FLOW ELEMENT:ORIFICE/VENTURI/ FLOW NOZZLE

CODE	NAME
17 . P0791	TECHNOMATIC SPA
U.K.	
18 . P0408	ISA CONTROLS LIMITED
U.S.A.	
19 . P0193	DANIEL MEASUREMENT & CONTROL

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310202 : PITOT TUBE / ANNUBAR

CODE	NAME
INDIA	
1 . P3481	DYNAFLUID VALVES AND FLOW CONTROLS PVT.LTD
2 . P3482	MINCO (INDIA) PVT. LTD
3 . P0151	ABB INDIA LIMITED
4 . P0171	CONTROL ENGINEERS
5 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
6 . P3510	EUREKA INDUSTRIAL EQUIPMENTS PVT. LTD.
7 . P0534	MICRO PRECISION PRODUCTS PRIVATE LTD.
8 . P3520	MINCO (INDIA) FLOW ELEMENTS PVT. LTD.
9 . P3416	UNICONTROLS INSTRUMENTS PVT. LTD.
ITALY	
10 . P0791	TECHNOMATIC SPA
U.K.	
11 . P0408	ISA CONTROLS LIMITED
U.S.A.	
12 . P0193	DANIEL MEASUREMENT & CONTROL

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310203 : ROTAMETERS

CODE	NAME
INDIA	
1 . P0151	ABB INDIA LIMITED
2 . P0153	CHEMTROLS INDUSTRIES LTD.
3 . P3199	EUREKA INDUSTRIAL EQUIPMENTS PRIVATE LIMITED
4 . P3510	EUREKA INDUSTRIAL EQUIPMENTS PVT. LTD.
5 . P3433	FLOWTECH INSTRUMENTS SERVICES
6 . P0398	INSTRUMENTATION ENGINEERS PVT. LTD.
7 . P0468	KROHNE MARSHALL PVT. LTD.
8 . P0633	PLACKA INSTRUMENTS & CONTROLS PVT. LTD. (Purge Rotameter only)
9 . P0680	ROTA INSTRUMENTATION
10 . P0891	YOKOGAWA INDIA LIMITED
GERMANY	
11 . P0467	KROHNE
12 . P0681	ROTA YOKOGAWA GMBH & CO. KG
JAPAN	
13 . P0888	AZBIL CORPORATION (Formerly YAMATAKE CORPORATION)
14 . P0816	TOKYO KEISO CO. LTD.
U.S.A.	
15 . P0679	EMERSON PROCESS MGT

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310204 : MASS FLOW METER (CORIOLIS TYPE)

CODE	NAME
INDIA	
1 . P0151	ABB INDIA LIMITED
2 . P0153	CHEMTROLS INDUSTRIES LTD.
3 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
4 . P3417	SIEMENS LTD.
5 . P0891	YOKOGAWA INDIA LIMITED
GERMANY	
6 . P0121	BOPP & REUTHER MESSTECHNIK GMBH
7 . P0238	ENDRESS + HAUSER GMBH & CO.,
8 . P0467	KROHNE
U.S.A.	
9 . P0706	SCHLUMBERGER RESOURCE MANAGEMENT LTD.

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310205 : TURBINE FLOW METER

CODE	NAME
INDIA	
1 . P0151	ABB INDIA LIMITED
2 . P0153	CHEMTROLS INDUSTRIES LTD.
3 . P0275	FMC SANMAR LTD.
4 . P3462	ROCKWIN FLOWMETER INDIA PVT.LTD.
GERMANY	
5 . P0121	BOPP & REUTHER MESSTECHNIK GMBH
HOLLAND	
6 . P0397	INSTROMET INTERNATIONAL N.V
JAPAN	
7 . P0888	AZBIL CORPORATION (Formerly YAMATAKE CORPORATION)
8 . P0412	ITOCHU CORPORATION (REP.KUBOTA CORPN.)
SINGAPORE	
9 . P0611	OVAL ASEA PACIFIC PTE LTD
U.K.	
10 . P0090	BARTON INSTRUMENT SYSTEMS LIMITED
11 . P0192	EMERSON PROCESS MGT
U.S.A.	
12 . P0679	EMERSON PROCESS MGT
13 . P0675	ROCKWELL INTERNATIONAL CORPN.

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310206 : VORTEX METER

CODE	NAME
INDIA	
1 . P0151	ABB INDIA LIMITED
2 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
3 . P0468	KROHNE MARSHALL PVT. LTD.
4 . P3417	SIEMENS LTD.
5 . P0891	YOKOGAWA INDIA LIMITED
GERMANY	
6 . P0121	BOPP & REUTHER MESSTECHNIK GMBH
7 . P0238	ENDRESS + HAUSER GMBH & CO.,
8 . P0467	KROHNE
JAPAN	
9 . P0412	ITOCHU CORPORATION (REP.KUBOTA CORPN.)
U.S.A.	
10 . P0706	SCHLUMBERGER RESOURCE MANAGEMENT LTD.

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310207 : PD METER

CODE	NAME
INDIA	
1 . P0153	CHEMTROLS INDUSTRIES LTD.
2 . P3102	ROCKWIN FLOW METERS (I) PVT. LTD.
3 . P3462	ROCKWIN FLOWMETER INDIA PVT.LTD.
GERMANY	
4 . P0121	BOPP & REUTHER MESSTECHNIK GMBH
SINGAPORE	
5 . P0611	OVAL ASEA PACIFIC PTE LTD
U.S.A.	
6 . P0679	EMERSON PROCESS MGT
7 . P0706	SCHLUMBERGER RESOURCE MANAGEMENT LTD.

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310208 : MAGNETIC FLOW METER

CODE	NAME
INDIA	
1 . P3479	ADEPT FLUIDYNE PVT.LTD
2 . P0151	ABB INDIA LIMITED
3 . P0153	CHEMTROLS INDUSTRIES LTD.
4 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
5 . P3427	ENDRESS+HAUSER (INDIA) PVT. LTD.
6 . P3510	EUREKA INDUSTRIAL EQUIPMENTS PVT. LTD.
7 . P0468	KROHNE MARSHALL PVT. LTD.
8 . P3459	SBEM PVT. LTD.
9 . P3417	SIEMENS LTD.
10 . P0891	YOKOGAWA INDIA LIMITED
GERMANY	
11 . P0121	BOPP & REUTHER MESSTECHNIK GMBH
12 . P0467	KROHNE
JAPAN	
13 . P0888	AZBIL CORPORATION (Formerly YAMATAKE CORPORATION)

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310209: INSERTION TYPE FLOWMETER

CODE	NAME
INDIA	
1. P3417	SIEMENS LTD.

All rights reserved

310210 : ULTRASONIC FLOW METER

CODE	NAME
INDIA	
1 . P3479	ADEPT FLUIDYNE PVT.LTD ((Insertion Type only))
2 . P0153	CHEMTROLS INDUSTRIES LTD.
3 . P3465	EIP ENVIRO LEVEL CONTROLS PRIVATE LIMITED
4 . P3427	ENDRESS+HAUSER (INDIA) PVT. LTD.
5 . P3417	SIEMENS LTD.
6 . P0891	YOKOGAWA INDIA LIMITED

All rights reserved

310211 :ORIFICE METER

CODE	NAME
INDIA	
1 . P0153	CHEMTROLS INDUSTRIES LTD.

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310212: METERING SKID

CODE	NAME
INDIA	
1 .	CHEMTROLS INDUSTRIES LTD. ((For Liquid & Gas))

All rights reserved

310301 : PRESSURE GAUGES

CODE	NAME
1 . P3185	(standard normal type)
INDIA	
2 . P3477	NESSTECH INSTRUMENTS PRIVATE LIMITED
3 . P3483	WIKA INSTRUMENTS INDIA PVT.LTD
4 . P0081	A N INSTRUMENTS PVT. LTD.
5 . P3103	BAUMER TECHNOLOGIES INDIA PVT. LTD.(FORMERLY WAAREE INSTRUM
6 . P3496	FORBES MARSHALL (HYD) PRIVATE LIMITED (Up to 0.6 to 600Kg/cm2)
7 . P3466	GAUGES BOURDON INDIA PVT. LTD (Mfg. unit of GIC)
8 . P0304	GENERAL INSTRUMENTS CONSORTIUM,
9 . P0371	H.GURU INDUSTRIES
10 . P3470	ITEC MEASURES PRIVATE LIMITED
11 . P0512	MANOMETER (INDIA) PVT. LTD.
12 . P3469	MICRO PROCESS CONTROLS
13 . P3517	MILLENNIUM INSTRUMENTS LIMITED
14 . P0622	PEEJEE ENGG. WORKS
15 . P3456	PRECISION MASS PRODUCTS PVT. LTD.
16 . P0646	PREMIUM INST. & CONTROLS LTD.

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310301 : PRESSURE GAUGES

CODE	NAME
17 . P3454	THERMAL INSTRUMENT INDIA PVT.LTD.
18 . P0874	WALCHANDNAGAR INDUSTRIES LTD.
GERMANY	
19 . P0212	DRESSER EUROPE S.A.
20 . P0880	WIKA ALEXENDER WIEGAND GMBH & CO.
ITALY	
21 . P0746	SPRIANO SPA
JAPAN	
22 . P0558	NAGANO KEIKI SEISAKUSHO
SWITZERLAND	
23 . P0690	RUEGER SA
U.K.	
24 . P0136	BUDENBERG GAUGE CO. LTD.

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310302 : VOL. SEAL PR. GAUGES

CODE	NAME
INDIA	
1 . P3483	WIKA INSTRUMENTS INDIA PVT.LTD
2 . P0081	A N INSTRUMENTS PVT. LTD. (=<600# Except Urea Service)
3 . P3496	FORBES MARSHALL (HYD) PRIVATE LIMITED ((Diaphragm Seal Pressure Gauge) (0.06 to 40 Kg/cm2; Low Pressure Gauge range (100mm WC to 6000mmWC)
4 . P3470	ITEC MEASURES PRIVATE LIMITED
5 . P3469	MICRO PROCESS CONTROLS
6 . P3517	MILLENNIUM INSTRUMENTS LIMITED
7 . P3456	PRECISION MASS PRODUCTS PVT. LTD.
8 . P3454	THERMAL INSTRUMENT INDIA PVT.LTD.
GERMANY	
9 . P0212	DRESSER EUROPE S.A.
10 . P0880	WIKA ALEXENDER WIEGAND GMBH & CO.
ITALY	
11 . P0746	SPRIANO SPA
JAPAN	
12 . P0558	NAGANO KEIKI SEISAKUSHO
SWITZERLAND	
13 . P0690	RUEGER SA
U.K.	
14 . P0136	BUDENBERG GAUGE CO. LTD.

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310303 : LOCAL D/P INDICATORS

CODE	NAME
INDIA	
1 . P3466	GAUGES BOURDON INDIA PVT. LTD (Mfg. unit of GIC)
2 . P3469	MICRO PROCESS CONTROLS
3 . P3517	MILLENNIUM INSTRUMENTS LIMITED
4 . P3456	PRECISION MASS PRODUCTS PVT. LTD.
5 . P0781	SWITZER INSTRUMENT CO.,
U.K.	
6 . P0090	BARTON INSTRUMENT SYSTEMS LIMITED
7 . P0198	DELTA CONTROLS LTD.

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310304 : PRESSURE & D/P TRANSMITTERS

CODE	NAME
GERMANY	
1 . P3430	VEGA GRIESHABER KG
INDIA	
2 . P0151	ABB INDIA LIMITED
3 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
4 . P3427	ENDRESS+HAUSER (INDIA) PVT. LTD.
5 . P0787	HONEYWELL AUTOMATION INDIA LIMITED
6 . P3417	SIEMENS LTD.
7 . P0891	YOKOGAWA INDIA LIMITED
GERMANY	
8 . P0735	SIEMENS AG, GERMANY
JAPAN	
9 . P0888	AZBIL CORPORATION (Formerly YAMATAKE CORPORATION)
10 . P0892	YOKOGAWA ELECTRIC CORPORATION
SINGAPORE	
11 . P0262	EMERSON PROCESS MGT SINGAPORE LTD
12 . P0740	SMAR SINGAPORE PTE. LTD.
U.S.A.	
13 . P0363	HONEYWELL INC.,
14 . P0544	MOORE PRODUCTS COMPANY

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310305 : VOL. SEAL PR./DP TRANSMITTER

CODE	NAME
INDIA	
1 . P0151	ABB INDIA LIMITED
2 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
3 . P3427	ENDRESS+HAUSER (INDIA) PVT. LTD.
4 . P0787	HONEYWELL AUTOMATION INDIA LIMITED
5 . P3417	SIEMENS LTD.
6 . P0891	YOKOGAWA INDIA LIMITED
JAPAN	
7 . P0888	AZBIL CORPORATION (Formerly YAMATAKE CORPORATION)
8 . P0287	FUJI ELECTRIC SYSTEMS CO. LTD. (Except Urea Service)
9 . P0892	YOKOGAWA ELECTRIC CORPORATION
SINGAPORE	
10 . P0262	EMERSON PROCESS MGT SINGAPORE LTD
U.S.A.	
11 . P0544	MOORE PRODUCTS COMPANY

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310310 : PRESSURE & D/P SWITCHES INCLUDING VOL. SEAL

CODE	NAME
INDIA	
1 . P3427	ENDRESS+HAUSER (INDIA) PVT. LTD.
2 . P0379	INDFOS INDUSTRIES LTD. (except vol.seal)
3 . P3405	KAUSTUBHA UDYOG
4 . P3469	MICRO PROCESS CONTROLS
5 . P3456	PRECISION MASS PRODUCTS PVT. LTD.
6 . P0781	SWITZER INSTRUMENT CO., (except vol.seal)
JAPAN	
7 . P0888	AZBIL CORPORATION (Formerly YAMATAKE CORPORATION)
8 . P0558	NAGANO KEIKI SEISAKUSHO
U.K.	
9 . P0198	DELTA CONTROLS LTD.
U.S.A.	
10 . P0743	SOR INC.
11 . P0899	UNITED ELECTRIC CONTROLS CO.

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310311 : VOL. SEAL PRESSURE.&DP SWITCHES (UREA SERVICE)

CODE	NAME
INDIA	
1 . P3477	NESSTECH INSTRUMENTS PRIVATE LIMITED
2 . P3427	ENDRESS+HAUSER (INDIA) PVT. LTD.
3 . P3456	PRECISION MASS PRODUCTS PVT. LTD.
ITALY	
4 . P0746	SPRIANO SPA
U.K.	
5 . P0198	DELTA CONTROLS LTD.
U.S.A.	
6 . P0743	SOR INC.

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310401 : TRANSPARENT/ REFLEX / BICOLOR MAG.LEVEL GAUGES

CODE	NAME
INDIA	
1 . P0151	ABB INDIA LIMITED
2 . P3414	BLISS ANAND PRIVATE LIMITED
3 . P3181	CHEMTROLS SAMIL (INDIA) PVT LTD.
4 . P3433	FLOWTECH INSTRUMENTS SERVICES
5 . P3466	GAUGES BOURDON INDIA PVT. LTD (Mfg. unit of GIC)
6 . P3400	NISAN SCIENTIFIC PROCESS EQUIPMENTS PVT. LTD. (Transparent/ Reflex type Level Gauge : Upto 600#; Tubular Type Level Gauges : Upto 150#)
7 . P3186	PUNE TECHTROL PVT.LTD. (<=300# rating only)
8 . P0792	TECNOMATIC (INDIA) PVT. LTD.
9 . P3491	V.AUTOMAT & INSTRUMENTS (P) LTD
10 . P0871	V.AUTOMAT & INSTRUMENTS (P) LTD. (upto 300#)
AUSTRIA	
11 . P0672	RICHARD KLINGER AG
ITALY	
12 . P0150	CESARE BONETTI SPA
13 . P0791	TECHNOMATIC SPA
JAPAN	
14 . P0577	NIHON KLINGAGE CO. LTD.
U.S.A.	
15 . P0161	CLARK-RELIANCE CORP.

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310401 : TRANSPARENT/ REFLEX / BICOLOR MAG.LEVEL GAUGES

CODE	NAME
16 . P0425	JERGUSON GAUGE & VALVE CO.
17 . P0889	TYCO INTERNATIONAL INC.,U.S.A.

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310402 : LEVEL SWITCHES (FLOAT & DISPLACER TYPE)

CODE	NAME
GERMANY	
1 . P3430	VEGA GRIESHABER KG ((Tuning fork, Capacitance, Radar))
INDIA	
2 . P0151	ABB INDIA LIMITED
3 . P3414	BLISS ANAND PRIVATE LIMITED
4 . P3181	CHEMTROLS SAMIL (INDIA) PVT LTD.
5 . P3466	GAUGES BOURDON INDIA PVT. LTD (Mfg. unit of GIC)
6 . P3186	PUNE TECHTROL PVT.LTD.
7 . P3459	SBEM PVT. LTD.
8 . P3417	SIEMENS LTD. ((Ultrasonic, Vibrating Fork, Capacitance, Paddle))
9 . P3491	V.AUTOMAT & INSTRUMENTS (P) LTD
10 . P0871	V.AUTOMAT & INSTRUMENTS (P) LTD. (upto 300# , Non-critical service)
BELGIUM	
11 . P0502	MAGNETROL INTERNATIONAL N.V.
U.K.	
12 . P0408	ISA CONTROLS LIMITED
13 . P0441	KDG MOBREY LTD.
U.S.A.	
14 . P0743	SOR INC.

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310403 : DISPLACER TYPE LEVEL TRANSMITTERS

CODE	NAME
INDIA	
1 . P0153	CHEMTROLS INDUSTRIES LTD.
2 . P3183	DRESSER VALVE INDIA PVT LTD (Rating <= 600#)
3 . P3491	V.AUTOMAT & INSTRUMENTS (P) LTD
BELGIUM	
4 . P0502	MAGNETROL INTERNATIONAL N.V. (LVDT)
FRANCE	
5 . P0518	DRESSER MASONEILAN
GERMANY	
6 . P0282	FOXBORO ECKARDT GmbH
ITALY	
7 . P0618	PARCOL SPA (Pneumatic Transmission only)

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310404 : NUCLEONIC LEVEL TRANSMITTER

CODE	NAME
GERMANY	
1 . P3430	VEGA GRIESHABER KG
INDIA	
2 . P3465	EIP ENVIRO LEVEL CONTROLS PRIVATE LIMITED
GERMANY	
3 . P0101	BERTHOLD TECHNOLOGIES GMBH & CO.KG
4 . P0238	ENDRESS + HAUSER GMBH & CO.,
U.S.A.	
5 . P0439	KAY RAY

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310405 : CAPACITANCE TYPE LEVEL TRANSMITTER

CODE	NAME
GERMANY	
1 . P3430	VEGA GRIESHABER KG
INDIA	
2 . P3427	ENDRESS+HAUSER (INDIA) PVT. LTD.
3 . P3417	SIEMENS LTD.
BELGIUM	
4 . P0502	MAGNETROL INTERNATIONAL N.V.
GERMANY	
5 . P0238	ENDRESS + HAUSER GMBH & CO.,
6 . P0467	KROHNE
U.K.	
7 . P0441	KDG MOBREY LTD.

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310406 : TANK LEVEL INSTRUMENTS

CODE	NAME
INDIA	
1 . P0151	ABB INDIA LIMITED
2 . P3465	EIP ENVIRO LEVEL CONTROLS PRIVATE LIMITED
3 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
4 . P3186	PUNE TECHTROL PVT.LTD.
5 . P3459	SBEM PVT. LTD.
6 . P3417	SIEMENS LTD. ((Radar Level Transmitter, Guded Wave Radar))
GERMANY	
7 . P0238	ENDRESS + HAUSER GMBH & CO., (Non-contact & servo)
8 . P0467	KROHNE (Non-contact type)
JAPAN	
9 . P0816	TOKYO KEISO CO. LTD.
SINGAPORE	
10 . P0240	ENRAF SINGAPORE PTE. LTD.
U.S.A.	
11 . P0480	L & J TECHNOLOGIES

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310408 : RESITIVE ELECTRODE TYPE LEVEL INSTRUMENT

CODE	NAME
U.S.A.	
1 . P0161	CLARK-RELIANCE CORP.
2 . P0706	SCHLUMBERGER RESOURCE MANAGEMENT LTD.

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310409 : SPECIAL LEVEL SWITCHES (VIBRATION FORK/RF ADMITTANCE)

CODE	NAME
INDIA	
1 . P0151	ABB INDIA LIMITED
2 . P3465	EIP ENVIRO LEVEL CONTROLS PRIVATE LIMITED
3 . P3404	PROTOCONTROL INSTRUMENTS (I) PVT. LTD. (For Non Critical application)
GERMANY	
4 . P0238	ENDRESS + HAUSER GMBH & CO.,
U.S.A.	
5 . P0743	SOR INC.

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310410 : ULTRASONIC LEVEL TRANSMITTER

CODE	NAME
GERMANY	
1 . P3430	VEGA GRIESHABER KG
INDIA	
2 . P3465	EIP ENVIRO LEVEL CONTROLS PRIVATE LIMITED
3 . P3417	SIEMENS LTD.

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310411 :TANK FARM MANAGEMENT

CODE	NAME
INDIA	
1 . P3427	ENDRESS+HAUSER (INDIA) PVT. LTD. (Servo, Radar)

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310412 : GUIDED WAVE RADAR

CODE	NAME
GERMANY	
1 . P3430	VEGA GRIESHABER KG
INDIA	
2 . P3427	ENDRESS+HAUSER (INDIA) PVT. LTD.

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310413 : NUCLEONIC DENSITY METER

CODE	NAME
GERMANY	
1 . P3430	VEGA GRIESHABER KG
INDIA	
2 . P3465	EIP ENVIRO LEVEL CONTROLS PRIVATE LIMITED

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310501 : TEMPERATURE ELEMENTS (THERMOCOUPLE, RTD)

CODE	NAME
INDIA	
1 . P3477	NESSTECH INSTRUMENTS PRIVATE LIMITED
2 . P3483	WIKA INSTRUMENTS INDIA PVT.LTD
3 . P0151	ABB INDIA LIMITED
4 . P3184	ALTOP INDUSTRIES LTD. (only normal type (MI))
5 . P0201	DETRIV INSTRUMENTATION & ELECTRONICS LTD (Only Normal Type)
6 . P0227	ELECTRICAL & ELECTRONICS CORPORATION,
7 . P0232	ELEIND ENGINEERING PVT. LTD. (Only Normal Type)
8 . P3427	ENDRESS+HAUSER (INDIA) PVT. LTD.
9 . P3439	EXOTHERM INSTRUMENTS
10 . P3466	GAUGES BOURDON INDIA PVT. LTD (Mfg. unit of GIC)
11 . P0304	GENERAL INSTRUMENTS CONSORTIUM,
12 . P3436	GOA INSTRUMENTS INDUSTRIES PVT. LTD.
13 . P0390	INDUSTRIAL INSTRUMENTATION, (Only Normal Type)
14 . P3470	ITEC MEASURES PRIVATE LIMITED
15 . P3469	MICRO PROCESS CONTROLS
16 . P3517	MILLENNIUM INSTRUMENTS LIMITED
17 . P3456	PRECISION MASS PRODUCTS PVT. LTD.

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310501 : TEMPERATURE ELEMENTS (THERMOCOUPLE, RTD)

CODE	NAME
18 . P3402	PYRO ELECTRIC INSTRUMENTS GOA PVT. LTD. (A.Thermocouple Assemblies with / without Thermowelss; B. RTD Assemblies with / without Thermowells.)
19 . P3507	TECHNO INSTRUMENTS
20 . P3420	TEMPSENS INSTRUMENTS (I) PVT. LTD.
21 . P3454	THERMAL INSTRUMENT INDIA PVT.LTD. (All Ranges)
22 . P3416	UNICONTROLS INSTRUMENTS PVT. LTD.
GERMANY	
23 . P0716	SENSYCON (M/S DEGUSSA AG)
24 . P0884	W.C. HERAEUS GMBH
HOLLAND	
25 . P0807	THERMO ELECTRIC CO. LTD.
JAPAN	
26 . P0888	AZBIL CORPORATION (Formerly YAMATAKE CORPORATION)
27 . P0600	OKAZAKI MANUFACTURING CO.

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310502 : BIMETALLIC THERMOMETER

CODE	NAME
1 . P3185	
INDIA	
2 . P3477	NESSTECH INSTRUMENTS PRIVATE LIMITED
3 . P0081	A N INSTRUMENTS PVT. LTD.
4 . P3103	BAUMER TECHNOLOGIES INDIA PVT. LTD.(FORMERLY WAAREE INSTRUM
5 . P3496	FORBES MARSHALL (HYD) PRIVATE LIMITED ((-50 'C to -400'C))
6 . P3466	GAUGES BOURDON INDIA PVT. LTD (Mfg. unit of GIC)
7 . P0304	GENERAL INSTRUMENTS CONSORTIUM,
8 . P3436	GOA INSTRUMENTS INDUSTRIES PVT. LTD.
9 . P0371	H.GURU INDUSTRIES
10 . P3470	ITEC MEASURES PRIVATE LIMITED
11 . P0468	KROHNE MARSHALL PVT. LTD.
12 . P3517	MILLENNIUM INSTRUMENTS LIMITED
13 . P3456	PRECISION MASS PRODUCTS PVT. LTD.
14 . P3454	THERMAL INSTRUMENT INDIA PVT.LTD.
ITALY	
15 . P0791	TECHNOMATIC SPA
JAPAN	

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310502 : BIMETALLIC THERMOMETER

CODE	NAME
16 . P0558	NAGANO KEIKI SEISAKUSHO
SWITZERLAND	
17 . P0690	RUEGER SA
U.S.A.	
18 . P0827	TREND INSTRUMENT INC.

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310503 : DIAL THERMOMETER (Hg in Steel/Glass)

CODE	NAME
1 . P3185	
INDIA	
2 . P3477	NESSTECH INSTRUMENTS PRIVATE LIMITED
3 . P3483	WIKA INSTRUMENTS INDIA PVT.LTD
4 . P0081	A N INSTRUMENTS PVT. LTD.
5 . P3103	BAUMER TECHNOLOGIES INDIA PVT. LTD.(FORMERLY WAAREE INSTRUM
6 . P3496	FORBES MARSHALL (HYD) PRIVATE LIMITED (HG in Steel / Glass); (-50 'C to 600'C))
7 . P3466	GAUGES BOURDON INDIA PVT. LTD (Mfg. unit of GIC)
8 . P0304	GENERAL INSTRUMENTS CONSORTIUM,
9 . P3436	GOA INSTRUMENTS INDUSTRIES PVT. LTD. (Liquid filled, Gas filled, Mercury in steel)
10 . P0371	H.GURU INDUSTRIES
11 . P3470	ITEC MEASURES PRIVATE LIMITED
12 . P3469	MICRO PROCESS CONTROLS
13 . P3517	MILLENNIUM INSTRUMENTS LIMITED
14 . P0622	PEEJEE ENGG. WORKS
15 . P3456	PRECISION MASS PRODUCTS PVT. LTD.
16 . P3454	THERMAL INSTRUMENT INDIA PVT.LTD.

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310503: DIAL THERMOMETER (Hg in Steel/Glass)

	CODE	NAME
17.	P0874	WALCHANDNAGAR INDUSTRIES LTD.

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310504 : RADIATION PYROMETER

CODE	NAME
INDIA	
1 . P3420	TEMPSENS INSTRUMENTS (I) PVT. LTD.
GERMANY	
2 . P0735	SIEMENS AG, GERMANY
ITALY	
3 . P0189	C.C.R. TECHNICO
JAPAN	
4 . P0155	CHINO CORPN.
U.K.	
5 . P0482	LAND INFRARED
U.S.A.	
6 . P0873	WAHL INSTRUMENTS

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310505 : TEMPERATURE TRANSMITTER

CODE	NAME
INDIA	
1 . P0151	ABB INDIA LIMITED
2 . P3427	ENDRESS+HAUSER (INDIA) PVT. LTD.
3 . P3417	SIEMENS LTD.
4 . P0891	YOKOGAWA INDIA LIMITED
JAPAN	
5 . P3415	M. SYSTEM CO., LTD., (Model No. B6U-B; Model No. 27HU-B)

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310506: TEMPERATURE SWITCHES

CODE	NAME
INDIA	
1 . P3436	GOA INSTRUMENTS INDUSTRIES PVT. LTD.

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310507: SPECIAL TEMPERATURE ELEMENTS

CODE	NAME
INDIA	
1. P3513	THERMAL INSTRUMENT INDIA PVT. LTD.

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310601 : GATE/PLUG VALVES

CODE	NAME
INDIA	
1 . P0077	AUDCO INDIA LIMITED(L&T VALVES DIVN.)
2 . P0115	BHEL (VALVES DIVISION)
3 . P3181	CHEMTROLS SAMIL (INDIA) PVT LTD. (For Plug Valves only)
4 . P3424	FLOWSERVE INDIA CONTROL PVT. LTD. (Plug Valve upto 12" 300#, uptp 6" 600#)
5 . P0473	KSB PUMPS LIMITED (VALVES DIVN)
6 . P3441	NU TECH CONTROLS (MOV Gate : ½" to 8" - 2500#; 10" to 14" - 300#)
7 . P3105	SAMSON CONTROLS PVT. LTD. (Upto 34" - 300 #)
8 . P3460	VALVE-TECH INDUSTRIES ((MOV - 8" Upto 2500#) Non Critical)
9 . P3448	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (GATE VALVE : Upto 14" 150#; 2"-12" upto 600#; 2"-12" 900# to 1500#; PLUG VALVE:Upto 16" 150#;2"-12" upto 300#;2"-3" upto 600#)
india	
10 . P3461	VALTECH INDUSTRIES (Upto 28" - 150#)
CANADA	
11 . P0857	VELAN INC. (Size : ¼" to 24" (Rating upto 2500 #), Size : 26" to 30" (Rating upto 600#))
FRANCE	
12 . P0507	MALBRANQUE S.A.
ITALY	
13 . P0150	CESARE BONETTI SPA
14 . P0253	FASANI S.P.A.
15 . P0628	PETROL VALVES S.R.L

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310601 : GATE/PLUG VALVES

CODE	NAME
JAPAN	
16 . P0520	MATSURA H. P MACHINE WORKS CO.LTD.,
U.K.	
17 . P0097	BEL VALVES

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310602 : GLOBE / ANGLE VALVES

CODE	NAME
INDIA	
1 . P3449	AST S.P.A (Up to 8" 900#, Urea Grade Also)
2 . P0153	CHEMTROLS INDUSTRIES LTD. ((For Water and Steam))
3 . P3425	CIRCOR FLOW TECHOLOGIES INDIA PVT. LTD. (Globe 2" to 16" 300#, Angle 12" 2500#)
4 . P3183	DRESSER VALVE INDIA PVT LTD (Rating <= 600# , Size 3/4 to 6")
5 . P3437	EMET CONTROLS PVT. LTD. (Globe Valve Upto 4" 300#, Angle Valve upto 1½" 2500#)
6 . P3424	FLOWSERVE INDIA CONTROL PVT. LTD. (Globe Valve upto 30" 600#, upto 24" 900#, upto 16" 2500#, upto 4" 4500#)
7 . P0400	INSTRUMENTATION LTD. (PALAKKAD) (=<2500#,except slurry,noise,cavitatation)
8 . P3401	KOSO INDIA PVT. LTD. (Globe Valves :Upto 8": 2500#, 10" to 18": 300#; Angle Valves : Upto 8" : 300#)
9 . P3463	L&T VALVES LTD. (Upto 24" - 1500#, except Urea Grade)
10 . P3495	MASCOT VALVES PRIVATE LIMITED (UP TO 12"-150-300#)
11 . P0536	MIL CONTROLS LIMITED (Globe Valves:Size upto 24" & Rating upto 2500#(except slurry); Angle Valves:Upto 20" & Rating upto 2500# (except slurry))
12 . P3441	NU TECH CONTROLS (10" 150# for non-critical services)
13 . P3455	PNEUCON VALVES PVT. LTD. (Globe Valves, Upto 6" - 300#, Non Critical)
14 . P0656	R K CONTROL INSTRUMENTS PVT. LTD. (½" to 4" 1500#; 6" to 8" 150#, Water and Non-critical services)
15 . P3105	SAMSON CONTROLS PVT. LTD. (Upto 6" & Rating :=<600# (for small Projects))
16 . P3406	SEVERN GLOCON INDIA PVT. LTD. (1" - 30" 900#; Upto 20" 2500#)
17 . P3426	TECNIK VALVES PVT. LTD. (Globe Valve (upto 4" - 150#, Air & Water service))

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310602 : GLOBE / ANGLE VALVES

CODE	NAME
18 . P3508	TECNIK VALVES PVT.LTD.
19 . P3460	VALVE-TECH INDUSTRIES ((MOV - 8" Upto 300#, 4" Upto 2500#) Non Critical)
india	
20 . P3461	VALTECH INDUSTRIES (Upto 3" - 300#)
FRANCE	
21 . P0518	DRESSER MASONEILAN (=<2500#,Urea service also)
GERMANY	
22 . P0058	ARCA-REGLER GMBH (=< 2500#)
ITALY	
23 . P0618	PARCOL SPA (=<2500#,Urea service also)
JAPAN	
24 . P0888	AZBIL CORPORATION (Formerly YAMATAKE CORPORATION) (=<2500#)
25 . P0582	NIPPON FISHER CO. LTD. (=<2500#)
SINGAPORE	
26 . P0261	FISHER XOMOX (=< 2500#)
U.S.A.	
27 . P0854	FLOWSERVE (=<2500#)

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310603 : BALL VALVES

CODE	NAME
INDIA	
1 . P3419	ANAND TEKNOW AIDS ENGINEERING INDIA LIMITED (UPTO 6", 600# (ON-OFF))
2 . P3434	BRAY CONTROLS INDIA PVT. LTD. (Upto 4" - 300#)
3 . P3505	CAIR EUROMATIC AUTOMATION PVT. LTD. (Non -critical services)
4 . P3484	DELVAL FLOW CONTROLS PVT.LTD. (up to 8"-300# and 8"-18"- 600#)
5 . P3437	EMET CONTROLS PVT. LTD. (Upto 8" 150#, For Air Service)
6 . P3424	FLOWSERVE INDIA CONTROL PVT. LTD. (Upto 16" 600#)
7 . P3450	INTERVALVE POONAWALLA LIMITED (Upto 10" 150#)
8 . P3401	KOSO INDIA PVT. LTD. (Upto 8": 2500 # , 10" to 18": 900#)
9 . P3463	L&T VALVES LTD. (Upto 24" - 2500#, except Urea Grade)
10 . P3495	MASCOT VALVES PRIVATE LIMITED (UP TO 14"-300#)
11 . P3464	METSO INDIA PVT. LTD. (ON-OFF VALVE Upto 18" - 150#)
12 . P3468	MICROFINISH VALVES PVT. LTD. (Ball Valve :24" - 300#, 18" - 600#, 16" - 900#)
13 . P3441	NU TECH CONTROLS (14" 600# for non-critical services)
14 . P3111	PENTAIR VALVES AND CONTROLS INDIA PRIVATE LIMITED (=< 150 #)
15 . P3455	PNEUCON VALVES PVT. LTD. (Upto 6" - 150#. Non Critical)
16 . P3196	ROTEX MANUFACTURERS & ENGINEERS PRIVATE LIMITED (6" - 600#, 6" to 10" - 300#)
17 . P3105	SAMSON CONTROLS PVT. LTD. (Upto 24" - 1500#)

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310603 : BALL VALVES

CODE	NAME
18 . P3460	VALVE-TECH INDUSTRIES ((On-Off Metal Seated Valve 18" - 150#) Non Critical)
19 . P3518	VENTIL FLOWSERVE PVT. LTD. (1.5" TO 12" 150#)
20 . P0865	VIRGO ENGINEERS LTD. (=<600# with Maccair actuators)
21 . P3448	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (Upto 16" 150#)
india	
22 . P3461	VALTECH INDUSTRIES (Upto 6" - 150#)
CANADA	
23 . P0857	VELAN INC. (Ball Valves (On/Off) Size : ¼" to 6" (Rating upto 2500 #), Size: 8" to 16"(Rating upto 900#), Size: 18" to 30" Rating upto 300#))
GERMANY	
24 . P3409	PERRIN GmbH (Size: ½ " to 12" & Rating 150# to 2500#; Size: 14" to 18" & Rating: 150# to 1500#; Size : 20" to 24" & Rating: 150# & 300#)
ITALY	
25 . P0476	GTC ITALIA, S.R.L. (=<300#)
26 . P0628	PETROL VALVES S.R.L
27 . P0631	PIBIVIESSE SRL (rating upto 2500 #)
SINGAPORE	
28 . P0568	METSO AUTOMATION (=<2500#)
29 . P0606	ORBIT VALVES PLC (=<2500#)

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310604 : BUTTERFLY VALVES

CODE	NAME
INDIA	
1 . P3451	ADVANCE VALVES PVT.LTD. (Size: 2" to 24" upto 600 #)
2 . P3434	BRAY CONTROLS INDIA PVT. LTD. (Upto 300#)
3 . P3505	CAIR EUROMATIC AUTOMATION PVT. LTD. (Non -critical services)
4 . P3484	DELVAL FLOW CONTROLS PVT.LTD. (2"-24" 150# and 2"-14" 300#)
5 . P3437	EMET CONTROLS PVT. LTD. (Upto 4" 900#, 6" 150# to 16" 150#, double eccentric)
6 . P3424	FLOWSERVE INDIA CONTROL PVT. LTD. (Upto 30" 300#, upto 12" 600#)
7 . P0400	INSTRUMENTATION LTD. (PALAKKAD) (=< 300#)
8 . P3450	INTERVALVE POONAWALLA LIMITED (2" to 48" 150#)
9 . P3401	KOSO INDIA PVT. LTD. (Upto 12": 600#, 12" to 40": 300#)
10 . P3463	L&T VALVES LTD. (Upto 36" - 1500#, except Urea Grade)
11 . P3495	MASCOT VALVES PRIVATE LIMITED (UP TO 30"-150#)
12 . P3464	METSO INDIA PVT. LTD. (CONTROL VALVE Upto 4" - 300# ; ON-OFF VALVE Upto 16" - 300#)
13 . P3441	NU TECH CONTROLS (16" 300# for non-critical services)
14 . P3111	PENTAIR VALVES AND CONTROLS INDIA PRIVATE LIMITED (=< 150 #)
15 . P3455	PNEUCON VALVES PVT. LTD. (Upto 8" - 150#, Non Critical)
16 . P0656	R K CONTROL INSTRUMENTS PVT. LTD. (Upto 8" 150# Cooling Water, Non-critical services)
17 . P3196	ROTEX MANUFACTURERS & ENGINEERS PRIVATE LIMITED (Upto 8" - 150#)

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310604 : BUTTERFLY VALVES

CODE	NAME
18 . P3105	SAMSON CONTROLS PVT. LTD. (Upto 32 - 150#)
19 . P3406	SEVERN GLOCON INDIA PVT. LTD. (Up to 42"-150#, up to 30"-300#, up to 30"-600#)
20 . P3460	VALVE-TECH INDUSTRIES (Non-Crtical)
21 . P0865	VIRGO ENGINEERS LTD. (=<300#)
22 . P3448	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (Upto 16" 300#)
KOREA	
23 . P3403	KOREA UNICOM VALVE CO. LTD. (For Rating =<300 #)
USA	
24 . P3198	BRAY CONTROLS, USA (Rating : <= 300#)
india	
25 . P3461	VALTECH INDUSTRIES (Upto 6" - 300#)
ITALY	
26 . P3193	ORTON S.r.l. (Upto 2500#)
27 . P0618	PARCOL SPA (=< 2500# Urea Service also)
SINGAPORE	
28 . P0448	KEYSTONE (Upto 2500#)
29 . P0568	METSO AUTOMATION (Upto 2500#)
U.K.	
30 . P0489	LEEDS VALVE LTD

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310605: SAUNDERS (PINCH) VALVES

CODE	NAME
INDIA	
1 . P0093	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (Upto 150#)

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310606 : SOLENOID VALVES

CODE	NAME

1 .

INDIA

2 . P0062 ASCO (INDIA) LIMITED

3 . P3438 AVCON CONTROLS PVT. LTD. (For Non-critical areas)

4 . P0682 ROTEX AUTOMATION LIMITED

5 . P3447 SCHRADER DUNCAN LTD. (1/8" to 1½" Port size (For Non-critical Applications))

6 . P3444 U FLOW AUTOMATION (Non-critical)

GERMANY

7 . P0375 IMI NORGREN-HERION FLUIDTRONIC GMBH&CO.

U.K.

8 . P0031 ALEXENDER CONTROLS LTD.,

9 . P0061 ASCO JOUCOMATIC LTD.

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310607 : PRDS & SPRAY NOZZLE,VENT VALVES upto 2500#

CODE	NAME
INDIA	
1 . P3106	ARCA (FORBES MARSHAL) (Mech.spray nozzle type desuperheater only)
2 . P0153	CHEMTROLS INDUSTRIES LTD. ((PRDS Combine & Split))
3 . P3425	CIRCOR FLOW TECHOLOGIES INDIA PVT. LTD. (1" to 20" Upto 150#, 1" to 10" Upto 1500#, 1" to 8" Upto 2500#)
4 . P0170	CONTROL COMPONENTS INC.
5 . P3401	KOSO INDIA PVT. LTD. (Hp steam Inlet Size & Rating: 10" 2500# MP/LP Steam Outlet size Rating: 12" 600#)
6 . P3495	MASCOT VALVES PRIVATE LIMITED (UP TO 8"-150-2500#)
7 . P3105	SAMSON CONTROLS PVT. LTD. (Upto 6" - 150#)
SWEDEN	
8 . P0135	CCI VALVE TECHNOLOGY AB
U.S.A.	
9 . P0174	SPX VALVES & CONTROLS (COPES-VULCAN LTD)

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310611 : ELECTRIC ACTUATOR

CODE	NAME
INDIA	
1 . P3445	CAIR EUROMATIC AUTOMATION PVT.LTD. (Non-critical)
2 . P3500	AUMA INDIA PRIVATE LIMITED
3 . P3505	CAIR EUROMATIC AUTOMATION PVT. LTD.
4 . P1147	MARSH AUTOMATION PVT. LTD. (FOR SAFE AREA)
GERMANY	
5 . P0684	ROTORK CONTROL (DEUTSCHLAND) GMBH
ITALY	
6 . P0117	BIFFI ITALIA S.R.L.
U.S.A.	
7 . P0493	LIMITORQUE, U.S.A.

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310613 : AIR FILTER REGULATOR

CODE	NAME
INDIA	
1 . P0151	ABB INDIA LIMITED
2 . P0207	DIVYA CONTROL ELEMENTS PVT. LTD.
3 . P0633	PLACKA INSTRUMENTS & CONTROLS PVT. LTD.
4 . P3447	SCHRADER DUNCAN LTD. (¼" to 2" Port Size)
5 . P0722	SHAVO NORGREN (INDIA) PVT. LTD.

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310614 : LIMIT/PROXIMITY SWITCHES

CODE	NAME
INDIA	
1 . P3445	CAIR EUROMATIC AUTOMATION PVT.LTD. (Non-critical)
2 . P3505	CAIR EUROMATIC AUTOMATION PVT. LTD.
3 . P3195	EL-O-MATIC INDIA PRIVATE LIMITED
4 . P0608	OSNA ELECTRONICS PVT. LTD. (Intrinsically Safe Proximity Switches)
5 . P3109	PEPPERL + FUCH
6 . P3404	PROTOCONTROL INSTRUMENTS (I) PVT. LTD. (For Non Critical application)
7 . P3196	ROTEX MANUFACTURERS & ENGINEERS PRIVATE LIMITED
GERMANY	
8 . P3108	PEPPERL + FUCH
SINGAPORE	
9 . P0625	PEPPERL + FUCHS PTE LTD.
U.S.A.	
10 . P0363	HONEYWELL INC.,

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310615 : VALVE ACTUATOR (PNEUMATIC / ROTARY)

CODE	NAME
INDIA	
1 . P3434	BRAY CONTROLS INDIA PVT. LTD.
2 . P3195	EL-O-MATIC INDIA PRIVATE LIMITED
3 . P3515	MICROFINISH VALVES PRIVATE LIMITED
4 . P3196	ROTEX MANUFACTURERS & ENGINEERS PRIVATE LIMITED
5 . P3447	SCHRADER DUNCAN LTD. (Linear Actuator, ½" to 20" dia & Rotary Actuators 14 N-m to 3260 N-m Torque (For Non-critical Applications))
6 . P3521	SUSIN I-TORK INDIA PRIVATE LIMITED

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310616 : SELF ACTUATED PRESSURE CONTROL VALVES

CODE	NAME
INDIA	
1 . P3197	NIRMAL INDUSTRIAL CONTROLS PRIVATE LIMITED (Size: ½" to 6" & Rating : <= 300 #)
2 . P3441	NU TECH CONTROLS (Upto 10" 600#)
3 . P3455	PNEUCON VALVES PVT. LTD. (Upto 4" - 150#, Non Critical)
4 . P3105	SAMSON CONTROLS PVT. LTD. (Upto 2" - 150#)

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310617: SLAM SHUT OFF VALVE

CODE	NAME
INDIA	
1 . P3197	NIRMAL INDUSTRIAL CONTROLS PRIVATE LIMITED (Size: ½" to 6" & Rating: <= 300 #)

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310618: ELECTROPNEUMATIC POSITIONER

CODE	NAME
INDIA	
1. P3417	SIEMENS LTD.

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310619: TURBINE BYPASS VALVES

CODE	NAME
INDIA	
1 . P3425	CIRCOR FLOWTECHOLOGIES INDIA PVT. LTD. (2" to 24" upto 2500#)

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310620 : DESUPERHEATERS

CODE	NAME
INDIA	
1 .	CIRCOR FLOW TECHOLOGIES INDIA PVT. LTD. (Upto 24" 300#, Upto 28" 150#, Multi-Nozzle 3" to 4" Upto 2500#)
2 . P3437	EMET CONTROLS PVT. LTD. (Desuperheating Control Valves 1½" 600# x 3" 2500#)
3 . P3495	MASCOT VALVES PRIVATE LIMITED (UP TO 8"-150-2500#)

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310621 : PRESSURE REDUCING STATION

CODE	NAME
INDIA	
1 . P3425	CIRCOR FLOW TECHOLOGIES INDIA PVT. LTD. (1" to 20" Upto 150#, 1" to 10" Upto 1500#, 1" to 8" Upto 2500#)

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310622 : PRESSURE REGULATOR

CODE	NAME
INDIA	
1 . P0153	CHEMTROLS INDUSTRIES LTD.
2 . P3518	VENTIL FLOWSERVE PVT. LTD.

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310701 : SAFETY VALVES & THERMAL RELIEF VALVES upto 2500#

CODE	NAME
INDIA	
1 . P3449	AST S.P.A (Pressure relief valve Up to 8" 2500#; Up to 10" 300# , Urea Grade Also; Series SMFN & SMF & SU-7000)
2 . P3414	BLISS ANAND PRIVATE LIMITED (8" x 10" 300#; 6" x 8" 600#; 4" x 6" 1500#)
3 . P3188	FAINGER LESER VALVES (P) LTD. (UPTO 600#, 1/2" TO 6")
4 . P0400	INSTRUMENTATION LTD. (PALAKKAD)
5 . P0711	MEKASTER ENGG. LTD.(FORMERLY SEBIM VALVES INDIA PVT. LTD.) (upto 600#, Safety - 4"x6",Th.Relief-3/4"x1")
6 . P3502	NIRMAL INDUSTRIAL CONTROLS PVT.LTD. (Up to 2500#)
7 . P3441	NU TECH CONTROLS (Upto 2" - 300# x 3" - 150#)
8 . P0838	PENTAIR SANMAR LTD. (Formerly TYCO SANMAR LTD.)
9 . P3472	UNI KLINGER LIMITED (Safety Valves: IBR & NON IBR: 4" x 6" - 1500#; 6" x 8 - 600#; 8" x 10" - 300#; Safety Valves: IBR for Boiler Service : 4" x 6" - 1500#; Thermal Relief Valves: ½"-1 ½" - 1500#; 1"-1½" - 600#)
10 . P3460	VALVE-TECH INDUSTRIES (Non-Crtical)
11 . P3518	VENTIL FLOWSERVE PVT. LTD. (1/4" TO 1")
12 . P3448	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (Pressure Relief Valve Upto 8" 150# x10 150#; Upto 6" 300# x 8"150#, Upto 3" 600# x 4" 150#; Thermal Relief Valves : Series 9 Upto ½" 2500# x ½")
CANADA	
13 . P0214	DRESSER VALVE & CONTROLS
FRANCE	
14 . P0698	SAPAG GEC ALSTHOM
GERMANY	
15 . P0121	BOPP & REUTHER MESSTECHNIK GMBH
ITALY	

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310701 : SAFETY VALVES & THERMAL RELIEF VALVES upto 2500#

CODE	NAME
16 . P0618	PARCOL SPA (For Urea Service also)
17 . P0784	TAI MILANO S.P.A (For Urea Service also)
JAPAN	
18 . P0412	ITOCHU CORPORATION (REP.KUBOTA CORPN.)
THAILAND	
19 . P0794	TELEDYNE FLUID SYSTEMS
U.K.	
20 . P0186	CROSSBY VALVE & ENGG. COMPANY LTD.
21 . P0252	FARRIS
U.S.A.	
22 . P0213	DRESSER INDUSTRIES INCORPORATED

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310703 : VACUUM BREAKERS

CODE	NAME
INDIA	
1 . P3509	GROTH CONTINENTALMANUFACTURING PRIVATE LIMITED
2 . P3443	PROTEGO INDIA PVT. LTD. (With Flame Arrestors (Breather Valves))
GERMANY	
3 . P0126	BRAUNSCHWEIGER FLAMMENFILTER GMBH
ITALY	
4 . P0618	PARCOL SPA
5 . P0784	TAI MILANO S.P.A
JAPAN	
6 . P0411	ITOCHU CORPORATION
U.K.	
7 . P0021	SAFETY SYSTEMS UK LTD.
8 . P0878	WHESSOE VAREC LIMITED

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310704 : RUPTURE DISCS

CODE	NAME
INDIA	
1 . P0134	BS&B SAFETY SYSTEMS (INDIA) LIMITED
BELGIUM	
2 . P0258	FIKE EUROPE
FRANCE	
3 . P0698	SAPAG GEC ALSTHOM
THAILAND	
4 . P0794	TELEDYNE FLUID SYSTEMS
U.S.A.	
5 . P0169	CONTINENTAL CONTROLS INC.

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310705 : PILOT RELIEF VALVES

CODE	NAME
INDIA	
1 . P3449	AST S.P.A (Inlet size:- Upto 3", Upto 1500#, Outlet Size:- Upto 4", Upto 300 #; Inlet size:- Upto 4", Upto 300 #; Inlet size:- Upto 6" Upto 150# Outlet Size:- Upto 8" Upto 150 #)
2 . P3414	BLISS ANAND PRIVATE LIMITED (Size : 1" x 2" 2500#)
3 . P3509	GROTH CONTINENTALMANUFACTURING PRIVATE LIMITED
4 . P3472	UNI KLINGER LIMITED (PILOT OPERATED RELIEF VALVES: 4"X 6" - 900#; 8" X 10" - 300#)

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310706 : LOW PRESSURE RELIEF VALVES

CODE	NAME
INDIA	
1 . P3509	GROTH CONTINENTALMANUFACTURING PRIVATE LIMITED
2 . P3443	PROTEGO INDIA PVT. LTD. (Less Than 1 Bar With Flame Arrestors (Breather Valves))

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310708 : FLAME ARRESTOR

CODE	NAME
INDIA	
1 . P3509	GROTH CONTINENTALMANUFACTURING PRIVATE LIMITED
2 . P3443	PROTEGO INDIA PVT. LTD.

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310801 : CONTROL PANEL

CODE	NAME
INDIA	
1 . P0230	ELECTRONICS CORPORATION OF INDIA LTD
2 . P3458	EX- PROTECTA
3 . P3442	HULASI METALS PVT. LTD. (For safe area.)
4 . P0389	INDUSTRIAL CONTROL APPLIANCES (P) LTD.,
5 . P3485	IRIS AUTOMATION PVT.LTD.
6 . P0421	JAISUN & HUTCHISUN CONTROLS LTD.,
7 . P3407	PRIMA AUTOMATION (INDIA) PVT. LTD. (For package equipments)
8 . P0653	PYROTECH ELECTRONICS PVT.LTD.
9 . P3499	RITTAL INDIA PVT.LTD.
10 . P3432	TAN SWA TECHNOLOGIES INC
11 . P0841	UNITED ELECTRIC CO. (DELHI) PVT. LTD. (Upto 10 Mtrs.)
12 . P0891	YOKOGAWA INDIA LIMITED
HOLLAND	
13 . P0397	INSTROMET INTERNATIONAL N.V
14	Bharat Heavy Electrical Ltd. Electronics Division Bangalore

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310802 : PANEL ACCESS. (Relay,Switch,Lamp,Terminal,Push Button)

CODE	NAME
INDIA	
1 . P3487	CONNECTWELL INDUSTRIES PVT.LTD. (Terminal Block)
2 . P3411	ECONIX HI-TECH COMPONENTS PVT. LTD. (For Terminal Blocks & Accessories only)
3 . P3410	ELMEX CONTROLS PVT. LTD. (For Terminal Blocks & Accessories only)
4 . P3458	EX- PROTECTA
5 . P0430	JYOTI LIMITED (Relay)
6 . P0484	LARSEN & TOUBRO LTD.(CONTROL& AUTOMATION (Lamp, Push Button)
7 . P3421	PHOENIX CONTACT (INDIA) PVT. LTD. (For Terminal Blocks only)
8 . P3435	POWERCAM ELECTRICALS PVT. LTD. (For Pilot Lamp, Push Button only.)
9 . P0033	ROCKWELL AUTOMATION INDIA PVT. LTD. (Relays)
GERMANY	
10 . P0206	DIGITABLE THIELEN GMBH & CO
11 . P0630	PHOENIX CONTACT GMBH & CO.
12 . P0735	SIEMENS AG, GERMANY (Lamp,PushButton,Contactors)
13 . P0750	STAHL-UND APPARATEBAU HANS LEFFER GMBH (Lamp,PushButton)
14 . P0872	WAGO KONTAKLTECHNIK GMBH
15 . P0875	WEIDMULLER LTD. (Terminal)
JAPAN	
16 . P0605	OMRON CORPORATION (Relay)

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310802: PANEL ACCESS. (Relay,Switch,Lamp,Terminai,Push Button)

CODE	NAME
SINGAPORE	
17. P0625	PEPPERL +FUCHS PTE LTD. (Switch)

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310803 : PROGRAMABLE LOGIC CONTROLLER

CODE	NAME
INDIA	
1 . P3428	ABB INDIA LIMITED
2 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD. (Delta V SIS ESD System)
3 . P0296	GE FANUC SYSTEMS PRVITATE LIMITED
4 . P0787	HONEYWELL AUTOMATION INDIA LIMITED (Safety System)
5 . P0484	LARSEN & TOUBRO LTD.(CONTROL& AUTOMATION (Non Failsafe)
6 . P0543	MOORE CONTROLS LTD. (FailSafe)
7 . P3512	PHOENIX CONTACT INDIA PRIVATE LIMITED
8 . P0033	ROCKWELL AUTOMATION INDIA PVT. LTD. (Non Failsafe & Failsafe (ICS Triplex TMR, DMR))
9 . P3440	RTP CONTROLS INDIA PVT. LTD. (RTP 3000 TAS & SIS TMR/DMR SIL3 CERTIFIED PLS FOR TERMINAL AUTOMATION SYSTEM AND FIRE AND GAS APPLICATION)
10 . P0736	SIEMENS LTD. (Non Failsafe)
11 . P3417	SIEMENS LTD. (ESD- Simatic S7-400 FH / PLC - Simatic S-300, S7-400 (FMR/DMR))
12 . P0891	YOKOGAWA INDIA LIMITED (ESD System also)
SINGAPORE	
13 . P3503	TRISEN ASIA CONTROL PTE LTD.
GERMANY	
14 . P0348	HIMA PAUL HILDEBRANDT GMBH + CO KG (Failsafe)
ITALY	
15 . P0514	MARCONI ITALIANA (Non Failsafe)
JAPAN	

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310803 : PROGRAMABLE LOGIC CONTROLLER

CODE	NAME
16 . P0605	OMRON CORPORATION (Non Failsafe)

SINGAPORE

17 . P0829	TRICONEX (Fault Tolerant TMR)

U.S.A.

18 . P0295	GE FANUC AUTOMATION NORTH AMERICA, INC. (Fault Tolerant TMR)

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310804 : DISTRIBUTED CONTROL SYSTEM

CODE	NAME
INDIA	
1 . P3428	ABB INDIA LIMITED
2 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
3 . P0787	HONEYWELL AUTOMATION INDIA LIMITED
4 . P3467	ROCKWELL AUTOMATION INDIA PRIVATE LIMITED (PLANTPax (Offisite like DM Water Plant, ETP, Captive Power Plant, Sugar & Pharmaceutical Plant, Steel Sector, Mines))
5 . P3417	SIEMENS LTD. (Simatic - PCS7)
6 . P0891	YOKOGAWA INDIA LIMITED
USA	
7 . P3471	ROCKWELL AUTOMATION, INC (PlantPax)
GERMANY	
8 . P0735	SIEMENS AG, GERMANY
HOLLAND	
9 . P0284	INVENSYS
JAPAN	
10 . P0892	YOKOGAWA ELECTRIC CORPORATION
SINGAPORE	
11 . P0262	EMERSON PROCESS MGT SINGAPORE LTD
U.S.A.	
12 . P0084	BAILEY CONTROLS COMPANY
13 . P0363	HONEYWELL INC.,
14.	Bharat Heavy Electrical Ltd. Electronics Division Bangalore

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310805 : MULTIPLEXER / REMOTE I/O

CODE	NAME
INDIA	
1 . P0547	MTL INSTRUMENT LIMITED
2 . P3109	PEPPERL + FUCH
3 . P3512	PHOENIX CONTACT INDIA PRIVATE LIMITED
GERMANY	
4 . P3108	PEPPERL + FUCH
5 . P0750	STAHL-UND APPARATEBAU HANS LEFFER GMBH
JAPAN	
6 . P3415	M. SYSTEM CO., LTD., (Remote I/O: Model No. R3)
SINGAPORE	
7 . P0625	PEPPERL + FUCHS PTE LTD.
U.K.	
8 . P0554	M.T.L., U.K.

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310806 : RECEIVER INSTRUMENTS (INDICATOR,CONTROLLER,RECORDER)

CODE	NAME
INDIA	
1 . P0151	ABB INDIA LIMITED
2 . P0156	CHINO-LAXSONS (INDIA) PVT. LIMITED (Only Recorder)
3 . P0244	EUROTHERM DEL INDIA LIMITED
4 . P0787	HONEYWELL AUTOMATION INDIA LIMITED
5 . P3408	MASIBUS AUTOMATION & INSTRUMENTATION PVT. LTD. (Receiver Instruments except Recorder)
6 . P0543	MOORE CONTROLS LTD.
7 . P0891	YOKOGAWA INDIA LIMITED
GERMANY	
8 . P0735	SIEMENS AG, GERMANY
JAPAN	
9 . P0155	CHINO CORPN.
10 . P0490	HERAEUS ELECTRO-NITE INTERNATIONAL N.V.
11 . P0892	YOKOGAWA ELECTRIC CORPORATION
U.S.A.	
12 . P0363	HONEYWELL INC.,

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310807 : ALARM ANNUNCIATOR

CODE	NAME
INDIA	
1 . P0391	INDUSTRIAL INSTRUMENTS & CONTROLS
2 . P0729	SHREE ELECTRONICS
U.K.	
3 . P0554	M.T.L., U.K.
4 . P0674	ROCHESTER INSTRUMENT SYSTEMS LTD.,
U.S.A.	
5 . P0673	RILEY PANALARM
6 . P0677	RONAN ENGG. CO.,

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310808 : BARRIER/ISOLATOR/TRIP AMPLIFIER

CODE	NAME
INDIA	
1 . P0547	MTL INSTRUMENT LIMITED
2 . P3109	PEPPERL + FUCH
3 . P3512	PHOENIX CONTACT INDIA PRIVATE LIMITED
GERMANY	
4 . P0206	DIGITABLE THIELEN GMBH & CO
5 . P0282	FOXBORO ECKARDT GmbH
6 . P3108	PEPPERL + FUCH
7 . P0750	STAHL-UND APPARATEBAU HANS LEFFER GMBH
JAPAN	
8 . P3415	M. SYSTEM CO., LTD., (Signal Isolators Fittings: Model Nos. M2VS; M5VS; W2VS; W5VS; M3LU & 2M3LU2)
9 . P0892	YOKOGAWA ELECTRIC CORPORATION
SINGAPORE	
10 . P0625	PEPPERL + FUCHS PTE LTD.
SWITZERLAND	
11 . P0145	CAMILLE BAUER AG
U.K.	
12 . P0554	M.T.L., U.K.
U.S.A.	
13 . P0363	HONEYWELL INC.,

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310809 : TEMPERATURE SCANNER

CODE	NAME
INDIA	
1 . P0390	INDUSTRIAL INSTRUMENTATION,
2 . P3404	PROTOCONTROL INSTRUMENTS (I) PVT. LTD.

All rights reserved

310810: CCTV / ACCESS SYSTEM

CODE	NAME
INDIA	
1. P0787	HONEYWELL AUTOMATION INDIA LIMITED

All rights reserved

310815 : MISCELLENOUS ITEMS (RTU / SCADA ETC)

CODE	NAME
INDIA	
1 . P3428	ABB INDIA LIMITED
2 . P3512	PHOENIX CONTACT INDIA PRIVATE LIMITED
3 . P0033	ROCKWELL AUTOMATION INDIA PVT. LTD.
4 . P3417	SIEMENS LTD. (Simatic WINcc)

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310816: ENERGY METER

CODE	NAME
JAPAN	
1. P3415	M. SYSTEM CO., LTD., (Model No. 53U)

All rights reserved

310821 :SURGE PROTECTION DEVICES

CODE	NAME
INDIA	
1. P3421	PHOENIX CONTACT (INDIA) PVT. LTD.

All rights reserved

310824: WIRING DUCTS

CODE	NAME
INDIA	
1 . P3422	TRINITY TOUCH PVT. LTD.

All rights reserved

310825 : DIN RAIL

CODE	NAME
INDIA	
1 . P3487	CONNECTWELL INDUSTRIES PVT.LTD.
2 . P3422	TRINITY TOUCH PVT. LTD.

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310826 : INTERFACE MODULE

CODE	NAME
INDIA	
1 . P3487	CONNECTWELL INDUSTRIES PVT.LTD.
2 . P3422	TRINITY TOUCH PVT. LTD.

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310827: CABLE CONNECTOR

CODE	NAME
INDIA	
1. P3421	PHOENIX CONTACT (INDIA) PVT. LTD.

All rights reserved

310828: ADVANCE PROCESS CONTROL SYSTEM

CODE	NAME
INDIA	
1 . P0891	YOKOGAWA INDIA LIMITED

All rights reserved

310829: VIDEO WALL DLP CUBE AND VIDEO WALL CONTROLLER

CODE	NAME
INDIA	
1 . P3504	Delta Electronics India Private Limited

All rights reserved

310901 : MACHINE MONITORING SYSTEM

CODE	NAME
SWITZERLAND	
1 . P3480	MEGGITT SA
JAPAN	
2 . P3452	SHINKAWA ELECTRIC COMPANY LTD.
GERMANY	
3 . P0131	BRUEL & KJAER GMBH
SINGAPORE	
4 . P0738	SKF CONDITION MONITORING INC.
U.S.A.	
5 . P0100	BENTLEY NEVEDA LLC
6.	Bharat Heavy Electrical Ltd. Electronics Division Bangalore

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310902 : SPEED INDICATOR

CODE	NAME
GERMANY	
1 . P3108	PEPPERL + FUCH
JAPAN	
2 . P0725	SHINKAWA ELECTRIC CO.
SINGAPORE	
3 . P0625	PEPPERL + FUCHS PTE LTD.
SWITZERLAND	
4 . P0419	JACQUET
U.S.A.	
5 . P0100	BENTLEY NEVEDA LLC

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310903 : ANTI SURGE CONTROLLER

CODE	NAME
SINGAPORE	
1 . P3503	TRISEN ASIA CONTROL PTE LTD.
2 . P0167	COMPRESSOR CONTROL CORPORATION
3 . P0215	DRESSER - RAND CO.
4 . P0830	INVENSYS TRICONEX
5	Bharat Heavy Electrical Ltd. Electronics Division Bangalore

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311001 : BURNER MANAGEMENT SYSTEM

CODE	NAME
INDIA	
1 . P0216	DURAG INDUSTRIE ELEKTRONIK GMBH & CO KG
GERMANY	
2 . P0735	SIEMENS AG, GERMANY
JAPAN	
3 . P0888	AZBIL CORPORATION (Formerly YAMATAKE CORPORATION)
4 . P0540	MITSUBISHI HEAVY INDUSTRIES LTD.
5 . P0605	OMRON CORPORATION
U.S.A.	
6 . P0363	HONEYWELL INC.,
7.	Bharat Heavy Electrical Ltd. Electronics Division Bangalore

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311002: FURNACE CAMERA, HEATER, THREMAL IMAGER

CODE	NAME
INDIA	
1. P3420	TEMPSENS INSTRUMENTS (I) PVT. LTD.

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311101 : TERMINAL AUTOMATION SYSTEM

CODE	NAME
INDIA	
1 . P3428	ABB INDIA LIMITED
2 . P0153	CHEMTROLS INDUSTRIES LTD.
3 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
4 . P0787	HONEYWELL AUTOMATION INDIA LIMITED

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311501 : I/P CONVERTER

CODE	NAME
INDIA	
1 . P0151	ABB INDIA LIMITED
2 . P0263	EMERSON PROCESS MANAGEMENT (I) PVT. LTD.
3 . P0891	YOKOGAWA INDIA LIMITED
JAPAN	
4 . P0892	YOKOGAWA ELECTRIC CORPORATION
U.S.A.	
5 . P0678	EMERSON PROCESS MANAGEMENT LTD
6 . P0544	MOORE PRODUCTS COMPANY

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311601 : INSTRUMENT POWER & CONTROL CABLES

CODE	NAME
INDIA	
1 . P3514	ASSOCIATED CABLES PRIVATE LIMITED
2 . P0068	ASSOCIATED CABLES PVT. LTD.
3 . P0070	ASSOCIATED FLEXIBLES & WIRES PVT. LTD.
4 . P3501	CENTURION POWER CABLES PVT.LTD.
5 . P0176	CORDS CABLE INDUSTRIES LTD.
6 . P0200	DELTON CABLES LTD
7 . P3110	INSUCON CABLES & CONDUCTORS (P) LTD. (For smaller non-critical projects)
8 . P0416	J K CABLES LIMITED
9 . P0442	KEI INDUSTRIES LIMITED
10 . P3522	MIRACLE CABLES INDIA PVT. LTD.
11 . P0617	PARAMOUNT CABLE CORPORATION
12 . P3474	SUYOG ELECTRICALS LTD.
13 . P8086	T C COMMUNICATION PVT LTD
14 . P3506	TC WIRE & CABLES PRIVATE LIMITED
15 . P0809	THERMO CABLES LIMITED
16 . P0820	TOSHNIWAL CABLES
17 . P3191	UDEY PYRO CABLES PVT. LTD.

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311601 :INSTRUMENT POWER & CONTROL CABLES

CODE	NAME
ITALY	
18. P3516	RAMCRO S.P. A.

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311602 : EXTENSION & COMPENSATING CABLES

CODE	NAME
INDIA	
1 . P3514	ASSOCIATED CABLES PRIVATE LIMITED
2 . P0068	ASSOCIATED CABLES PVT. LTD.
3 . P0070	ASSOCIATED FLEXIBLES & WIRES PVT. LTD.
4 . P3501	CENTURION POWER CABLES PVT.LTD.
5 . P0176	CORDS CABLE INDUSTRIES LTD.
6 . P0200	DELTON CABLES LTD
7 . P0304	GENERAL INSTRUMENTS CONSORTIUM,
8 . P0416	J K CABLES LIMITED
9 . P0442	KEI INDUSTRIES LIMITED
10 . P0617	PARAMOUNT CABLE CORPORATION
11 . P3474	SUYOG ELECTRICALS LTD.
12 . P8086	T C COMMUNICATION PVT LTD
13 . P3506	TC WIRE & CABLES PRIVATE LIMITED
14 . P0809	THERMO CABLES LIMITED
15 . P0820	TOSHNIWAL CABLES
ITALY	
16 . P3516	RAMCRO S.P. A.

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311603 : SPECIAL CABLES (FOUNDATION FIELD BUS CABLES)

CODE	NAME
INDIA	
1 . P3489	LEONI CABLE SOLUTIONS (INDIA) PVT.LTD.
2 . P3486	M/S LAPP INDIA PVT.LTD.
3 . P3474	SUYOG ELECTRICALS LTD.
4 . P8086	T C COMMUNICATION PVT LTD
5 . P0809	THERMO CABLES LIMITED
6 .	THERMO CABLES LIMITED
ITALY	
7 . P3516	RAMCRO S.P. A. (PROFIBUS, MODBUS, COMMUNICATION CABLE (CAT-6, OFC))

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311606 : CABLE TRAYS & ACCESSORIES (AL./GI)

CODE	NAME
INDIA	
1 . P0312	GLOBE ELECTRICAL INDUSTRIES
2 . P0385	INDIANA ENGG WORKS PVT LTD
3 . P0529	METALITE INDUSTRIES
4 . P0619	PAREKH ENGINEERING COMPANY
5 . P3446	PARMAR METALS PVT. LIMITED
6 . P0695	SADHANA ENGINEERING CORPORATION
7 . P0756	STEELITE ENGINEERING LIMITED

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311607 : MULTI TRANSIT INLET SYSTEM

CODE	NAME
SWEDEN	
1 . P0522	MCT BRATTBERG AKTIEBOLAG
2 . P0685	ROXTEC AB
U.K.	
3 . P0339	HAWKE INTERNATIONAL

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311608 : JUNCTION BOX & CABLE GLAND

CODE	NAME
INDIA	
1 . P0089	BALIGA LIGHTING EQUIPMENTS LIMITED
2 . P3458	EX- PROTECTA
3 . P0147	FCG FLAMEPROOF CONTROL GEARS PVT. LTD. (FORMERLY CEAG FLAME
4 . P0268	FLAMEPROOF EQUIPMENTS PVT. LTD.
5 . P3412	FLEXPRO ELECTRICALS PVT. LTD.
6 . P3475	PHOENIX MECANO (INDIA) PVT.LTD.
7 . P3499	RITTAL INDIA PVT.LTD.
8 . P3432	TAN SWA TECHNOLOGIES INC (JUNCTION BOX)
9 . P3422	TRINITY TOUCH PVT. LTD. (Only Cable Glands upto Size 25M)
GERMANY	
10 . P0750	STAHL-UND APPARATEBAU HANS LEFFER GMBH

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311615 : CS SEAMLESS PIPES

CODE	NAME
INDIA	
1 . P0814	INDIAN TUBE CO. (TATA DIV. OF TUBES & PIPES)
2 . P0800	ISMT LIMITED
3 . P0503	MAHARASHTRA SEAMLESS LTD.
FRANCE	
4 . P0834	ETS TROUVAY & CAUVIN
5 . P0629	PHOCEENNE
GERMANY	
6 . P0477	HORST KURVERS GmbH
7 . P0509	MANNESMANN HANDEL AG
ITALY	
8 . P0191	DALMINE SPA
9 . P0175	IBF SEAMLESS PIPES Spa
JAPAN	
10 . P0517	MARUBENI ITOCHU STEEL
11 . P0585	NIPPON STEEL CORPORATION
12 . P0588	NISSHO IWAI CORPORATION
13 . P0601	OKURA & CO. LTD.
14 . P0575	SOJITZ CORPORATION
15 . P0770	SUMITOMO METAL INDUSTRIES LTD.

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311615 : CS SEAMLESS PIPES

CODE	NAME
KOREA	
16 . P0370	HYUNDAI CORPORATION
U.K.	
17 . P0870	VOMAL INTERNATIONAL LIMITED

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311616 : SS SEAMLESS PIPES

CODE	NAME
INDIA	
1 . P0158	CHOKSI TUBE COMPANY LTD.
2 . P3488	DIVINE TUBES PVT.LTD. (UPTO 38 MM)
3 . P3418	MAXIM TUBES COMPANY PVT. LTD.
4 . P0593	NUCLEAR FUEL COMPLEX
5 . P0661	RATNAMANI METALS & TUBES LIMITED
6 . P0659	REMI EDELSTAHL TUBULARS LTD.(RAJENDRA MECHANICAL INDUSTRIES
FRANCE	
7 . P0629	PHOCEENNE
GERMANY	
8 . P0822	TPS-TECHNITUBE ROHRENWERKE GMBH
ITALY	
9 . P0191	DALMINE SPA
SPAIN	
10 . P2151	T.T.I. - TUBACEX TUBOS INOXIDABLES, S.A. (½" NB SS Pipe)

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311617 : SS TUBES

CODE	NAME
INDIA	
1 . P3497	ASTEC VALVES & FITTINGS PRIVATE LIMITED
2 . P0158	CHOKSI TUBE COMPANY LTD.
3 . P3488	DIVINE TUBES PVT.LTD. (UPTO 18 MM)
4 . P3418	MAXIM TUBES COMPANY PVT. LTD.
5 . P0593	NUCLEAR FUEL COMPLEX
6 . P0661	RATNAMANI METALS & TUBES LIMITED
7 . P0659	REMI EDELSTAHL TUBULARS LTD.(RAJENDRA MECHANICAL INDUSTRIES
JAPAN	
8 . P0412	ITOCHU CORPORATION (REP.KUBOTA CORPN.)
9 . P0587	NISHITANI & CO. LTD.
10 . P0771	SUMITOMO METAL INDUSTRIES LTD.

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311618 : PIPE FITTINGS

CODE	NAME
INDIA	
1 . P3476	COMFIT & VALVES PVT.LTD.
2 . P0222	EBY INDUSTRIES
3 . P0247	EXCEL HYDRO-PNEUMATICS PVT LTD,
4 . P3519	GLOBAL VALVES AND FITTING (INDIA) PVT. LTD. (FOR NON IBR APPLICATION)
5 . P0534	MICRO PRECISION PRODUCTS PRIVATE LTD.
6 . P2109	PRECISION ENGINEERING INDUSTRIES
7 . P0792	TECNOMATIC (INDIA) PVT. LTD.
8 . P3518	VENTIL FLOWSERVE PVT. LTD.
9 . P3413	WESMEC ENGINEERING PVT. LTD.
FRANCE	
10 . P0149	CELLIER S.A.
GERMANY	
11 . P0508	SIEMENS AG PGI
12 . P0813	THYSSEN-KRUPP STAHLUNION GmbH
ITALY	
13 . P0150	CESARE BONETTI SPA
14 . P0791	TECHNOMATIC SPA
JAPAN	
15 . P0771	SUMITOMO METAL INDUSTRIES LTD.

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311618 : PIPE FITTINGS

CODE	NAME
U.K.	
16 . P0203	DEWRANCE & CO. LTD.
17 . P0366	HOPKINSONS LIMITED
18 . P0811	THOMPSON VALVES LTD.
19 . P0856	VELAN ENGINEERING CO. LIMITED
U.S.A.	
20 . P0049	ANDERSON GREENWOOD & CO.
21 . P0181	CRANE COMPANY INTL. SALES

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311619 : COMPRESSION FITTINGS

CODE	NAME
INDIA	
1 . P3192	ARYA CRAFTS & ENGINEERING PVT.LTD. (Upto Line Pressure Class 600 # rating.)
2 . P3182	AURA INC
3 . P0088	BALDOTA VALVE & FITTING CO.PVT.LTD.
4 . P3476	COMFIT & VALVES PVT.LTD.
5 . P0247	EXCEL HYDRO-PNEUMATICS PVT LTD,
6 . P0248	EXCELSIOR ENGG WORKS
7 . P3194	FLUID CONTROLS PRIVATE LIMITED ((Double Ferrule Compression Tube Fittings))
8 . P3519	GLOBAL VALVES AND FITTING (INDIA) PVT. LTD. (FOR NON IBR APPLICATION)
9 . P3493	HAVI ENGINEERING INDIA PVT.LTD
10 . P3189	PANAM ENGINEERS
11 . P2109	PRECISION ENGINEERING INDUSTRIES
12 . P0664	RELIANCE ENGG. & ELECTRICAL CORPN.
13 . P3518	VENTIL FLOWSERVE PVT. LTD.
14 . P0862	VIKAS INDUSTRIAL PRODUCTS
15 . P3413	WESMEC ENGINEERING PVT. LTD.
SINGAPORE	
16 . P0620	PARKER HANNIFIN SINGAPORE PTE. LTD.,
U.S.A.	

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311619: COMPRESSION FITTINGS

	CODE	NAME
17.	P0778	SWAGELOCK COMPANY/CREXIMCO

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311620 : INSTRUMENT MINIATURE VALVES

CODE	NAME
INDIA	
1 . P0077	AUDCO INDIA LIMITED(L&T VALVES DIVN.)
2 . P3182	AURA INC
3 . P0115	BHEL (VALVES DIVISION)
4 . P0153	CHEMTROLS INDUSTRIES LTD.
5 . P3181	CHEMTROLS SAMIL (INDIA) PVT LTD.
6 . P3476	COMFIT & VALVES PVT.LTD.
7 . P0247	EXCEL HYDRO-PNEUMATICS PVT LTD,
8 . P0248	EXCELSIOR ENGG WORKS
9 . P3194	FLUID CONTROLS PRIVATE LIMITED
10 . P3519	GLOBAL VALVES AND FITTING (INDIA) PVT. LTD. (FOR NON IBR APPLICATION)
11 . P3493	HAVI ENGINEERING INDIA PVT.LTD
12 . P0473	KSB PUMPS LIMITED (VALVES DIVN)
13 . P3189	PANAM ENGINEERS
14 . P0792	TECNOMATIC (INDIA) PVT. LTD.
15 . P3518	VENTIL FLOWSERVE PVT. LTD.
16 . P3413	WESMEC ENGINEERING PVT. LTD.
FRANCE	

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311620 : INSTRUMENT MINIATURE VALVES

CODE	NAME
17 . P0149	CELLIER S.A.
ITALY	
18 . P0103	BFE BONNEY FORGE VALVE LICENSEE
19 . P0243	EUROMISURE CREMONA
20 . P0791	TECHNOMATIC SPA
JAPAN	
21 . P0464	KOSEI SANGYO LTD
22 . P0771	SUMITOMO METAL INDUSTRIES LTD.
U.K.	
23 . P0203	DEWRANCE & CO. LTD.
24 . P0366	HOPKINSONS LIMITED
25 . P0856	VELAN ENGINEERING CO. LIMITED
U.S.A.	
26 . P0049	ANDERSON GREENWOOD & CO.
27 . P0181	CRANE COMPANY INTL. SALES
28 . P0778	SWAGELOCK COMPANY/CREXIMCO

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311621 : PURGE ROTAMETER

CODE	NAME
INDIA	
1 . P3199	EUREKA INDUSTRIAL EQUIPMENTS PRIVATE LIMITED
2 . P0398	INSTRUMENTATION ENGINEERS PVT. LTD.
3 . P0633	PLACKA INSTRUMENTS & CONTROLS PVT. LTD.

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311622 : AIR HEADER/ADPOT

CODE	NAME
INDIA	
1 . P3497	ASTEC VALVES & FITTINGS PRIVATE LIMITED
2 . P3476	COMFIT & VALVES PVT.LTD.
3 . P3413	WESMEC ENGINEERING PVT. LTD.

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311623 : CONDENSATE POT

CODE	NAME
INDIA	
1 . P3497	ASTEC VALVES & FITTINGS PRIVATE LIMITED
2 . P3476	COMFIT & VALVES PVT.LTD.
3 . P3413	WESMEC ENGINEERING PVT. LTD.

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311624 : VALVE MANIFOLDS

CODE	NAME
INDIA	
1 . P3497	ASTEC VALVES & FITTINGS PRIVATE LIMITED
2 . P3476	COMFIT & VALVES PVT.LTD.
3 . P3519	GLOBAL VALVES AND FITTING (INDIA) PVT. LTD. (FOR NON IBR APPLICATION)
4 . P3494	HAVI ENGINEERING INDIA PVT.LTD
5 . P3518	VENTIL FLOWSERVE PVT. LTD.
6 . P3413	WESMEC ENGINEERING PVT. LTD.

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311626: CALIBRATION EQUIPMENT & SERVICES

CODE	NAME
INDIA	
1. P3420	TEMPSENS INSTRUMENTS (I) PVT. LTD.

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311627 : ENCLOSURES

CODE	NAME
INDIA	
1 . P3458	EX- PROTECTA
2 . P3499	RITTAL INDIA PVT.LTD.
3 . P3422	TRINITY TOUCH PVT. LTD. (Weatherproof size 80 X 80 mm)
4.	Bharat Heavy Electrical Ltd. Electronics Division Bangalore

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311628: MONOFLANGES

CODE	NAME
INDIA	
1. P3497	ASTEC VALVES & FITTINGS PRIVATE LIMITED

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311629 : CLOSE COUPLE HOOK-UPS (CCHU)

CODE	NAME
INDIA	
1 .	ASTEC VALVES & FITTINGS PRIVATE LIMITED
2 . P3476	COMFIT & VALVES PVT.LTD.

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311631 : INSTRUMENTATION VALVES (NEEDLE VALVE & CHECK VALVES

CODE	NAME
INDIA	
1 . P3497	ASTEC VALVES & FITTINGS PRIVATE LIMITED
2 . P3476	COMFIT & VALVES PVT.LTD.

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311701 : INSTRUMENT CONTRACTOR FOR INST. CONSTRUCTION/ERECTION WORKS

CODE	NAME
INDIA	
1 . P3178	ANI INSTRUMENT (upto 0.5 Crores)
2 . P3429	GODREJ & BOYCE MFG. CO. LTD.
3 . P3177	INSTROCON ENGINEERS AND CONTROLS (I) PVT. LTD (upto 0.5 Crores)
4 . P3172	JASUBHAI ENGINEERING PVT. LTD.
5 . P3180	L&T (CONSTRUCTION CONTRACTS DIVN.)
6 . P3179	MIRAJ INSTRUMENTATION SERVICE (upto 0.5 Crores)
7 . P3187	NARAYAN ENGINEERING (< RS. 5 LACS (SMALL PROJECT))
8 . P3175	PACE PROCESS CONTROL PVT. LTD.
9 . P3173	PETRON ENGG. CONSTRUCTION LTD.
10 . P3176	PROTECH CONTROL PVT. LTD. (upto 0.5 Crores)
11 . P3511	SPARK AUTOMATION
12 . P3171	TECHNIMONT ICB LTD.

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311801 : ELECTRICAL HEAT TRACING

CODE	NAME

1 .

INDIA

2 . P3478 THERMOPADS PVT.LTD.

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Coal to 2000 TPD Ammonium Nitrate, LSTK-1

Basic Design Memorandum of Electrical and C&I For CHP, AHP, LHP System

BHARAT HEAVY ELECTRICALS LIMITED
INDUSTRIAL SYSTEM GROUP
BANGALORE-12

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Coal to 2000 TPD Ammonium Nitrate, LSTK-1

CABLE ERECTION PHILOSPHY

BHARAT HEAVY ELECTRICALS LIMITED
INDUSTRIAL SYSTEM GROUP
BANGALORE-12

1.0 Scope

1.1. This document is intended to cover the aspects of cable raceway design and installation, laying and termination of various types of cables for the following packages.

- Ash handling plant.
- Coal handling plant and Lime handling plant

1.2. Design calculations for cable sizing and selection & design memorandum for fire sealing system are covered in a separate document.

1.3. Latest revisions of all drawings / documents shall be referred.

1.4. Reference standards/ documents-IS: 1255 (Code of practice for installation and maintenance of power cables).

2.0 Cable Raceway System

2.1. Cables shall generally be laid in galvanised MS cable trays in multi-tier arrangement. The trays shall in turn be supported on fixed (welded) type cable tray support systems in cable vaults, along structural members/ concrete surfaces inside plant buildings in auxiliary plant buildings and interconnecting trenches/ pipe-cum-cable trestles. Cable trays shall be fixed to the horizontal/vertical arm of supporting structure as per the reference drawings above. Cables can be routed through cable duct bank wherever required. Stability of trays shall be ensured. Cable trays shall be well away from hot steam pipelines and shall not be immediately above or below the steam pipes.

2.2. Cable trays shall be oriented vertically in cable rack/Pipe rack area of CHP/LHP and AHP route, except in areas like MCC room, Pump Houses, Compressor Houses, TP's, Cable trays will be oriented horizontally. In other areas also if so required due to reasons such as space restriction, accessibility, plant aesthetics, operational clearances, etc. as per approved layout drawings. Branching of cables from main route shall be done through cable trench/slit/cable troughs. The cable slits to be used for motor/ equipment power/ control supply shall be sand filled & covered with PCC after cabling.

2.3. Cable trays shall have standard width of 150mm, 300mm & 600mm and standard lengths of 2.5m. Minimum thickness of mild steel sheets used for fabrication of cable trays shall be 2mm. Minimum thickness of side coupler pate shall be 3 mm. Cable trays shall be ladder type for power and control cables, while perforated type cable trays shall be used for instrumentation cables. For instrumentation and control purpose, some perforated type cable trays of width 100 & 50 mm may be used.

2.4. Deleted

2.5. The cable tray Support system is designed to withstand:

- weight of the cable trays.
- weight of the cables.
- Concentrated load of 75 Kg between every support span.
- Factor of safety of minimum 1.5 is considered.

2.6. Cable trays shall be ladder/perforated type as specified complete with matching fittings (like brackets, elbows, bends, tees, crosses, etc.) accessories (like side coupler plates, etc.) and hardware (like bolts, nuts, washers, G.I. strap, hook etc.) as required. Cable trays, fittings and accessories shall be fabricated out of rolled mild steel sheets free from flaws such as laminations, rolling marks, pitting etc. These (including hardware) shall be hot dip galvanized as per relevant IS.

2.7. Suitable cable tray accessories such as horizontal and vertical bends, crosses, tees, reducers etc. shall be used in conjunction with straight runs of cable trays wherever required as per approved layout drawings to ensure a continuous and break-free tray support system for cables. Cable tray accessories shall be fabricated from straight tray as per site requirement. However for Switchgear room, pre-fabricated tray accessories shall be supplied as per approved drawing titled "TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES",. They shall be applied with one coat of red lead primer, one coat of oil primer followed by two finishing coats of aluminium paint.

2.8. The cable tray support system shall comprise of galvanized MS channel/ angle as main supports. The main supports MS members shall be fixed by welding in any of the following ways:

a) Welded to steel inserts available in the concrete surface.
b) Welded to steel structural members.

Support system shall be site fabricated as per requirement from galvanised MS structural members.

2.9. Deleted.

2.10. Horizontal/Vertical runs of cable trays shall be supported at intervals of 1500mm approximately. Vertical runs (risers) shall be supported at approximately every 1000mm interval. The cable tray supporting system shall be fabricated out of ISMC 150/100 for vertical support & ISA 50 for horizontal support. The minimum design vertical spacing for trays shall be 300 mm measured from the bottom of the upper tray to the bottom of the lower tray for cable laying convenience and effective heat dissipation.

The cable tray numbering shall be provided at every 30 meter and at each end of cable tray & branch connection.

2.11. All cable way sections shall have identification, designations as per cable way layout drawings and painted/ stencilled at each end of cable way and where there is branch connection to another cable way. Minimum height of letter shall not be less than 75mm. For long lengths of cable trays, the identification shall be painted at every 10m. Risers shall additionally be painted / stencilled with identification numbers at every floor.

2.12. The cable trays and supports system shall be of approved Makes, and conforming to their respective approved drawings. Cable tray support shall be designed for loading as per technical specifications.

2.13. Cable trays shall be grounded as per the provisions of the approved grounding document for the project.

2.14. Directly buried cables

a. Cable trenches shall be constructed for directly buried cables. Construction of cable trench for cables shall include excavation, preparation of sieved sand bedding, riddled soil cover, supply and installation of brick or concrete protective covers, back filling and compacting, supply and installation of route markers and joint markers. Laying of cables and providing protective covering shall be as per IS: 1255 and "INSTALLATION DETAILS OF CABLE TRAYS SUPPORT "
b. RCC cable route and RCC joint markers shall be provided wherever required. The voltage grade of the higher voltage cables in route shall be engraved on the marker. Location of underground cable joints shall be indicated with cable marker with an additional inscription "Cable Joint". The marker shall project 150 mm above ground and shall be spaced at an interval of 30 meters and at every change in direction. They shall be located on both sides of road crossings/drain crossings. Top of cable marker/joint marker shall be sloped to avoid accumulation of water/dust on marker.
c. Directly buried cables, if essential, shall not have concentration of more than 4 cables in one route.

2.15 For outside cable trench to inside cable trench connection, pipe sleeves in walls as under will be provided for each cable tray for transiting the cables from one side to the other above the finished floor level

- For each 600mm wide tray: 3 nos. 200 diameter PVC pipes.
- For each 300mm wide tray: 2 nos. 200 diameter PVC pipes.
- For each 150mm wide tray: 1 no. 200mm diameter PVC pipes.

The trays shall be stopped approximately 200mm short of the wall on both sides and cables passed through the pipe sleeves as above, the pipe sleeves being aligned horizontally with the respective cable trays. This method is adopted for smooth passage of cables and effective sealing of cable openings. All openings shall be sealed with fire sealing compound. For cable entry to pump house / building, outside cable trays running on walls / structure shall enter by means of wall opening. Alternatively, cable pull pit shall be provided outside and shall connect to cable trench inside by means of pipe sleeves as indicated above. Pull-pits shall be filled with sand and provided with a RCC cover with lifting hook. The cable entry and exit from Switchgear room/pump houses/building shall be taken from 1.5 mtr. (minimum) above FFL to avoid water ingress in cable trenches. Where cables cross roads/ rail tracks, the cables shall be laid in 'hume pipe' /'Duct banks with High Density PE pipes encased in PCC (10% spare of each size, subject to minimum one) with suitable water-proof manholes'.

2.10 Local cabling in various auxiliary plants or pump houses from the main tray runs to equipment terminal boxes shall be through notches in floor, which will be filled up with sand and then provided with lean concrete covering matching with the floor after completion of cable laying.

2.11 Cable troughs shall be used for branching out few cables from main cable route. These shall be U-shaped, fabricated of mil steel sheets of thickness 2 mm and shall be hot dip galvanized. Troughs shall be standard width of 50mm & 75 mm with depth of 25 mm.

3 General Philosophy of Cable Installation

3.1 Laying, dressing, clamping and jointing/ termination process of power, control and instrumentation cables shall follow the requirements of IS: 1255.All precautions as per IS: 1255 & Field Quality Plan (FQP) shall be taken while handling the cables. Cable runs shall be uniformly spaced, properly supported and protected. All bends in runs shall be as per specification and made with due consideration to avoid sharp bending and kinking of cable.

The bending radius of various types of cables shall not be less than those specified by cable manufacturers or that specified in IS: 1255 Table 5.

3.2 For the purpose of cable laying, the cables are categorised as under:

- HT: Power cables of 33kV/ 11kV / 3.3kV grade
- LT: Power cables of 1.1kV grade, catering to loads at 415VAC/230V AC/ 220V DC/24V DC
- Control: Control cables of 1.1KV grade generally carrying control signals at 220V DC/110V AC.
- Instrumentation: (Also called screened control cables): Screened cables of cross-section 1.5sqmm or lower generally carrying very low voltage very low current signals.

The arrangement of single core & multi core cables shall be as per cable sizing document and as per derating factors considered. Further, refer following details as indicated below: -

- FOR AIR/RESTRICTED AIR CIRCULATIONS: - (For single core cable: - Maximum 3 nos. trefoils per tray separated by 2 cable dia / For muti core cable: - Maximum 9 nos. cable per tray touching each other.)
- For Ground CALCULATIONS: - (For single core cable: - Maximum 3 nos. trefoils in horizontal formation touching / For muti core cable: - Maximum 3 nos. cable touching each other.

3.3 All cables shall be provided with identification tags indicating the cable numbers in accordance with the cable circuit schedule. Cable tags shall be fixed at terminal ends, at tray intersection / bend and at each side of floor/ wall/ duct crossings etc and at every 20m in cable trench/tray or buried run. Cable tray routing points shall be located where they are readily visible and not concealed by equipment, fire proofing or other materials.

Cable tag shall be of 2 mm thick aluminium with number punched on it and securely attached to the cable by not less than two turns of 20 SWG GI wire conforming to IS:280. Alternatively, cable tags can be made of nylon, cable marking ties with cable number heat stamped on the cable tags.

3.4 Single core cables for a. c. three phase circuits, when laid on trays, shall be in trefoil formation (each trefoil with RYB phases formation), with distance of four times the diameter of cable between trefoil centrelines. The trefoil formation shall be duly secured to the cable tray by means of trefoil clamps of nonmagnetic material, clamped at every 1000mm interval. All multicore cables shall be laid touching formation.

3.5 Power and control cables shall be laid on separate tiers. The laying of different voltage grade cables shall be on different tiers according to the voltage grade of the cables as defined in clause 3.2 above. In horizontal tray stacks, H.T. cables shall be laid on top most tier and cables of subsequent lower voltage grades on lower tiers of trays.

3.6 1100 V grade multi-core power cables carrying continuous current when laid on trays shall be placed in single layer, touching and clamped by means of cable ties/clamps.

The cable clamps/ties required to clamp multicore cables shall be of SS-316 material, 12mm wide, polyester coated ladder lock type. The clamps/ties shall have self-locking arrangement & shall have sufficient strength. The cable clamps/ties shall be supplied in finished individual pieces of suitable length to meet the site requirements.

Cables of sizes indicated below, shall be clamped individually.

- Single core cables: 500 sq mm or higher (when not laid in trefoil formation- e.g. dc circuits)/ neutral cables)
- Multi-core cables: 95 sq mm or higher

3.7 Control and instrumentation cables shall be laid in multi layers, but not exceeding three layers in any section. Special purpose cables (e.g. IPB, WAN etc.) shall be laid as per system manufacturer/ supplier recommendations with due regard to segregation of routes for redundant circuits.

3.8 While power, control and instrumentation cables shall generally be laid in separate trays.

3.9 Cables shall be placed on trays on the basis of their types and functions as under for horizontal formations:

Cables of sizes indicated below, shall be clamped individually.

- HT cables: in the top tier(s).
- LT power cables: in the tray(s) below the HT cable trays.
- Control cables: in the tray(s) next below to the LT power cable tray(s).
- Instrumentation cables (screened control cables): in the bottom most, perforated tray(s).

HT Power, LT Power and LT Control/Instrumentation cables shall be separated from each other by at least 300mm.

3.10 For vertical formations, the outermost tray shall be considered as the topmost tray and the order indicated in clause 3.9 shall be followed. In rare cases, where there is no clear distinction of bottom/ top trays, the order convenient for linking the horizontal and vertical formations avoiding criss-crossing, or exit of cables shall be followed subject to approval of site engineer.

3.11 Wherever it is not possible to accommodate cables as per the criteria indicated in the clauses 3.9 & 3.10 (due to layout constraints) for very short field runs, control cables may be laid in the same tray with the instrumentation cables with clear gap generally of 300mm. However, it may be reduced upto min 100mm, case to case basis where space constraint is there. Separator may be provided between the two types of cables, subject to approval of site engineer.

3.12 All cables associated with the unit shall be segregated from cables of other units. Interplant cables of station auxiliaries shall be laid in such a way that not more than half of the drives are lost in case of single incident of fire. Power and Control cables for ac drives and corresponding ac or dc drives shall be laid in segregated routes. Cable route for one set of auxiliaries of same unit shall be segregated from the other set. Segregation means physical isolation to prevent fire jumping or minimum one hour fire rating. Cables of unit critical drives shall be segregated in such a way that not more than half of the drives are lost in case of single incident of fire. In switchyard, control cables of each bay shall be laid on separate racks / trays.

3.13 To facilitate pulling of cables in GI conduits, powdered soft stone, plastic soap or other dry inert lubricant may be used where required. However, any material harmful to the cable sheaths shall not be used. GI pull wire of adequate size shall be laid in all conduits before installation.

3.14 No single core cable shall pass through a GI conduit/ pipe or duct singly except DC single core cables. AC single core cables shall pass through GI conduit/ pipe in trefoil formation only, or through PVC pipes. Conduit/pipe occupancy shall not exceed 40% of the conduit/pipe cross-section area. Pipes / conduits if used in corrosive areas shall have anti-corrosive coating both inside & outside. All openings in the floor/roof/wall /

cable tunnel/cable trenches made for conduit installation shall be sealed and made water proof. Different voltage grade shall be laid in separate conduits.

3.15 Wherever specific cable routes are not shown in cable schedules, cables may be laid through the shortest route as per the above criteria, as directed by site Engineer.

3.16 Power and control cables shall be secured fixed to trays/support with self-locking type clamps/ties. For horizontal trays arrangements, multicore power cables and control cables shall be secured at every five-meter interval. For vertical tray arrangement, individual multicore power cables and control cables shall be secured at every one meter. After completion of cable laying work in the particular vertical tray, all the control cables shall be binded to trays/supports by aluminium strips at every five-meter interval and at every bend.

3.17 For Cable unloading, pulling etc following guidelines shall be followed in general:

a) Cable drums shall be unloaded, handled and stored in an approved manner on hard and well drained surface so that they may not sink. In no case shall be drum be stored flat i.e. with flange horizontal. Rolling of drums shall be avoided as far as possible. For short distances, the drums may be rolled provided they are rolled slowly and in proper direction as marked on the drum. In absence of any indication, the drums may be rolled in the same direction as it was rolled during taking up the cables. For unreeling the cable, the drum shall be mounted on suitable jacks or on cable wheels and shall be rolled slowly so that cable comes out over the drum and not from below. All possible care shall be taken during unreeling and laying to avoid damage due to twist, kink or sharp bends. Cable ends shall be provided with sealed plastic caps to prevent damage and ingress of moisture.

b) While laying cable, ground rollers shall be used at every 2 meter interval to avoid cable touching ground. The cables shall be pushed over the rollers by a gang of people positioned in between the rollers. Cables shall not be pulled from the end without having intermediate pushing arrangements. Pulling tension shall not exceed the values recommended by cable manufacturer. Selection of cable drums for each run shall be so planned so as to avoid using straight through joints. Care should be taken while laying the cables so as to avoid damage to cables. If any particular cable is damaged, the same shall be repaired or changed to the satisfaction of Project Manager.

3.18 Cables shall be laid on cable trays strictly in line with cable schedule.

3.19 For road/rail crossings, buried RCC hume pipes (at a depth of minimum 1000mm) shall be used. Alternatively, duct banks of high-density PE pipes encased in PCC as per specification requirement can be used.

3.20 If required the necessary modification in cable tray layout shall be made at site to suite condition i.e. to avoid fouling of cable trays with beam, columns, steel structure, pipes etc. with prior approval of Project Manager i.e. to avoid fouling of cable trays with beam, columns, steel structure, pipes etc. with prior required in cable trays installation a pre-fabricated type of accessories in line with technical specification requirement shall be used.

3.21 Recommended tightening torque shall be used for dowels and bolts.

3.22 Where there is a considerable risk of steam, hot oil or mechanical damage cable routes shall be protected by barriers or enclosures.

3.23 Fire retardant paint shall be applied after installation on cables in topmost tray of Horizontal formation in fire prone areas, like Boiler, TG, fuel oil area and any other strategic location etc.

4 Cable Termination & Jointing

4.1. Termination and jointing of cables shall conform to the requirements of IS: 1255 and shall be carried out as per the recommendations of termination and jointing kit supplier. Cable terminations at various electrical and electronic equipment terminals shall be done as per approved scheme/ interconnection diagrams. In each cable run some extra length shall be kept at suitable point to enable one LT/two HT straight through joints to made, should the cable develop fault at a later stage. Control cable termination inside equipment enclosure shall have sufficient lengths so that shifting of termination in terminal blocks can be done without requiring any splicing.

4.2. Termination and jointing of HT cables shall be done with pre – moulded type, taped type & heat shrinkable type termination/ jointing kits of proven design & type tested as per IS: 13573(for above 3.3kV) and IS: 13573 /VDE0278 (for 3.3kV). The kit shall be complete with tinned copper solderless crimping type cable lugs & ferrule as per DIN standard.

4.3. When the equipment is supplied with undrilled gland plates for cable/ conduit entry into the equipment, all drilling & cutting on the gland plate and any minor modification work required to complete the job shall be carried out at site as per cable glanding requirement. A plan showing the holes for cable entry in the gland plate shall be developed at site in consultation with site engineer for drilling holes (gas cutting is not allowed). Types of glands to be used are as under.

- Material: Nickel-Chromium plated brass, heavy duty conforming to BS:6121
- Type: Double compression

All cable entry points shall be sealed & made vermin and dust proof. Unused openings shall be effectively sealed by 2mm thick aluminium sheets.

4.4. Termination of cables shall be done as per termination drawings & interconnection diagrams furnished. Shorting & looping of cores/ wires at terminals and between the panels if required shall be carried out as per approved scheme.

4.5. All cable entries in the equipment shall be sealed by cable glands supplied with the equipment. Any discrepancy in cable glands/ lugs with respect to cable size shall be brought to the notice of site engineer.

4.6. Adequate length of cables shall be pulled inside the switchboards, control panels, terminal boxes etc. so as to permit neat termination/ dressing of each core/conductor.

4.7. Power cable terminations shall be carried out in specified manner to avoid strain on the terminals.

4.8. Control cable cores entering switchboard or control panels shall be neatly bunched and strapped with cable clamps & ties and suitably supported to keep them in position at the terminal block. All spare cores shall be neatly dressed and suitably grounded / insulated with blank ferrules.

4.9. Screened control cables of small cross-sectional area, (0.5 sq mm) shall be terminated by means of cage clamp termination system.

4.10. Individual cores of control cables shall have ferrules for identification. Ferrule numbers shall be provided as per the control schemes and other related documents.

4.11. Cable lugs/ferrules shall be solderless crimping type suitable for power and control cables as per the DIN 46239. Aluminium solderless crimping lugs/ ferrules shall be used for Aluminium cables and Copper lugs/ferrules shall be used for Copper cables. Bimetallic washers or bimetallic type lugs shall be used for bimetallic connections.

4.12. Cable joint(s) shall normally be made at an appropriate point (s) in the straight run of cables only when the length of the run is more than the standard drum length supplied by the cable manufacturer, or when a joint is necessitated due to site constraints. In such cases, when jointing is unavoidable, the same shall be made by means of specified cable-jointing kit. Prior approval of Engineer shall be taken for deciding location of joint. However, no joints shall be allowed in trip circuits, protection circuits and CT/PT circuits. Also joints in critical equipment shall not be permitted. Further, to avoid joints, the cable drum length shall be governed by technical specification and LV/MV DBR.

4.13. Junction boxes may be used, wherever required, for jointing/ marshalling of control and instrumentation cables.

5 Trefoil Clamp

The cable trefoil clamps shall be used for clamping of MV & LV single core cables to be routed in trefoil formation using trefoil clamps Trefoil clamps for single core cables shall be pressure die cast aluminium or fibre glass or nylon and shall include necessary fixing accessories like G.I. nuts, bolts, washers, etc.

6 Grounding of Cabling System

6.1. Armour grounding:

- Armour of the HT cables and LT single core cables shall be grounded only at one end of cable preferably the source end.
- Armour of other cables shall be grounded at both ends of cable.

6.2. Screen Grounding:

- Screen of multi-core cables shall be grounded at both ends.
- Screen of single-core power cables shall be grounded at one end.
- Screen of electronic grounding system cables shall be grounded as per the Control System panel manufacturer recommendation.

Coal to 2000 TPD Ammonium Nitrate, LSTK-1

DESIGN PHILOSOPHY FOR ELECTRICAL EQUIPMENT

BHARAT HEAVY ELECTRICALS LIMITED
INDUSTRIAL SYSTEM GROUP
BANGALORE-12

1. Scope

1.1 This document covers the general approach to be followed for design considerations applicable to the layout engineering of electrical equipment such as auxiliary service transformers, busducts, MV/ LV switchgear panels, battery, battery chargers, Lighting Distribution Boards (LDBs), etc., as supplied under the contract in terms of the safety, operability and maintainability of these equipment. Detailed aspects related to cabling layout and erection, are covered separately in the Cable Erection Philosophy

1.2 This document, along with respective equipment OGA and other relevant drawings, and project layout requirements will form the design basis for developing electrical layout drawings for various buildings and areas for CHP, LHP and AHP package.

1.3 The areas covered under this document are as under:

a) Switchgear Rooms.
b) 220 V DC Battery Room.
c) Cable Vaults for switchgear rooms of CHP/AHP/LHP.
d) Interplant Cabling Layout.
e) Auxiliary plants, buildings and areas of CHP/AHP/LHP.

1.4 The equipment covered under this document are as under:

a) Power Transformers
b) Busduct (Non-segregated Phase type).
c) Neutral Grounding Equipment.
d) CHP/AHP Aux. transformer (dry type)
e) MV (11kV/ 3.3kV) switchgear
f) LV switchgear, Motor Control Centres (MCCs),
g) AC and DC Distribution Boards, Lighting/ Welding Distribution Boards, etc.).
h) 220V Battery and Chargers
i) Cable Trays and Support System
j) Cables (HT, LT Power & Control Cables).
k) Any other equipment as per system requirement.

2. Reference Documents

2.1. The latest amendments of the following will be applicable:

- Indian Electricity Rules 1956
- IS: 10028 [Code of Practice for Selection, Installation and Maintenance of Transformers]
- TAC Regulations
- CBIP Manual on Transformers
- Relevant IS /IEC Standards applicable for all Electrical Equipment

2.2. Any modification as required at site shall be done in consultation with BHEL site engineer.

3. Location Aspects

3.1. Transformers and their neutral grounding equipment will be located outdoors in the transformer yard. Foundation arrangement for the same will be provided in line with the OGA drawings and Transformer Foundation Plan. Neutral pits for NGR shall be kept near to NGR.

Arrangement for movement of power transformers to access road, in terms of the necessary rail track, mooring posts and jacking points will be provided in line with the respective transformer OGAs/ foundation plans and & as per operational requirement

3.2. Outdoor neutral grounding equipment for various transformers will be located in close proximity to the respective transformer.

3.3. MV and LV switchgear, MV Switchboards, Motor Control Centres (MCCs) and Distribution Boards (DBs)) will be located indoors in the rooms/ areas designated for the same as per Final approved Electrical Single Line Diagram for Auxiliary Power Distribution

3.4. Service transformers feeding LV switchboards will generally be located as under:
a. Dry-type transformers: Indoor, adjacent to the switchboard being fed.
b. Dry-type transformer: outdoor with shed.

3.5. Deleted

3.6. 220V Batteries will be located in separate rooms designated for the same, while chargers and DCDBs will generally be located in the LV switchgear room. Suitable ventilation arrangement as per contract will be provided for battery rooms. Wash basin shall be provided in battery room along with continuous water supply. Cable trays & conduits shall not be laid on the floor in battery room.

3.7. 220V Batteries will normally be located in single tier formation where the individual cell weight exceeds 50kg. For cell weight of 50kg and below, batteries will be placed in two-tier formation.

3.8. Wherever local 220V DC system is specified, separate room will be provided for batteries.

3.9. Switchgear in CHP LHP & AHP buildings will generally be cellar mounted, and located inside switchgear/ MCC rooms. To avoid water ingress in SWGR rooms wall opening at 1.5m height (minimum) shall be provided for cable entry.

3.10. Minimum two personnel entrance/ exits, preferably on opposite sides, along with one rolling shutter of adequate size and capacity will be provided for every switchgear room of offsite plant area to ensure safe entry/ egress for operating personnel. Distance between two entry/exit not to exceed 30m, also comply with NBC regulations

3.11. For movement of electrical panels into auxiliary plant switchgear rooms, rolling shutter or double swing doors with a removable transom arrangement on top will be provided. With the transom in locked position, the door will act as one of personnel entrance/ exits. All doors of switch gear room shall be minimum 2-hour fire rated

3.12. Cable entry to panels will generally be from the bottom, for which suitable provisions will be made in terms of cut-outs/ openings in the switchgear room floors in case of floor mounted equipment.

3.13. Fuse distribution boards (for small power applications), and lighting panels will be wall/ column-mounted.

3.14. In cable vaults clear height in walkway or cross over below the cable trays shall be 1.8m. Width of passage will be 800mm. Space of 800 around the cable trays shall be provided for easy laying & maintenance of cable.

3.15. False floor to route cables is not permitted.

4. Statutory Clearances and Operating clearances

4.1. Statutory Clearances

a. Minimum clearances as per Indian Electricity Rules will be ensured in the layout arrangements for electrical equipment, Switchboards (including dry type transformers within enclosures):

Disposition	Safety Clearance as per IE Rules
In front of the switchboards	Clear space of 1 metre in width.
In rear of the switchboards	More than 0.75 metres.
Sides (in case rear clearance exceeds 0.75 metres)	Sufficient for human passage

b. In case operating clearances exceed minimum statutory clearances, the former will be ensured.

4.2. Operating Clearances

a) Minimum operating clearances will be provided as under:

1. Oil-filled Service Transformers

Disposition	Clearance
Around tank and radiators	1.5 Meter
In front of power cable box	1.5 Meter

2. Dry type transformer

Disposition	Clearance
Clearance between HV Cable Box face to wall/column/ panel	1.5 Meter
Clearance between LV Busduct/ Cable Box face toadjacent panel)	To suit layout (minimum 1.0 Metres)
Side clearance (swing doors side)	0.75 Metre + door swing. Sufficient space for withdrawal of the transformer core/ coil assembly from at least one side will be ensured.

3. MV Switchgear (3.3KV and 11KV)

Disposition	Clearance
Front clearance (panel operating face to wall/ column/rear of another panel line-up)	2.0 Meter (Min.)
Front clearance (panel operating face to facing panel operating face)	2.5 Meters (Min.)

Rear clearance (panel cover to wall/ column)	1.5 Metres (Min.)
Side clearance (end of panel line-up to another line-up/ wall/ column)	1.0 Meter + space provision for one no. panel (Both sides)

4. LV Switchgear and Battery charger

Disposition	Clearance
Front clearance (Breaker/ draw-out panel operating face to wall/ column/ non-draw-out panel front/ rear of another panel line-up)	1.5 Meter
Front clearance (Breaker/ draw-out panel operating face to facing draw-out panel face)	1.5/1.75 Meter
Front clearance (Non-draw-out panel face to wall/ column/ rear of another panel line-up)	1.5 Meter
Rear clearance (panel cover to wall/ column)	1.0m – For Single Front, 1.5m – For Double Front
Side clearance (end of panel line-up to another line-up/wall/ column)	1.0 Meter + space provision for one no. panel (Both sides)

5. Height of HT/LT switchgear room

a. With Busduct - 4.5M(Min)
b. Without Busduct - 4.0M(Min)

6. Neutral Grounding Equipment

Disposition	Clearance
Front, rear and side clearance-Indoor	200mm for rear & sided And 1500 for front
Front, rear and side clearance-Outdoor	0.75 metres all around

7. Battery

a. Single tier Arrangement

Disposition	Clearance
Clearance between two cells, and adjacent rows of cells	As per battery manufacturer recommendations
Clearance between cell banks, and between cell banks and wall/ column face	1.0 Meter

b. Two-tier arrangement

Disposition	Clearance
Clearance between two cells, and adjacent rows of cells	As per battery manufacturer recommendations
Clearance between cell banks, and between cell banks and wall/ column face	1.0 Meter

8. The areas where HT & LT SWGRs are kept in same SWGR room, HT switchboard clearances shall be followed.

5. Civil Aspects

5.1. Foundation arrangement (e.g. rail track, wheel/ roller locking arrangement, mooring posts, jacking pads, embedded insert plates, foundation channels, pockets, openings, etc.) will be provided for equipment as per respective equipment OGA and foundation plan drawings. The Foundation top of transformer & rail top shall beat EL +/- 0.0M.

5.2. DELETED

5.3. Pipes will not generally be routed through any switchgear rooms. If, due to project constraints, passage of vertical piping through switchgear rooms is unavoidable, the piping will be located sufficiently away from the switchgear in the room, and enclosed with brickwork after routing.

5.4. Vertical cable chases, whenever routed through switchgear/ MCC rooms, will be enclosed with brickwork after completion of cabling.

5.5. While developing electrical equipment layout, expansion joints, where provided in the structural beam-work supporting the floor, will be avoided (i.e., panels will not rest atop expansion joints).

5.6. Rooms for battery will be provided with acid proof tiling, and acid proof painting on the exposed building structure, if lead acid Plante type battery is provided.

5.7. DELETED

6. Fire Safety

Fire-fighting system for various electrical areas will be provided as per contract for which separate documents will be applicable.

Coal to 2000 TPD Ammonium Nitrate, LSTK-1

DESIGN MEMORANDUM FOR GROUNDING SYSTEM

BHARAT HEAVY ELECTRICALS LIMITED
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1.0 SCOPE

1.1 This document covers the design of below and above grade grounding system for the CHP/AHP/LHP area.

1.2 The following aspects of below grade grounding system design are covered:
(a) Determination of size of ground conductor.
(b) Calculation for ring electrode system for CHP/AHP/LHP area.

1.3 The methodology and material details of above grade grounding system are also covered in this document.

1.4 Instrument, electrical earth shall be separate. Less than 1 OHM earth pit to be ensured.

2.0 DESIGN PHILOSOPHY OF BELOW GRADE GROUNDING SYSTEM

2.1 Type of grounding

2.1.1 CHP/AHP/LHP area not covered by the main ground grid are provided with ring electrode type grounding system using mild steel rod material for limiting the ground resistance below 1 ohm.
Detailed calculations for the above are covered in Annexure-A and B.

2.1.2 The earth conductor below grade level shall be buried in earth at a minimum depth of 600 mm below grade level. Earth conductor where it crosses trenches, pipes, ducts, tunnels, rail tracks of CHP area like Transformer area etc., it shall be at least 300mm below them.

2.1.3 Ground grid shall be connected to all auxiliary plant grounding systems through at least two interconnections with test facility. The interconnecting conductors will run parallel to and as close as possible to the interconnecting cable path on pipe cum cable trestle/ duct bank/ trench as applicable.

2.1.4 One run of 40 Dia earth rod shall be laid all along the length of Conveyor, Pipe cum cable rack and cable rack as a part of below ground earthing system.

2.1.5 Risers with an effective cross-sectional area equivalent to below ground earth conductor are provided from the below ground grounding system for connection of above ground (equipment) earth leads.

2.1.6 Above ground earthing details shall be as per "Typical Above ground earthing details" and below ground earthing details shall be as per "Typical below ground earthing details"

2.1.7 For electronic grounding, refer note no 13 of Typical below ground earthing details.

2.1.8 All system neutrals (including neutrals of Auxiliary transformers) are connected to two nos. treated test pits, which in turn are connected to the ground grid.

2.1.9 All lightning protection down conductors are connected to dedicated ground electrodes through isolating links and then to the grounding system.

2.1.10 Neutral connections and metallic conduits/pipes shall not be used for the equipment earthing. Lightning protection system down conductors shall not be connected to other earthing conductors above the ground level.

2.1.11 The sizes of conductors for below grade grounding are tabulated in Annexure-C, Table-1.

2.2 Design Criteria

2.2.1 Average soil resistivity shall be computed as per soil Resistivity Data Analysis (Shall be submitted later during Detailed Engineering) based on Soil Resistivity Measurements (Test results shall be submitted separately). For ring electrode system for CHP/AHP/LHP area, soil resistivity values of respective areas ERT locations shall be used.

2.2.2 The size of grounding conductor is based on the maximum ground fault current value of 63 kA for 1 second for 400 kV bus, with all below grade joints being welded type. The minimum rate of corrosion of steel for selection of grounding conductor is considered as 0.12 mm per year. The grounding grid has been sized for a life of 40 years.

3.0 DESIGN PHILOSOPHY OF ABOVE GRADE GROUNDING

3.1 Type of grounding

3.1.1 A continuous 50 X 6 mm Galvanised flat MS conductor (runway conductor) shall be installed along all cable trays/ racks, which shall serve as main grounding conductor for receiving individual ground connections. Taps of 50X6 Galvanised MS flat mm from runway conductor are connected to each section of other trays at an interval of about 10 m. The runway conductor is connected to the below grade grounding system at every available building column within plant buildings, and through risers at approximately 30 m interval in outdoor trestles/ trenches.

3.1.2 65x8 mm galvanised M.S. flats are run as main earth conductor along building columns / walls and securely fixed to the same by welding / clamping at intervals not exceeding 1000 mm and 750 mm respectively. Connections from runway conductor/submats are made to the main earth conductor.

3.1.3 Two separate & distinct ground connections shall be provided for grounding of each electrical equipment framework.

3.1.4 Crane rails, tracks, metal pipes and conduits shall also be effectively earthed at two points. Steel RCC columns, metallic stairs and rails etc. of the building housing electrical equipment shall be connected to the nearby earthing grid conductor by one earthing ensured by bonding the different sections of hand rails and metallic stairs.

3.1.5 Railway tracks are bonded across fish plates and earthed at regular intervals. At the point where rail track leaves plant area, the rail section is provided with insulated joint at both ends.

3.1.6 Metallic hand rails, fencing of transformer yard, etc. are connected to the below ground earthing system. Earthing conductor is buried at least 2000 mm outside the fence of electrical installations. Every alternate post of the fences and all gates are connected to earthing grid by one lead.

CALCULATION OF GROUNDING CONDUCTOR SIZE **Annexure-A**

As per IEEE-80 cross sectional area of earthing conductor shall be:

$A_{(mm2)}$= I x sqrt [{(t_c x a_r x r_r x 10^4)/ TCAP}/ ln { (K_0 + T_m)/ (K_0 + T_a)}]

where,

A=	Conductor cross section in sq. mm.			
I=	Ground fault current (rms) in kA	=	50	kA
t_c=	Time of flow of current	=	1	sec.
a_r=	Thermal coefficient of resistivity (As per IEEE 80)	=	0.00377	deg. C at 20 deg. C
r_r=	Ground conductor resistivity (As per IEEE 80)	=	15.9	micro-ohm cm

TCAP = Thermal capacity factor in J/cu.cm./ deg.C
= 3.800 [As per IEEE-80]

T_m = Max. allowable temp. = 1510 deg. C
(As per IEEE 80-2013)

T_a = Ambient temperature = 50 deg. C

T_r = Reference temperature = 20 deg. C

$$K_0 = \left(1/\alpha_r\right) - T_r$$

= (1/0.00377) - 20
= 245.25

Substituting these values, the conductor cross section = 470.357 sq.mm.

Since $A=pD^2/4$

Corresponding Diameter of Conductor D = 24.47 mm

Minimum rate of corrosion of steel considered = 0.12 mm. / yr.

Life for which the Earth Mat is designed = 40 yrs.

Total corrosion allowance for the expected life of the plant = 0.12 x 40 mm
4.8 mm.

Thus the Diameter of Conductor with corrosion allowance = 24.47 + 4.8 mm
= 29.27 mm

The conductor dia selected = 40 mm.

Dia of the conductor in metres. = **0.04** m.

Calculations For Below Grade Ring Electrode System

Annexure-B:

BELOW GRADE GROUNDING FOR AUXILIARY PLANT BUILDINGS

For auxiliary plant buildings, ring electrode type system consisting of a number of electrodes (each 3 m. long, 40 mm. dia M.S. rod) connected to a ring of 40 mm. dia M.S. rod buried at a depth of 0.6 m. around the periphery of plant building shall be provided. The number of electrodes shall be such that the resistance of the ring electrode system individually is less than 1 ohms.

Calculation for the required number of electrodes(Typical Calculation, However actual shall be submitted after soil resistivity

Calculation for the required number of electrodes (Caluse no 14.2.2 of IS 3043:2018)

$$R = \frac{(100 \times \rho)}{(2 \times \pi \times l)} \ln \frac{2*l}{d}$$

Where,

l :	length of rod or pipe (in cm)	=	300	
d :	minimum diameter of rod or pipe (in cm)	=	4.0	
ρ :	resistivity of the soil (in Ω-m)	=	30	***Assumed, actual shall be as per final soil resisitivity report***

Thus,

$$R = \frac{(100*30)}{(2*\pi*300)} \ln \frac{(2*300)}{4} = 7.974673751 \text{ Ohms}$$

With combination of electrodes and burried rod combination, all the auxiliary areas resistance ensured to be less than 1 Ohm and further suitably interconnected to give a resultant ground resistance of less than 1 ohms.

Annexure-C:

Material and Size Details Of Below Grade & Above Grade Grounding System

TABLE-1: BELOW GRADE GROUNDING SYSTEM - CONDUCTOR SIZES

SL. NO.	TITLE	MATERIAL	SIZE
1	ELECTRODES IN TEST PITS	MS ROD	40 MM. DIA, 3 METRES LONG
2	PERIPHERAL ELECTRODES FOR AUXILIARY PLANT RING ELECTRODES	MS ROD	40 MM. DIA, 3 METRES LONG
3	INTERCONNECTIING GROUNDING CONDUCTOR BETWEEN DIFFERENT GROUNDING SYSTEMS	MS ROD	40 MM. DIA, 3 METRES LONG
4	ELECTRODES FOR LIGHTNING PROTECTION DOWN CONDUCTORS	MS ROD	40 MM. DIA, 3 METRES LONG

TABLE-2: ABOVE GRADE GROUNDING SYSTEM - CONDUCTOR SIZES

REFER TABLE ATTACHED IN DOCUMENT CHAPTER-6: TYPICAL ABOVE GROUND EARTHING DETAILS

3.1.7 Each street lighting pole, flood lighting pole and the respective junction boxes are connected to an individual 40 mm dia (min), 2500 mm long M.S. electrode buried in ground provided for each pole with a 25 x 3 mm galvanised M.S. strip.

3.1.8 Cable screens and armour (wherever applicable) are earthed at both ends for multi core cables. For single core cables, the same is done at switchgear end only.

3.1.9 Above grade ground conductor connections are welded except at the equipment end, where the connections are bolted.

3.1.10 The sizes of conductors for above ground grounding are tabulated in Annexure-C, Table-2.

4.0 REFERENCES

4.1 Codes and Standards:

(1) IEEE Std. 80: IEEE Guide for safety in AC substation Grounding.
(2) IS 3043: Code of practice for grounding
(3) Indian Electricity Rules 1956

Coal to 2000 TPD Ammonium Nitrate, LSTK-1

DESIGN MEMORANDUM FOR LIGHTNING PROTECTION

BHARAT HEAVY ELECTRICALS LIMITED
INDUSTRIAL SYSTEM GROUP
BANGALORE-12

1.0 SCOPE

1.1 This document covers the design BASIS FOR calculations for lightning protection system for CHP/AHP/LHP area.

2.0 DESIGN BASIS & CRITERIA

Lightning protection for plants and buildings is provided based on the assessment of need for protection depending on the type, use and contents of the plant and buildings as laid down in IS/IEC-62305.

3.0 REFERENCES

3.1 Codes & standards

IS/IEC-62305-1-4: Protection against Lightning.
IS: 3043: Code of Practice for Earthing.
IEEE 142: IEEE recommended Practice for Grounding of Industrial and Commercial Power systems, (Green Book), Indian Electricity Rules 1956
IER : Indian Electricity Rules

4.0 ZONE OF PROTECTION

Not applicable

5.0 METHODOLOGY OF LIGHTNING PROTECTION ARRANGEMENT FOR PLANTS AND BUILDINGS

5.1 The need for lightning protection for each building/ structure is established as per the guidelines of IS: 62305-2. Risk index calculations for various plant buildings/ structures are detailed at clause no. 6.0.

5.2 Based on the above calculations, a system comprising of horizontal and vertical air terminations as per various class of protection shall be provided on the topmost surface of each building/ structure required to be protected. Tolerable Risk is considered as per table 4 of IS/IEC-62305-2

S.no	Type of Loss	R_T (y^{-1})
1	Loss of Human Life or permanent injuries	10^{-5}
2	Loss of service to the Public	10^{-3}

Lightning Protection is provided where calculated risk is greater than above values which shall be provided later during detail engineering.

5.3 Each such network shall be duly connected by means of down conductors to the below grade grounding system provided around the building/ structure through an electrode. Down conductors shall not be directly connected to the below grade grounding system. A test link shall be provided in each down conductor approximately 1500mm above ground for testing purposes.

5.4 As per table-6 of IS/IEC-62305-3, minimum cross-sectional area is 176 mm^2 for vertical air termination (Galvanised MS-Solid round) & that of horizontal air termination/ down conductor is 50 mm^2 Galvanised MS strip. However, considering the design life of power plant and mechanical strength aspect, higher sizes are chosen. The materials and sizes of the components of the system described above shall be as under:

S. No.	Item Particulars	Material	Size/ Details
1.	Vertical Air Termination	Galvanised MS Rod	20mm diameter, (314 mm^2) minimum 1000mm projecting above roof surface
2.	Horizontal Air Termination	Galvanised MS Strip	25x6mm (150 $mm^{2)}$
3.	Down conductor	Galvanised MS Strip	25x6mm (150 $mm^{2)}$
4.	Test Link	Galvanised MS Strip	150x25x6mm
5.	Electrode in ground	MS Rod	40mm diameter, 3000mm long

Further, separate dedicated riser shall be provided for Lightning down conductor connection purpose. Lightning protection system down conductors shall not be connected to other earthing conductors above the ground level. Lightning conductors shall not pass through or run inside G.I. conduits. The lightning protection system shall not be in direct contact with underground metallic service ducts and cables.

5.5 The layout, numbers/ details of the vertical air terminations, horizontal air terminations and down conductors shall be in accordance with the building dimensions/ profile, stipulations of IS/IEC-: 62305, and approved lightning protection system layout drawings. Generally, the following requirements shall apply:

S.no	Class of LPS	Protection method		Distance (in m) b/w down conductors (As per table-4 of IS/IEC--62305-3)
		Mesh size (m x m)	Protection angle	
1	I	5 X 5	As per table- of IEC-62305-3	10
2	II	10 X 10	As per table-2 of IEC-62305-3	10
3	III	15 X 15	As per table-2 of IEC-62305-3	15
4	IV	20 X 20	As per table-2 of IEC-62305-3	20

Notes:

- As per IEC 62305 part-3 sl.no. 5.2, the mesh method is a suitable form of protection where plane surfaces are to be protected. Hence, vertical air termination is not applicable. However, verticals Air-termination components as additional protection will be provided at corners, exposed points of the buildings.

- Distance between down conductor & vertical air termination is indicative. However, any minor variation (±) can be done during detail engineering/ execution depending on structure availability in respective area.

5.6 Installation details and notes for the lightning protection system shall be as per Typical Lightning Protection Details.

5.7 For details of riser connections to below grade grounding system and electrodes etc., Typical below ground earthing details shall be referred.

6.0 CALCULATION FOR ASSESSMENT OF NEED FOR PROTECTION

As per clause 6 of IS/IEC-62305-2, the need for protection is assessed on the probable number of dangerous events per annum i.e `N_d' and weighting factors depending upon the type, use & contents of buildings and plants as per Table-III

6.1 Exposure Risk:
Exposure risk is assessed from the formula:

$N_d = (N_g * A_d * C_d) *10^{-6}$

Where,

N_d= dangerous event per annum
A_d= collection area in m^2
N_g= Number of lightning flashes per Km^2 per year
C_d= location factor of the structure

Ng ≈0.1 T_d where

T_d = Thunderstorm days per year

For Lakhanpur (Jharsuguda) value is 85 as per NBC

Ng ≈ 0.1 * 85 ≈ 8.5

6.2 Collection Area:
Collection area A_c is given by the formula:
A_d= L * W + 2 * (3 *H) *(L + W) + ∏ (3 * H) ²

Where, L, W, H are the length, width and height of the structure (for calculated values of A_d, a separate document shall be submitted after finalization of buildings/structures during detailed Engineering)

6.3 Weighting Factors:
The values of weighting factors are taken from the Tables-A.1 to C.8 as given in the annexure-A, Annexure-B & Annexure-C of IEC-62305-2
(For values depending upon the use, type, contents etc. of the plants & buildings, a separate document shall be submitted after finalization of buildings/structures during detailed Engineering)

6.4 Overall Risk factor:
Overall risk calculation is as per IS/IEC-62305-2 clause-6
(For final calculated values & conclusions, a separate document shall be submitted after finalization of buildings/structures during detailed Engineering)

CONCLUSSION:
Based on above, Overall risk factor will be calculated for each building under CHP, LHP and AHP to assess the requirement of lightning protection for particular building. As per Clause 6.1, Page-18 of IEC:62305-1, "Protection against lightning is needed if the risk R (R1/R2) is higher than the tolerable level RT.

Coal to 2000 TPD Ammonium Nitrate, LSTK-1

DESIGN MEMORANDUM FOR FIRE SEALING SYSTEM

BHARAT HEAVY ELECTRICALS LIMITED
INDUSTRIAL SYSTEM GROUP
BANGALORE-12

1. Application

The fire proof sealing/fire stop system/fire protection coating system is required to prevent spreading of fire from one place to another (or one zone to another) through the openings in wall/floor and openings below Electrical switchgear/MCC/Distribution boards/Cabinets/Panels /CER/CCR etc.

2. Applicable Standard

ASTM-E-814	Standard Test Method for Fire Tests of Penetration Firestop Systems.
BS-476, PART-20 (Latest Edition)	Fire test on building materials & structures.
IS: 12458	Method of fire resistance test of firestops.
IS: 3809	Fire resistance test of structures.
UL: 1479	Fire Tests of Through-Penetration Firestops

3. Scope

Cable fire sealing system is provided for following areas of the power plant:

(a) Coal Handling plant.
(b) Ash Handling Plant
(c) Lime Handling Plant

4. System Description

4.1 The system provided for fire sealing for various openings in cable vault, vertical/horizontal raceways of cables penetrating walls/floors and the bottom of Electrical switchgears and panels in control Equipment room/MCCs/Distribution Boards/Cabinets/Panels/ CER/CCR shall be provided with fire stop systems of minimum 1-hour rating.

The fire proof cable penetration sealing system shall be of the following type:

i) Type-B

Type B fire sealing system shall be any proven fire sealing system rated for one hour. This will comprise of rest of wall and floor crossings of cables/cable trays, opening below HT/LT Switchgears/board and control/ DCS room.

Fire sealing system offered shall be out of any of the following system

a) Panel based sealing system
b) Powder/ mortar-based sealing system

Type of fire sealing considered for different areas is as under:

S. No.	Area	Type of Cable Penetration	Type of Fire Sealing System
1)	CHP/LHP switchgear and control room	Floor openings below panels Floor openings for risers Wall openings	Type-B Type-B Type-B
2)	Pump Houses and compressor house	Floor openings below panels Floor openings for risers Wall openings	Type-B Type-B Type-B

4.2 Fire stop sealing system offered does not require cable coating; hence the same is not envisaged.

4.3 The system shall be of type tested design as per as per BS-476, PART-20 (Latest edition) in general and technical specification requirements, however if required other relevant standard shall also be followed as per Clause No. 2 above. Detailed type test procedure shall be submitted for approval if type test reports are not found valid.

4.4 System offered shall be type tested at CBRI, Roorkee or by government approved Independent agency.

4.5 Type tests reports of the type tests conducted within last ten years from 01-04-2026 for following tests on fire proof sealing system and fire stop system for floor/wall opening/fire stop system for bottom of electrical switchgear MCCs/Panel shall be submitted as per specification requirement.

Accelerated ageing test.
Water absorption test.
Fire rating test.
Hose stream test.
Vibration test followed by Fire rating test.

4.6 All acceptance & routine tests shall be as per relevant standards. Type test reports shall only be submitted to prove the adequacy of the system; actual testing shall not be conducted.

4.7 Fire penetration system shall be suitable for site condition at 50^{O} C ambient temperature and relative humidity of 100%.

4.8 Asbestos shall not be used in construction of fire penetration seal system.

4.9 The penetration system shall not emit any corrosive or toxic fumes or smoke on unexposed face of barrier and shall be completely gas and smoke tight.

4.10 The penetration system shall be capable of withstanding mechanical loads, vibrations, wind pressure etc. and shall have no reaction with cable sheath/galvanising/painting of structural steel.

4.11 The penetration system of each wall/floor crossing shall be designed such that 20% addition of cables is possible at any later date without disturbance/wastage of material in the penetration system as per Technical Specification.

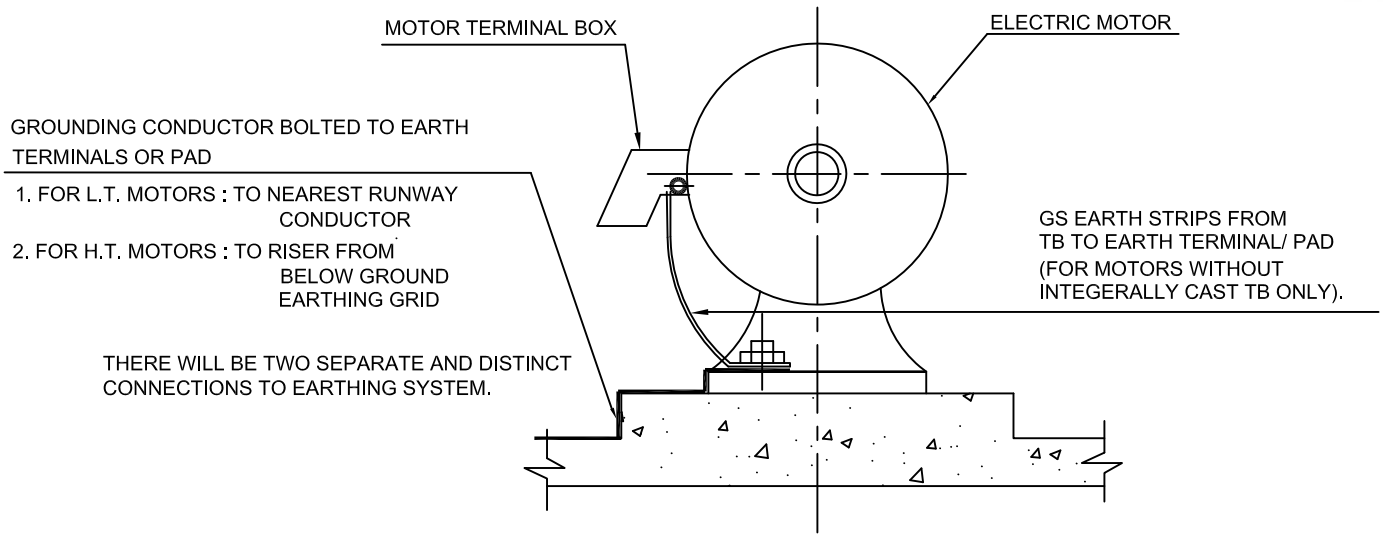
4.12 The penetration materials shall have anti-rodent and anti-termite properties. The penetration materials shall have no shrinkage or cracking after the setting for the complete life of the power Plant.

4.13 Under normal load, short circuit and fire conditions, cables may be subjected to movement and vibration. The FPCP sealing system shall be designed to withstand and perform satisfactorily under these conditions. The penetration system shall not affect the current carrying capacity of cables passing through it.

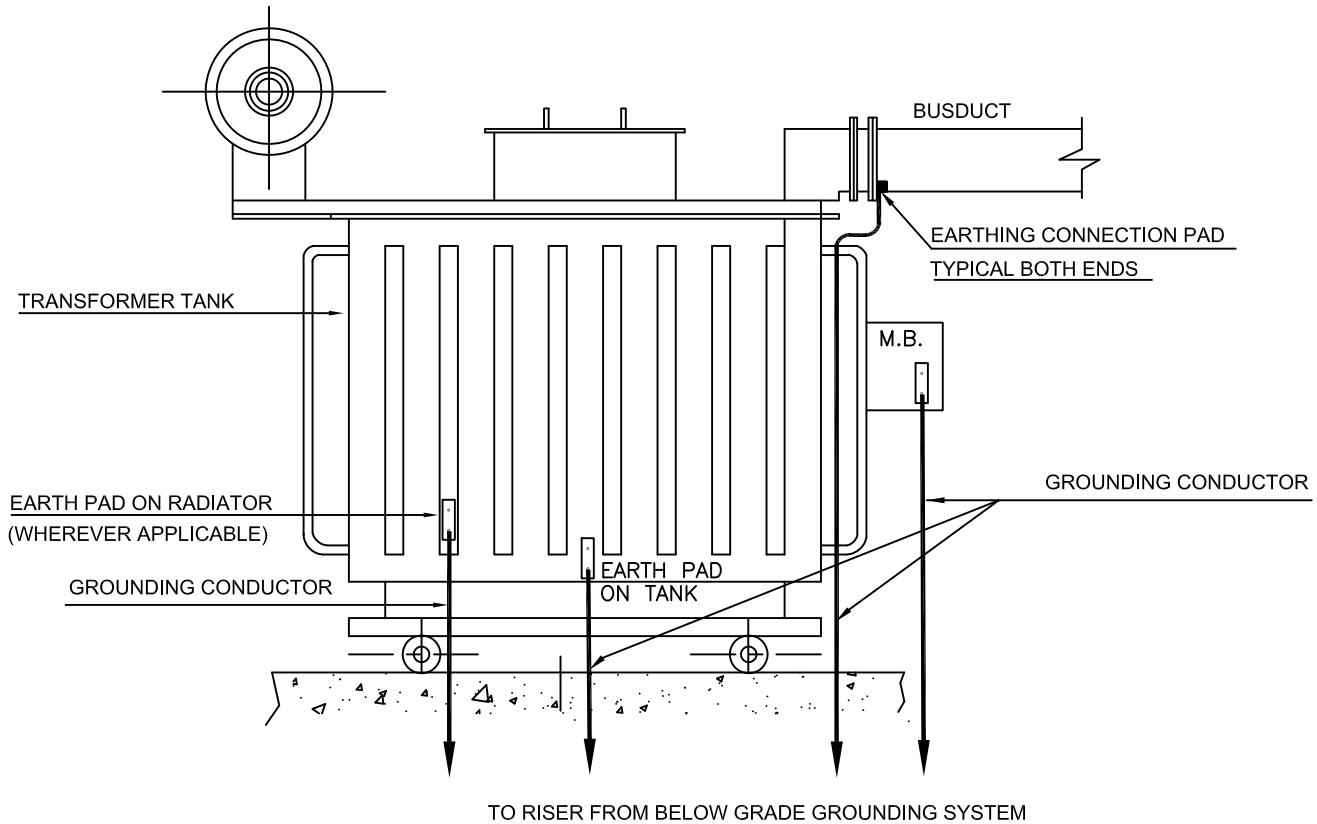
Coal to 2000 TPD Ammonium Nitrate, LSTK-1

TYPICAL ABOVE GROUND EARTHING DETAILS

BHARAT HEAVY ELECTRICALS LIMITED
INDUSTRIAL SYSTEM GROUP
BANGALORE-12



E1 : TYPICAL MOTOR GROUNDING DETAILS

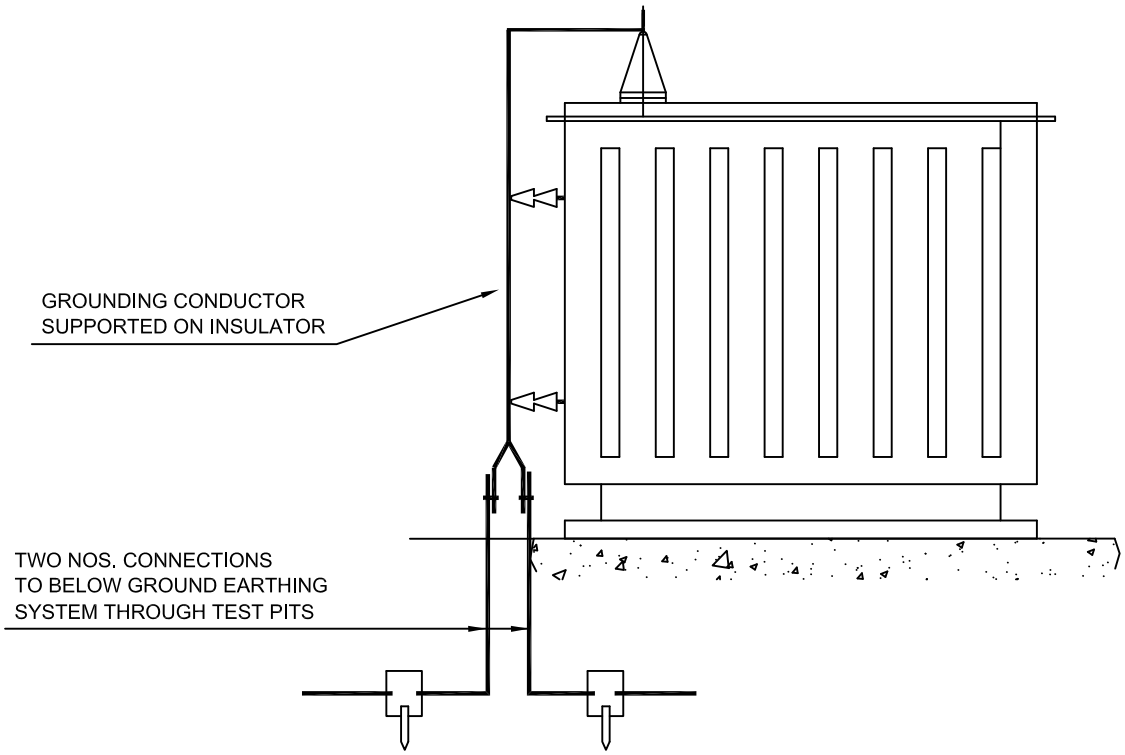


E2 : TRANSFORMER GROUNDING

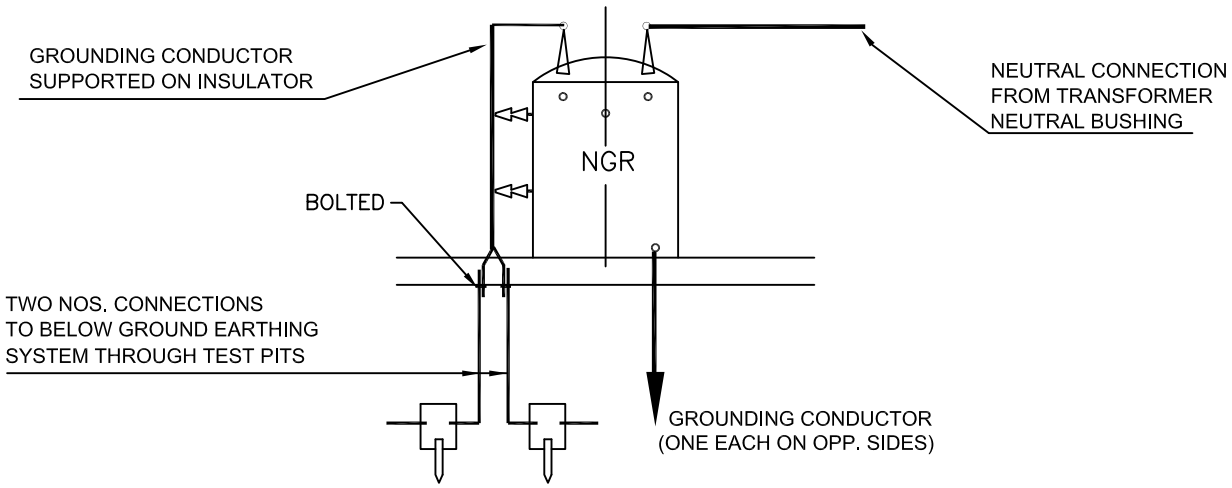
FOR GENERAL NOTES REFER SHT 12 & 13

TITLE

TYPICAL ABOVE GROUND EARTHING DETAILS



E3A : NEUTRAL EARTHING (DIRECTLY GROUNDED)

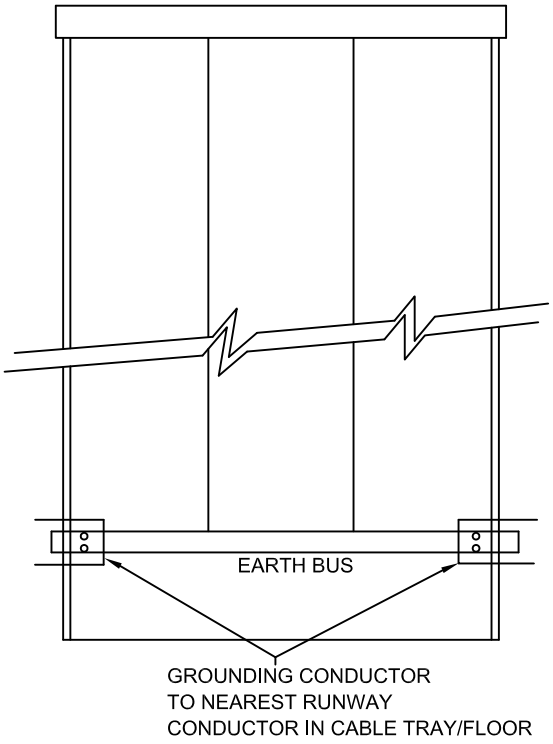


E3B : NEUTRAL EARTHING (THROUGH RESISTOR)

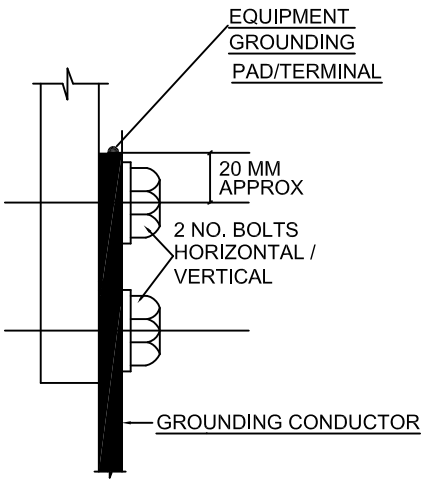
FOR GENERAL NOTES REFER SHT 12 & 13

TITLE

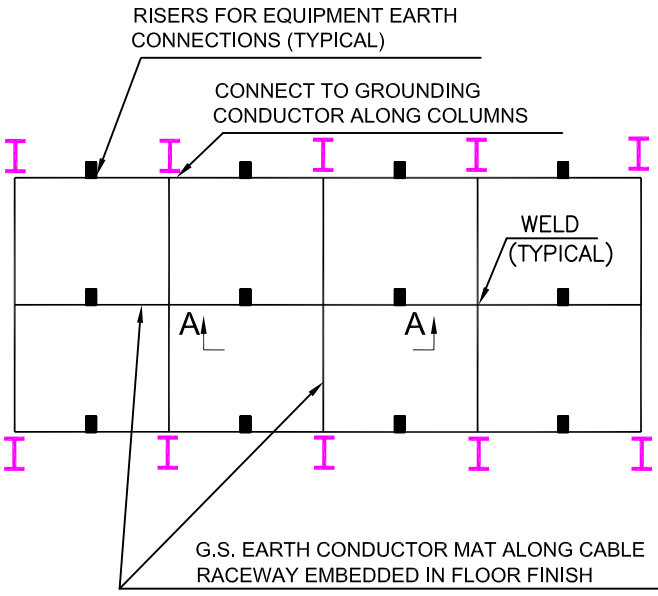
TYPICAL ABOVE GROUND EARTHING DETAILS

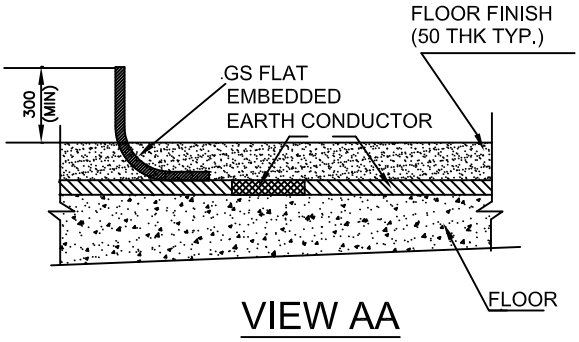


E4 : FLOOR MOUNTED PANEL GROUNDING



E5 : TYPICAL ARRANGEMENT BOLTED JOINT FOR EQUIPMENT GROUNDING





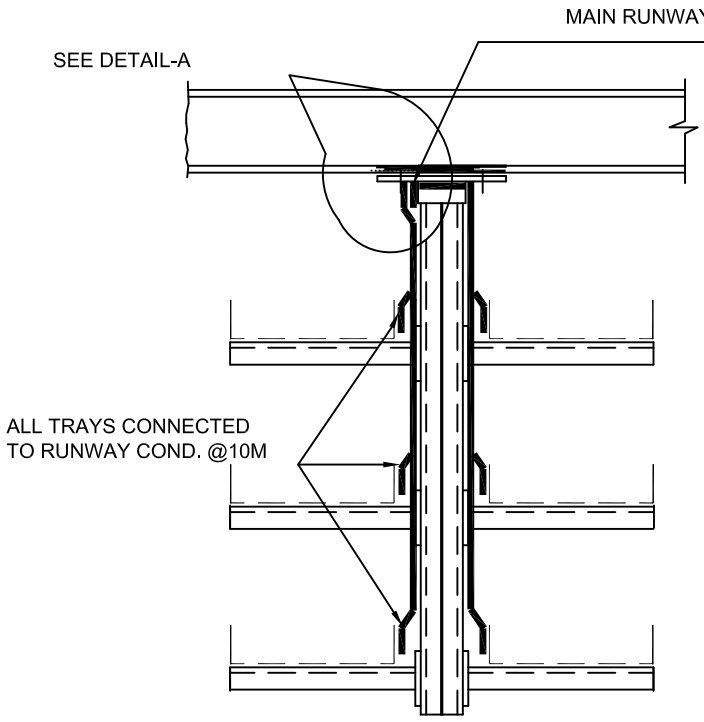
VIEW AA

E6 : FLOOR EARTH MAT TYPICAL DETAILS

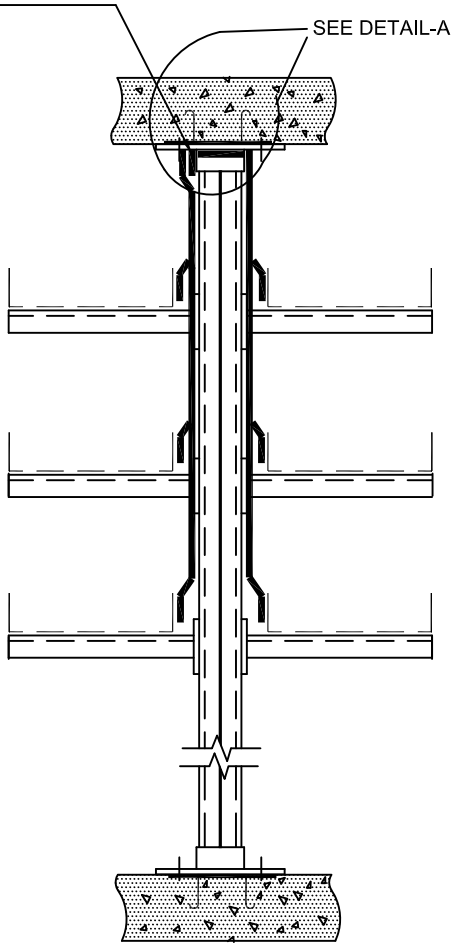
FOR GENERAL NOTES REFER SHT 12 & 13

TITLE

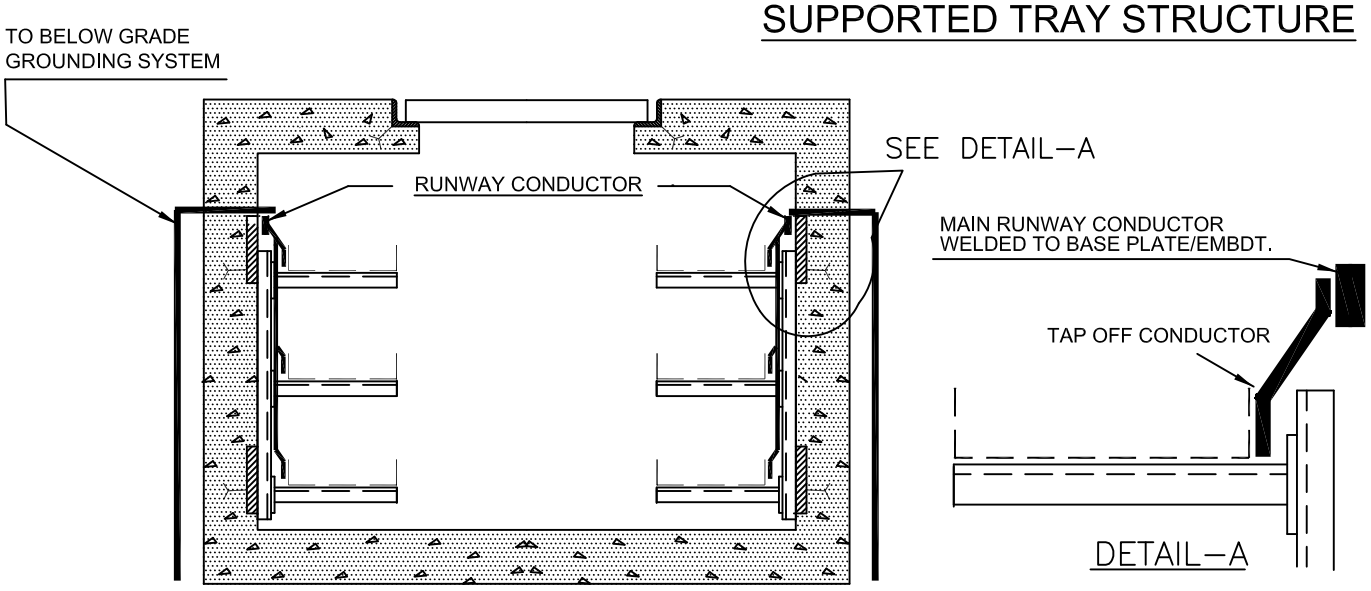
TYPICAL ABOVE GROUND EARTHING DETAILS



E7 : GROUNDING OF OVERHEAD TRAY STRUCTURE



E8 : GROUNDING OF FLOOR SUPPORTED TRAY STRUCTURE

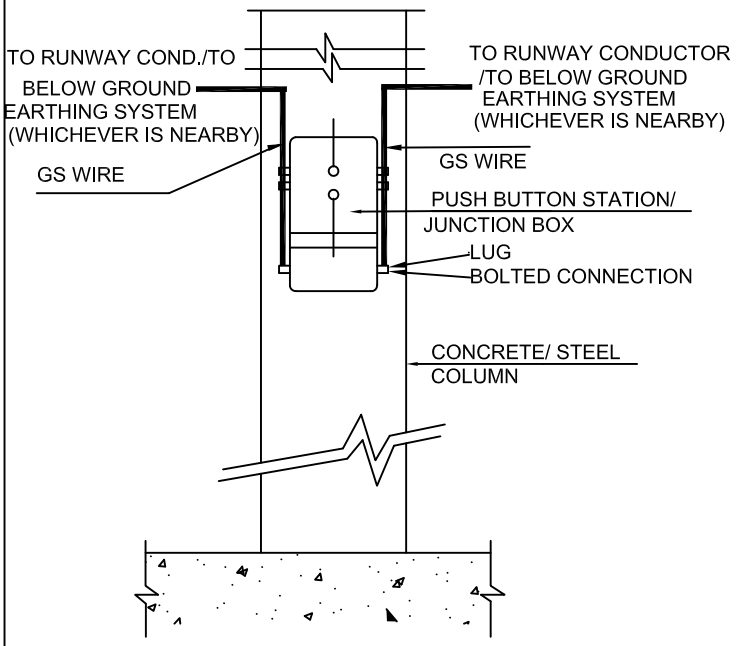


E9 : GROUNDING OF TRAYS IN CABLE TRENCH

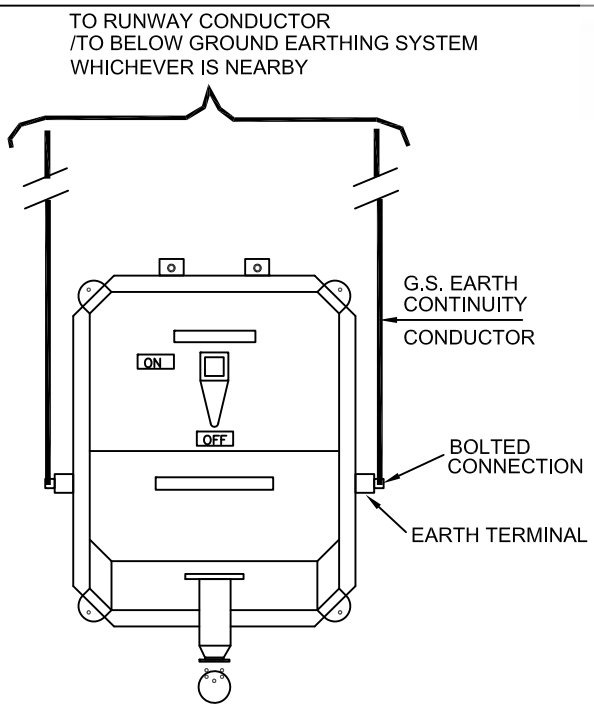
FOR GENERAL NOTES REFER SHT 12 & 13

TITLE

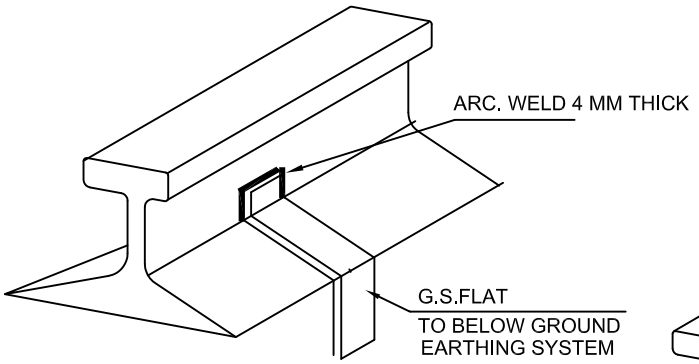
TYPICAL ABOVE GROUND EARTHING DETAILS

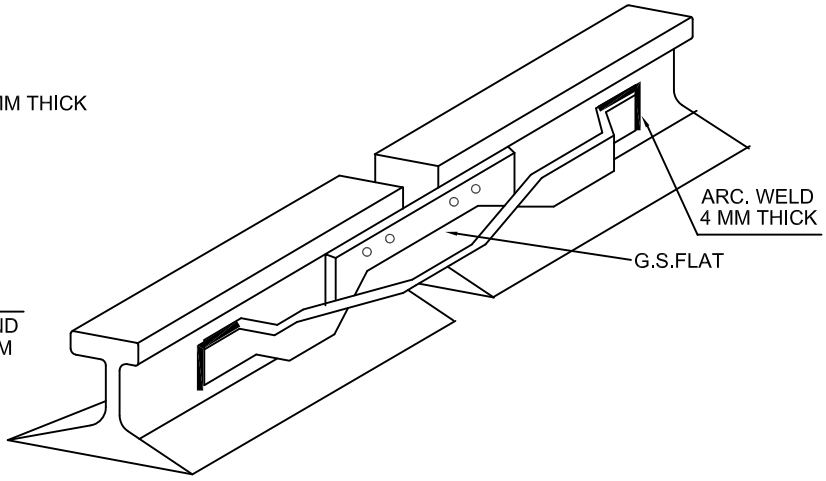


E10 : PUSH BUTTON STATION/ JUNCTION BOX GROUNDING

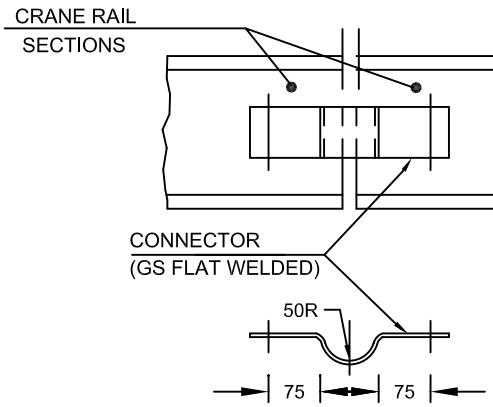


E11 : 3-PHASE WELDING RECEPTACLE GROUNDING





E12 : RAIL BONDING/GROUNDING

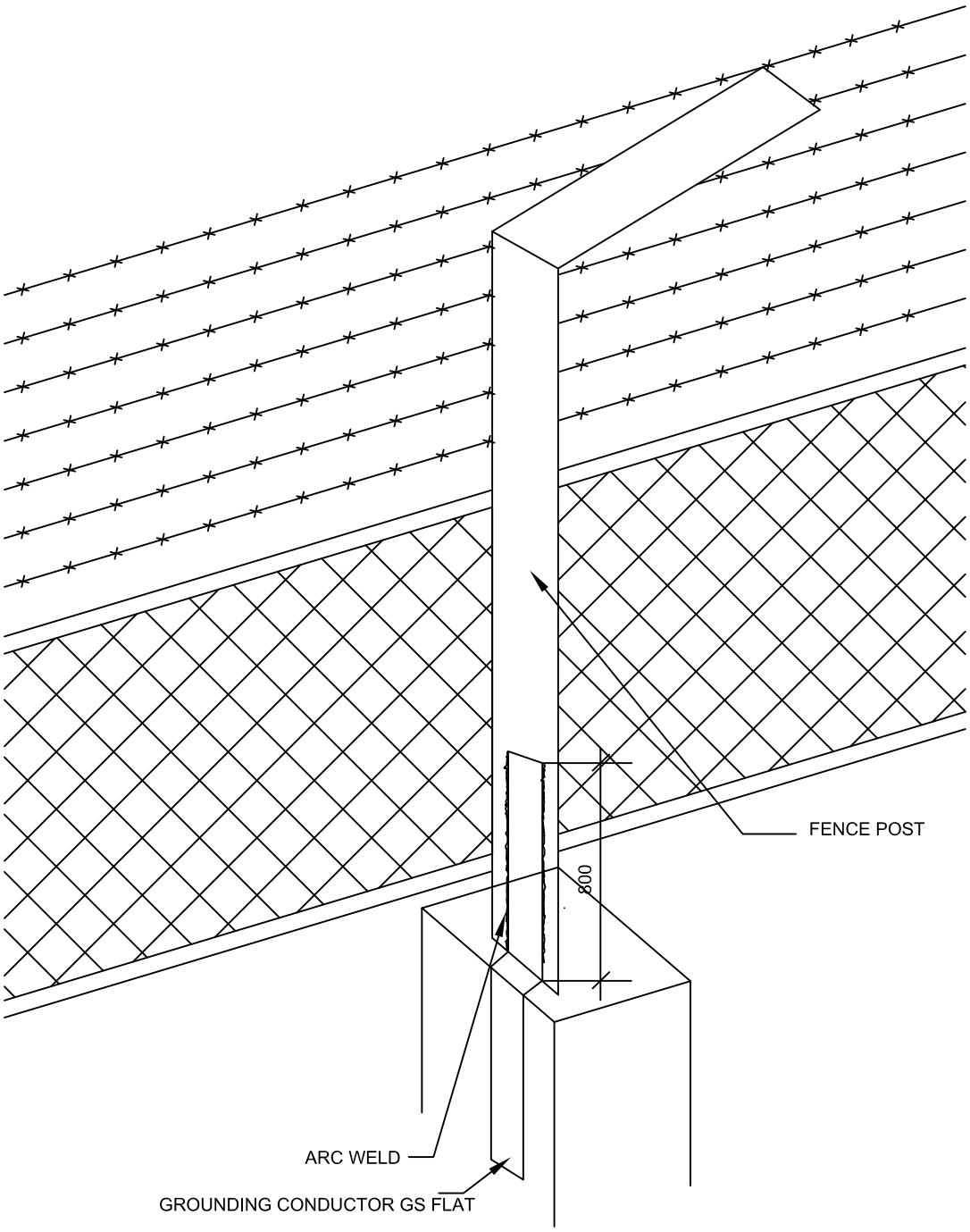


E13 : BONDING OF CRANE RAIL

FOR GENERAL NOTES REFER SHT 12 & 13

TITLE

TYPICAL ABOVE GROUND EARTHING DETAILS



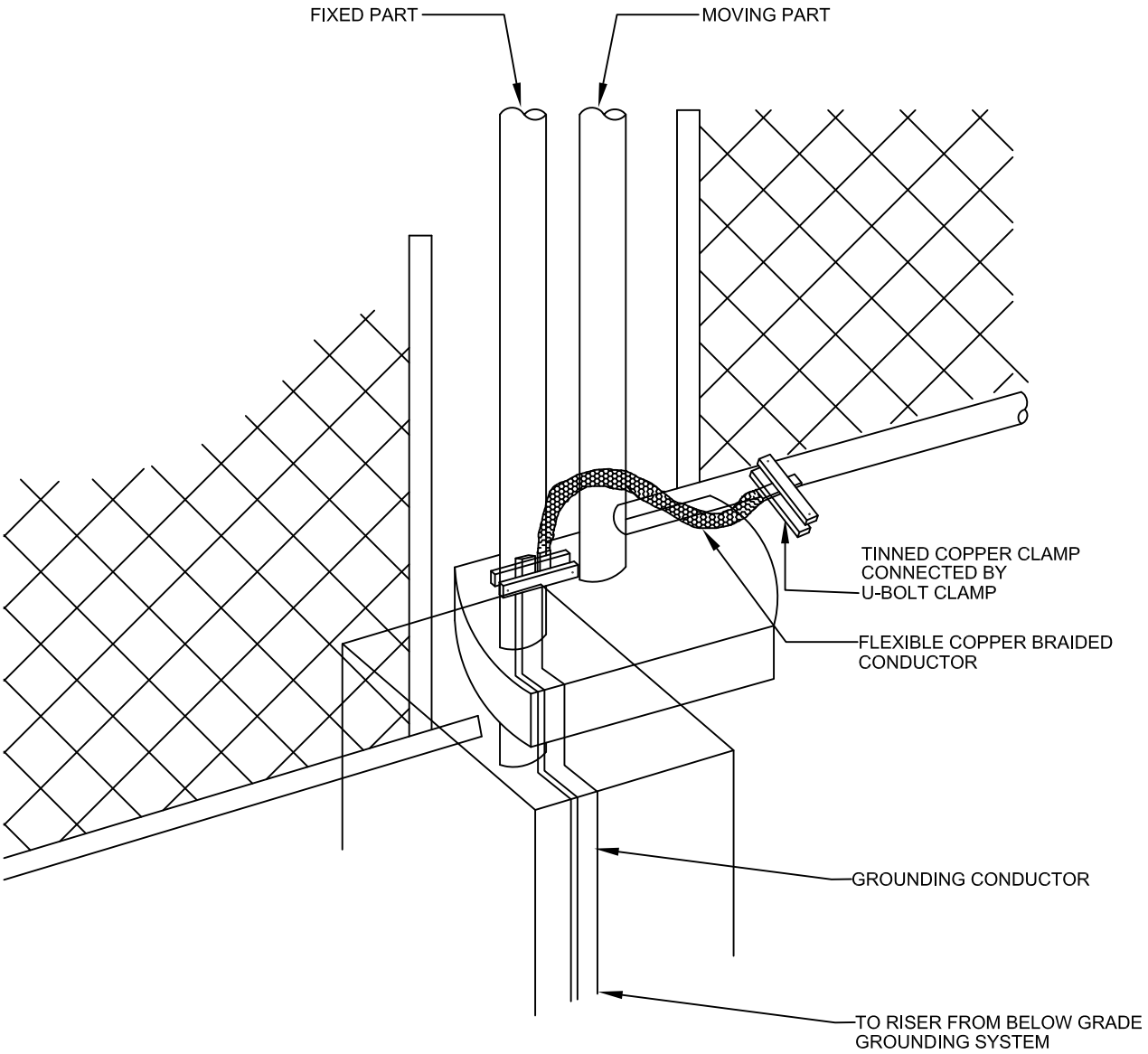
E14: FENCE GROUNDING

NOTE: EVERY ALTERNATE POST OF THE FENCE SHALL BE CONNECTED SHALL BE CONNECTED TO THE EARTHING GRID BY GS FLAT.

FOR GENERAL NOTES REFER SHT 12 & 13

TITLE

TYPICAL ABOVE GROUND EARTHING DETAILS

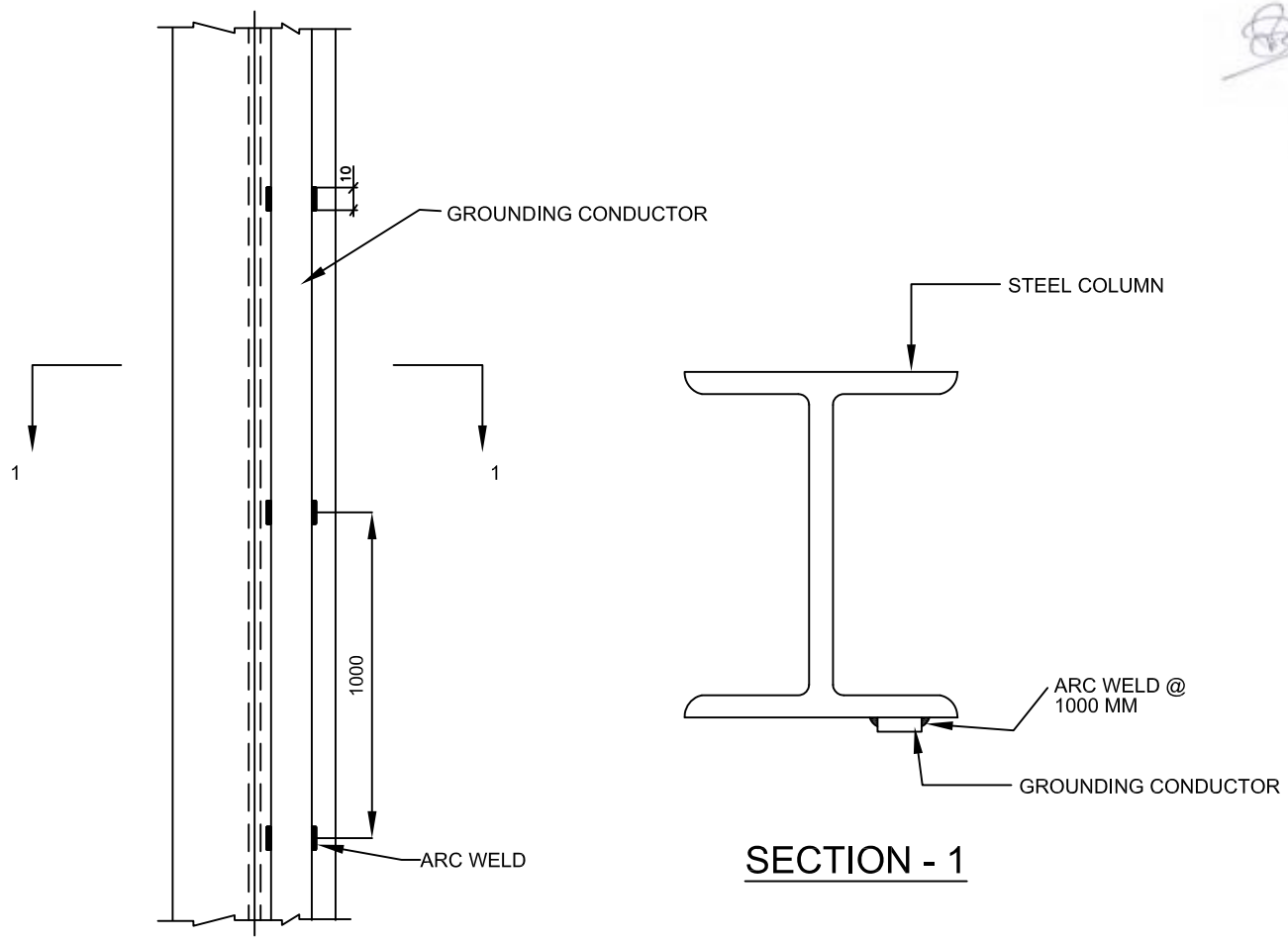


E15: FENCE GATE GROUNDING

FOR GENERAL NOTES REFER SHT 12 & 13

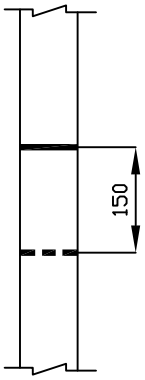
TITLE

TYPICAL ABOVE GROUND EARTHING DETAILS



SECTION - 1

E16: GROUNDING CONDUCTOR ALONG STEEL COLUMN



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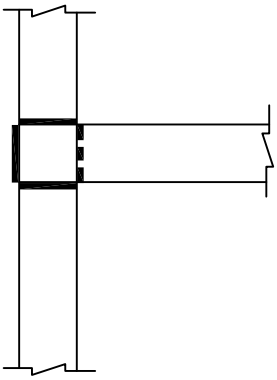

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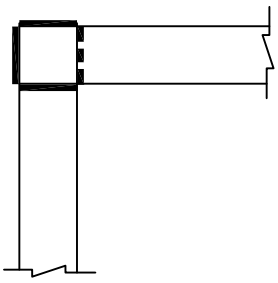
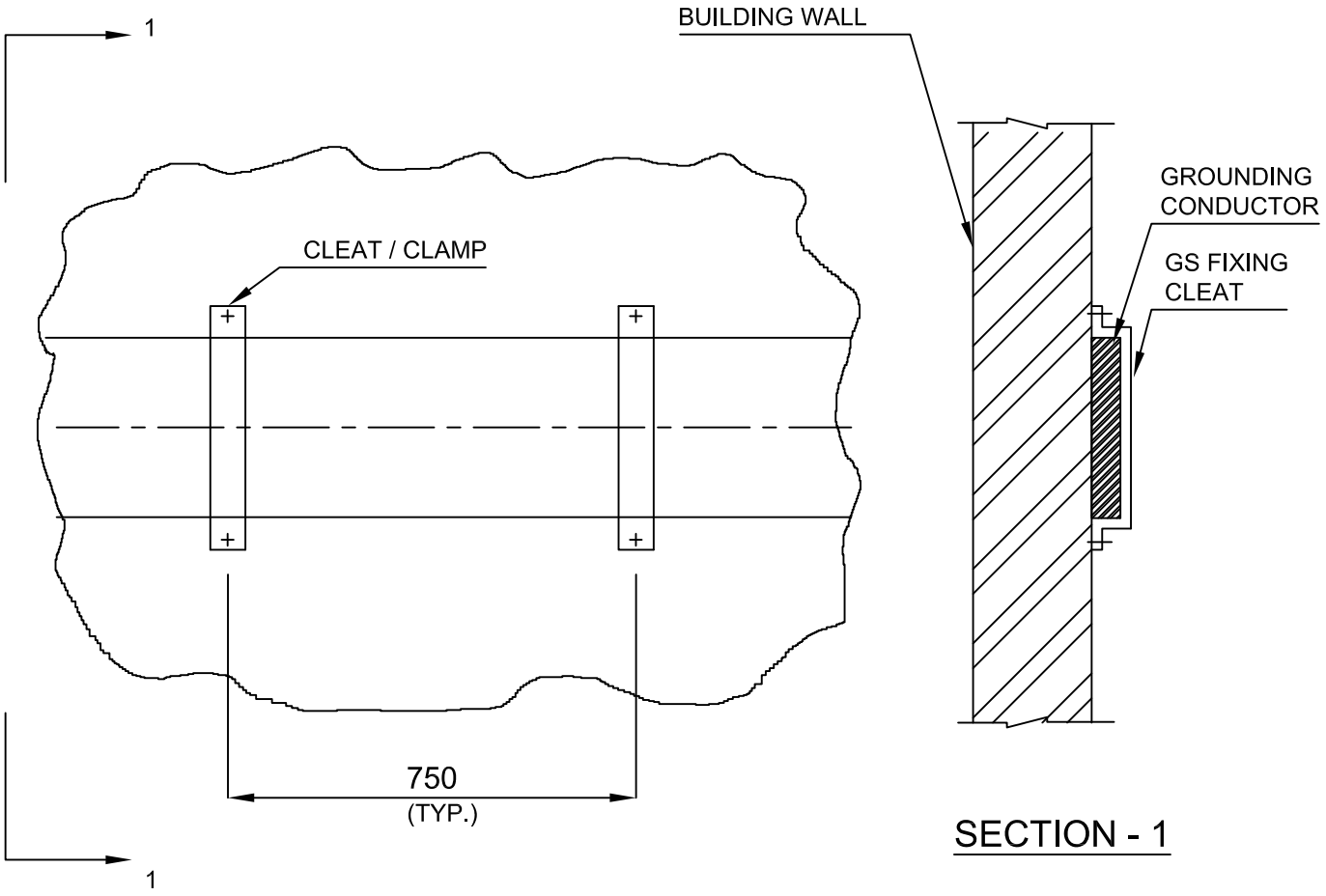


90° CHANGE

FOR GENERAL NOTES REFER SHT 12 & 13

TITLE

TYPICAL ABOVE GROUND EARTHING DETAILS

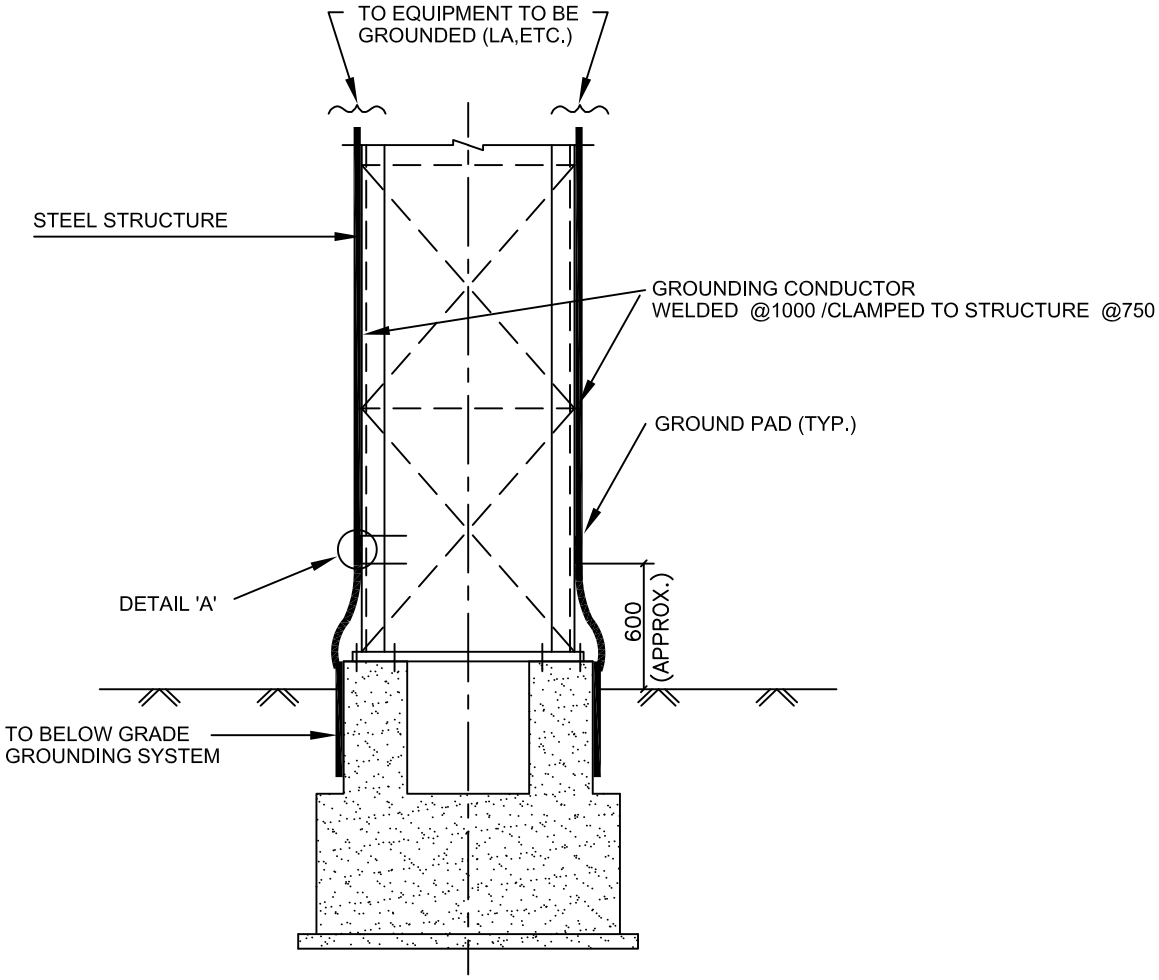


E17: GROUNDING CONDUCTOR ALONG BUILDING WALL

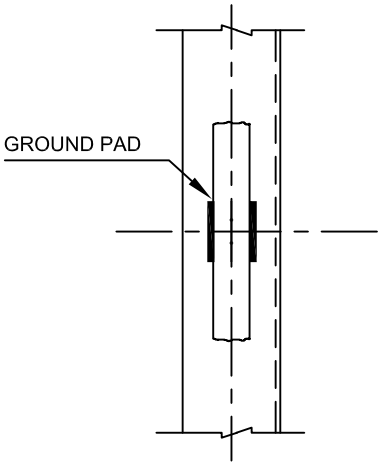
FOR GENERAL NOTES REFER SHT 12 & 13

TITLE

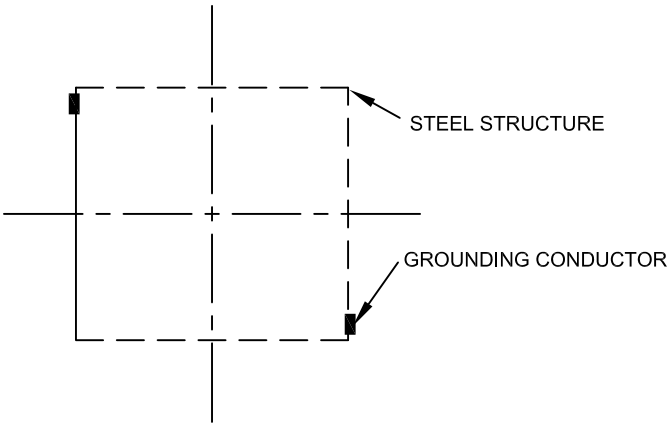
TYPICAL ABOVE GROUND EARTHING DETAILS



SECTION



DETAIL - A



PLAN

E18: STRUCTURE AND EQUIPMENT GROUNDING

FOR GENERAL NOTES REFER SHT 12 & 13

TITLE

TYPICAL ABOVE GROUND EARTHING DETAILS

NOTES:

1. THE DETAILS SHOWN IN THIS DRAWING ARE APPLICABLE TO THE ABOVE GRADE GROUNDING FOR COAL HANDLING , LIME HANDLING AND ASH HANDLING PLANT IN BHEL SCOPE. FOR OTHER AREAS RESPECTIVE BHEL UNIT DOCUMENTS SHALL BE REFERRED.

2. GALVANISED M.S. CONDUCTORS ARE USED FOR EQUIPMENT GROUNDING. SIZE OF GROUND CONDUCTOR SHALL BE AS PER TABLE ON SHEET 14.

3. ALL GROUND CONDUCTOR CONNECTIONS AT EQUIPMENT ENDS ARE BOLTED.

4. ALL FASTENERS (NUTS/BOLTS/WASHERS) SHALL BE GALVANISED / ZINC PASSIVATED.

5. FROM BELOW GRADE GROUNDING SYSTEM, RISERS OF 40 MM. DIA. MILD STEEL ROD SHALL BE BROUGHT OUT AND CONNECTED TO MAIN GROUND CONDUCTOR (65X8 MM GALVANISED MS FLAT) RUN ALONG BUILDING COLUMNS/ WALLS AND SECURELY FIXED TO THE SAME BY WELDING/ CLEATING AT INTERVALS OF 1000 MM AND 750MM RESPECTIVELY.
CONNECTIONS FROM EQUIPMENT EARTH TERMINALS, RUNWAY CONDUCTOR,FLOOR SUBMAT, ETC. SHALL BE CONNECTED TO THESE MAIN CONDUCTORS.

6. A CONTINUOUS 65X8 MM. GALVANISED M.S. FLAT EARTH CONDUCTOR (RUNWAY CONDUCTOR) SHALL BE INSTALLED ALONG ALL COLUMNS & STRUCTURES WHICH SHALL SERVE AS THE MAIN GROUNDING CONDUCTOR FOR RECEIVING INDIVIDUAL GROUND CONNECTIONS. ALL TRAY TIERS OF EACH SECTION SHALL BE CONNECTED TO THE RUNWAY CONDUCTOR AT AN INTERVAL OF ABOUT 10 M.
THE RUNWAY CONDUCTORS AT DIFFERENT BUILDING ELEVATIONS SHALL BE INTERCONNECTED BETWEEN THE MAIN RISERS ALONG COLUMNS/WALLS & SHALL ALSO BE CONNECTED TO THE NEAREST RISER/ STRUCTURAL COLUMNS AND THE DISTANCE BETWEEN EARTHING POINT SHALL NOT EXCEED 30M.
WHEREVER EARTH MAT IS NOT AVAILABLE,NECESSARY CONNECTIONS SHALL BE DONE BY DRIVING AN EARTH ELECTRODE IN THE GROUND.

7. ALL ELECTRICAL EQUIPMENT AND ASSOCIATED NON CURRENT CARRYING METAL WORKS, SUPPORTING STRUCTURES, ETC. SHALL BE CONNECTED TO MAIN RUNWAY CONDUCTOR OR BELOW GROUND EARTHING SYSTEM BY TWO SEPARATE & DISTINCT CONNECTIONS EACH OF 100% CAPACITY. ELECTRICAL CONTINUITY SHALL BE ENSURED BY BONDING DIFFERENT SECTIONS OF HAND RAILS & METALLIC STAIRS.

8. TWO SEPARATE AND DISTINCT GROUND CONNECTIONS SHALL BE PROVIDED FOR GROUNDING OF EACH ELECTRICAL EQUIPMENT FRAMEWORK.

9. ALL BUILDING STEEL COLUMNS, STRUCTURAL STEEL COLUMNS, DEVICES SUCH AS JUNCTION BOXES, PULL BOXES, PUSH BUTTON STATIONS, LOCKOUT SWITCHES, CABLE END BOXES ETC. SHALL BE GROUNDED WHETHER SPECIFICALLY SHOWN IN THE DRAWING OR NOT AS PER TABLE ON SHEET 14 OF 14.

10. GROUND CONDUCTOR CONNECTIONS ABOVE GRADE LEVEL SHALL BE GENERALLY MADE BY ELECTRIC ARC WELDING EXCEPT AT EQUIPMENT TERMINALS. M.S. GROUND CONDUCTOR ABOVE GROUND LEVEL SHALL BE TREATED WITH RED LEAD OXIDE AND AFTERWARDS THICKLY COATED WITH BITUMEN COMPOUND TO PREVENT CORROSION. DAMAGED PORTIONS OF GALVANISED MS SHALL BE COATED WITH TWO COATS OF COLD GALVANISING AND ANTI-CORROSIVE PAINT AFTER WELDING.

11. AT EQUIPMENT ENDS, ONLY BOLTED CONNECTION SHALL BE MADE FOR GROUNDING OF EQUIPMENT/ DEVICES AND REMOVABLE STRUCTURES. THE CONTACT SURFACE SHALL BE THROUGHLY CLEANED

TITLE

TYPICAL ABOVE GROUND EARTHING DETAILS

BEFORE CONNECTION TO ENSURE GOOD ELECTRICAL CONTACT.

12. GROUNDING CONDUCTORS ON FLOORS (I.E. SUBMATS) SHALL BE PROVIDED AS AN ALTERNATIVE TO THE SYSTEM DESCRIBED AT 5 & 6 ABOVE ONLY WHERE DIRECT CONNECTION OF EQUIPMENT/ PANELS TO RUNWAY CONDUCTOR/ MAIN GROUND LEADS IS NOT POSSIBLE DUE TO LAYOUT CONSTRAINT. IN SUCH CASES GROUND CONDUCTORS ON FLOORS SHALL BE LAID ON RCC SLAB BEFORE FLOOR FINISHING IS DONE AND CONNECTED TO THE BELOW GROUND EARTHING SYSTEM THROUGH TWO RISERS LOCATED PREFERABLY DIAMETRICALLY OPPOSITE TO EACH OTHER. SUITABLE RISER STUBS SHALL BE PROVIDED ABOVE THE FINISHED FLOOR IF THE EQUIPMENT IS NOT AVAILABLE AT THE TIME OF LAYING THE MAIN GROUNDING CONDUCTOR.

13. EACH STREET LIGHTING POLE, FLOOD LIGHTING POLE AND LIGHTING MAST WILL BE GROUNDED BY 25X3 MM GS FLAT, WHICH WILL BE CONNECTED TO ONE NO. 40 MM DIA & 3M LONG EARTH ROD DIRECTLY DRIVEN INTO GROUND. THE JUNCTION BOX AT EACH LIGHTING POLE IS GROUNDED AT ONE POINT FROM 1 NO. EARTHING TERMINAL BY 14 SWG GI WIRE.
A SEPARATE EARTHING CONDUCTOR SHALL BE PROVIDED FOR EARTHING LIGHTING FIXTURES, RECEPTACLES, SWITCHES, JUNCTION BOXES, LIGHTING CONDUITS, POLES ETC. THIS CONDUCTOR IN TURN SHALL BE CONNECTED TO MAIN EARTH GRID.

14. ELECTRICAL CONDUITS, PIPES AND CABLE TRAY SECTIONS SHALL BE BONDED TO ENSURE ELECTRICAL CONTINUITY AND CONNECTED TO EARTHING CONDUCTORS AT REGULAR INTERVALS.
STEEL/RCC COLUMNS, METALLIC STAIRS, HANDRAILS, CABLE TRAYS, METALLIC CONDUITS AND PIPES SHALL NOT BE USED AS EARTH CONTINUITY CONDUCTOR.

15. NEUTRAL CONNECTION SHALL NOT BE USED FOR THE EQUIPMENT EARTHING.

16. JOINTS SHALL BE AVOIDED AS FAR AS POSSIBLE. JOINTS SHALL BE MINIMUM FOR GENERATORS AND TRANSFORMER NEUTRAL CONNECTION TO EARTHING PIT TO MINIMIZE EARTH IMPEDANCE.

17. FLEXIBLE CONDUITS ARE CONNECTED TO RIGID CONDUITS BY GI WIRE TO ENSURE CONTINUITY.

18. CABLE TRAY PIPE RACK/ TRESTLE COLUMNS SHALL BE GROUNDED THROUGH GI FLAT THAT WILL BE CONNECTED TO BELOW GROUND EARTHING SYSTEM.

19. ALL BIMETALLIC CONNECTIONS (IF ANY) SHALL BE BRAZED TYPE AND SHALL BE TREATED TO PREVENT MOISTURE INGRESSION.

19. GROUNDING INSTALLATION SHALL CONFORM TO THE FOLLOWING:
(A) IS:3043
(B) CHAPTER 7 TYPICAL BELOW GROUND EARTHING DETAILS)
(C) INDIAN ELECTRICITY RULE.

TITLE

TYPICAL ABOVE GROUND EARTHING DETAILS

TABLE : ABOVE GRADE GROUNDING SYSTEM - CONDUCTOR SIZES

SL. NO.	TYPE OF EQUIPMENT	SIZE (MM)	MATERIAL	NO. OF LEADS
01	RISERS	65X8	GALVANISED MS FLAT	N.A.
02	SUB-MAT BURIED IN FLOOR FINISH	65X8	GALVANISED MS FLAT	N.A.
03	RUNWAY CONDUCTOR/ MAIN EARTH LEAD ALONG COLUMNS & STRUCTURES	65X8	GALVANISED MS FLAT	N.A.
04	11KV/ 3.3 KV/415V SWITCHGEAR/ MCC	65X8	GALVANISED MS FLAT	TWO
05	SYSTEM NEUTRALS	65X8	GALVANISED MS FLAT	TWO
06	415V DISTRIBUTION BOARDS	50X6	GALVANISED MS FLAT	ONE FOR EACH SECTION
07	FUSE DISTRIBUTION BOARDS, LDBS	50X6	GALVANISED MS FLAT	TWO
08	11KV & 3.3 KV MOTORS	65X8	GALVANISED MS FLAT	TWO
09	415V MOTORS : ABOVE 125KW	50X6	GALVANISED MS FLAT	TWO
10	415V MOTORS : ABOVE 25KW UPTO 125KW	25X6	GALVANISED MS FLAT	TWO
11	415V MOTORS : UPTO 25KW	25X3	GALVANISED MS FLAT	TWO
12	415V MOTORS : FRACTIONAL KW	8SWG	GS WIRE	TWO
13	CONTROL PANEL & CONTROL DESK	25X3	GALVANISED MS FLAT	TWO
14	PUSH BUTTON STATION & JUNCTION BOX	8SWG	GS WIRE	TWO
15	CABLE TRAYS, COLUMNS & STRUCTURES	50X6	GALVANISED MS FLAT	ONE
16	BUSDUCT ENCLOSERS			
i)	ISOLATED PHASE BUSDUCT	50X6	GALVANISED MS FLAT	TWO
ii)	SEGREGATED PHASE / NON SEGREGATED PHASE BUSDUCT	50X6	GALVANISED MS FLAT	TWO
17	RAILS & METAL PARTS,STEEL TANKS, FENCE	25X6	GALVANISED MS FLAT	TWO
18	TRANSFORMER TANKS / RADIATORS	50X6	GALVANISED MS FLAT	TWO
19	TRANSFORMER NEUTRAL GENERATOR ENCLOSURE	50X6	GALVANISED MS FLAT	TWO
20	WELDING OUTLETS 3-PHASE RECEPTACLES	50X6	GALVANISED MS FLAT	TWO
21	LOCAL PANELS, LIGHTING PANELS	25X3	GALVANISED MS FLAT	TWO
22	LIGHTING POLE/ MASTS	25X3	GALVANISED MS FLAT	ONE
23	LIGHTING FIXTURES, CONDUITS,SINGLE-PHASE RECEPTACLES, LIGHTING JBs , SWITCH BOXES	14SWG	GS WIRE	ONE

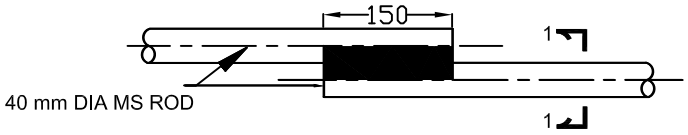
TITLE

TYPICAL ABOVE GROUND EARTHING DETAILS

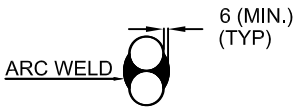
Coal to 2000 TPD Ammonium Nitrate, LSTK-1

TYPICAL BELOW GROUND EARTHING DETAILS

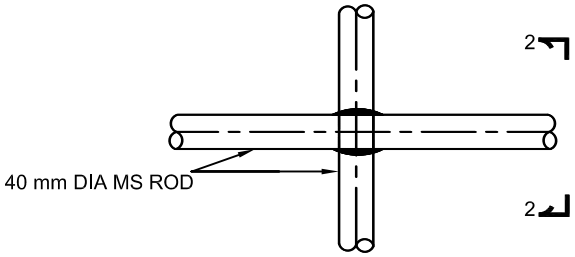
BHARAT HEAVY ELECTRICALS LIMITED
INDUSTRIAL SYSTEM GROUP
BANGALORE-12



LAP JOINT



SECTION 1-1



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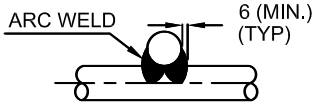

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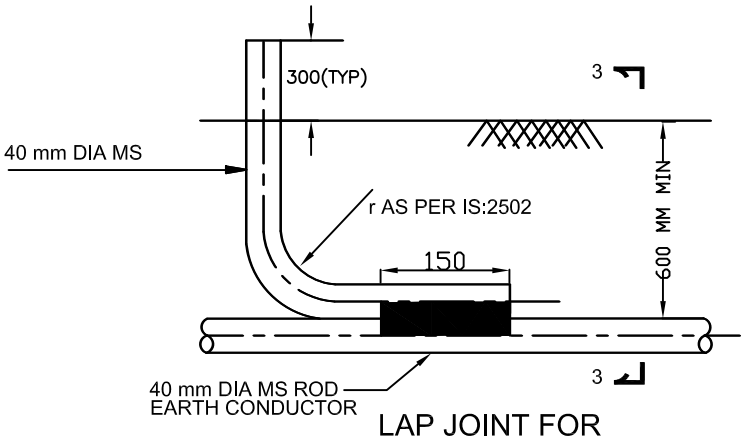
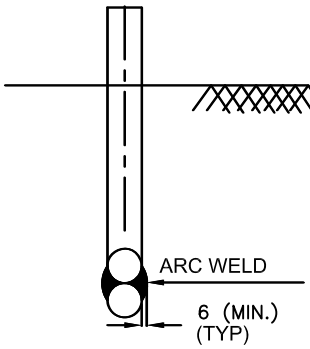


LAP JOINT FOR
RISER PIGTAIL



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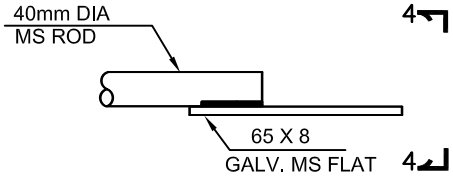

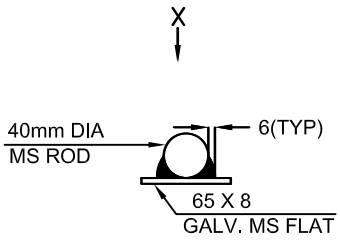

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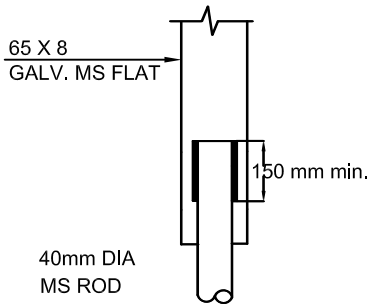
ROD FLAT JOINT

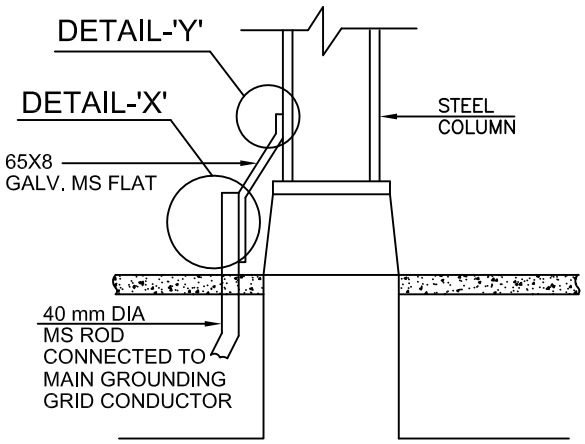


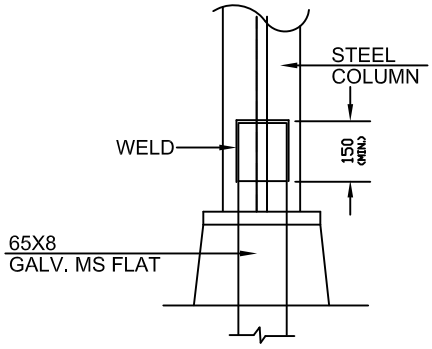
VIEW-X

WELDED JOINTS

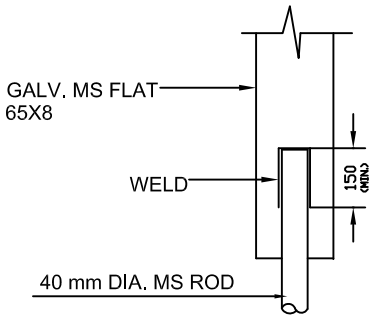
TITLE

TYPICAL BELOW GROUND EARTHING DETAILS



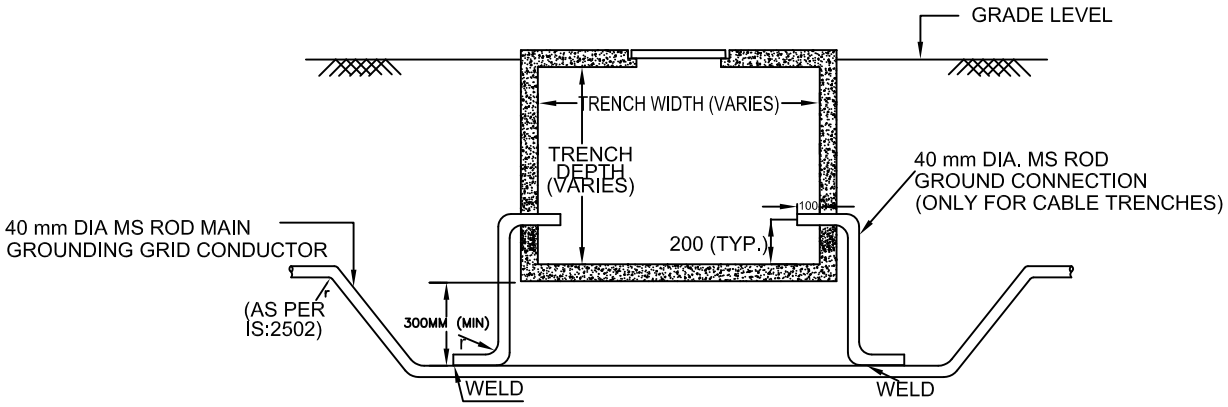


DETAIL-'Y'



DETAIL-'X'

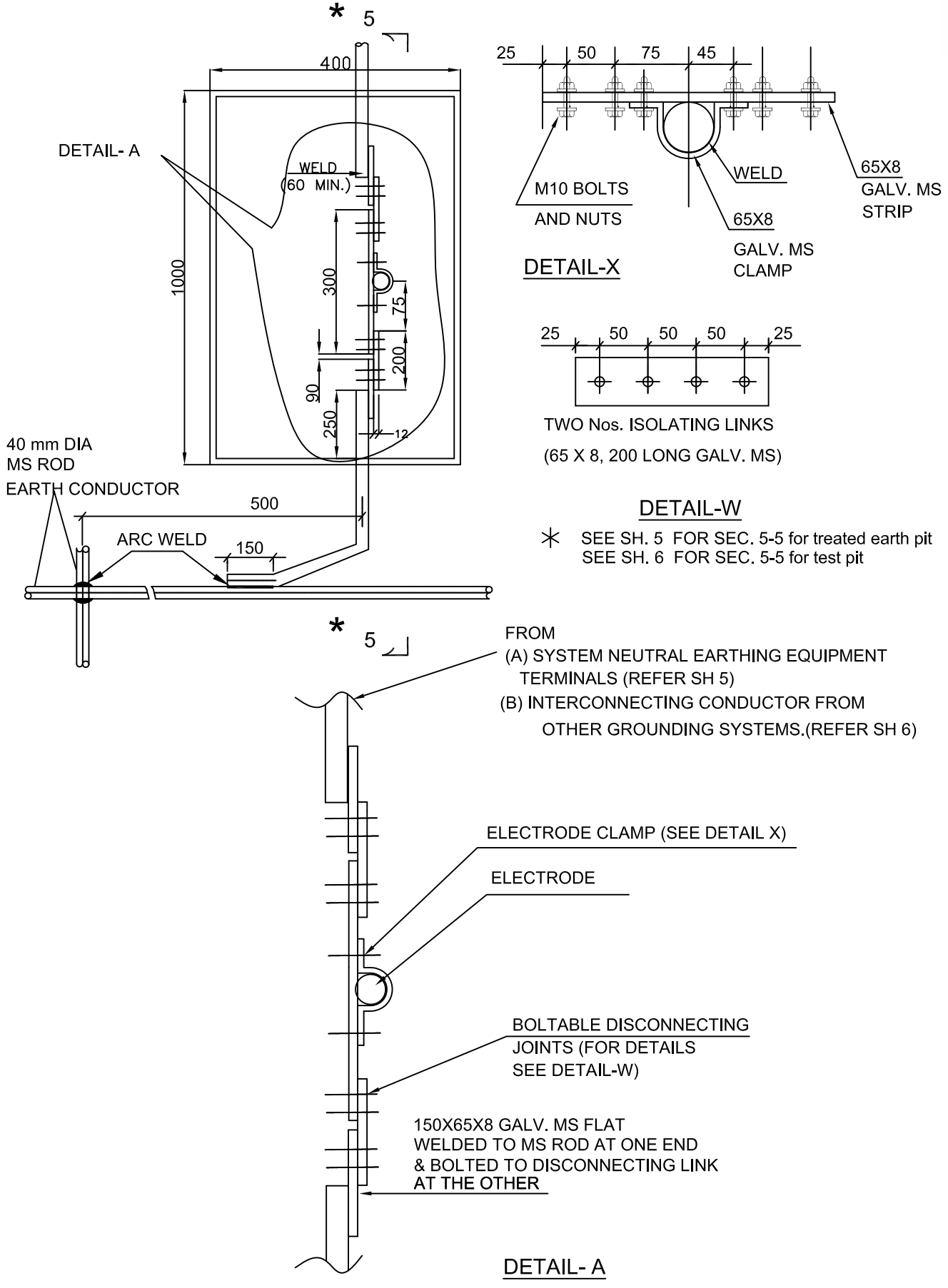
COLUMN GROUNDING



TRENCH CROSSING

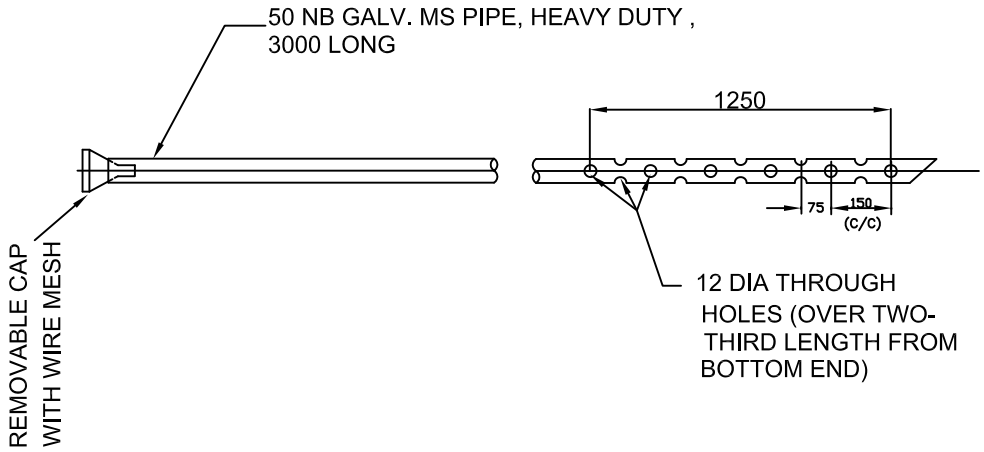
TITLE

TYPICAL BELOW GROUND EARTHING DETAILS

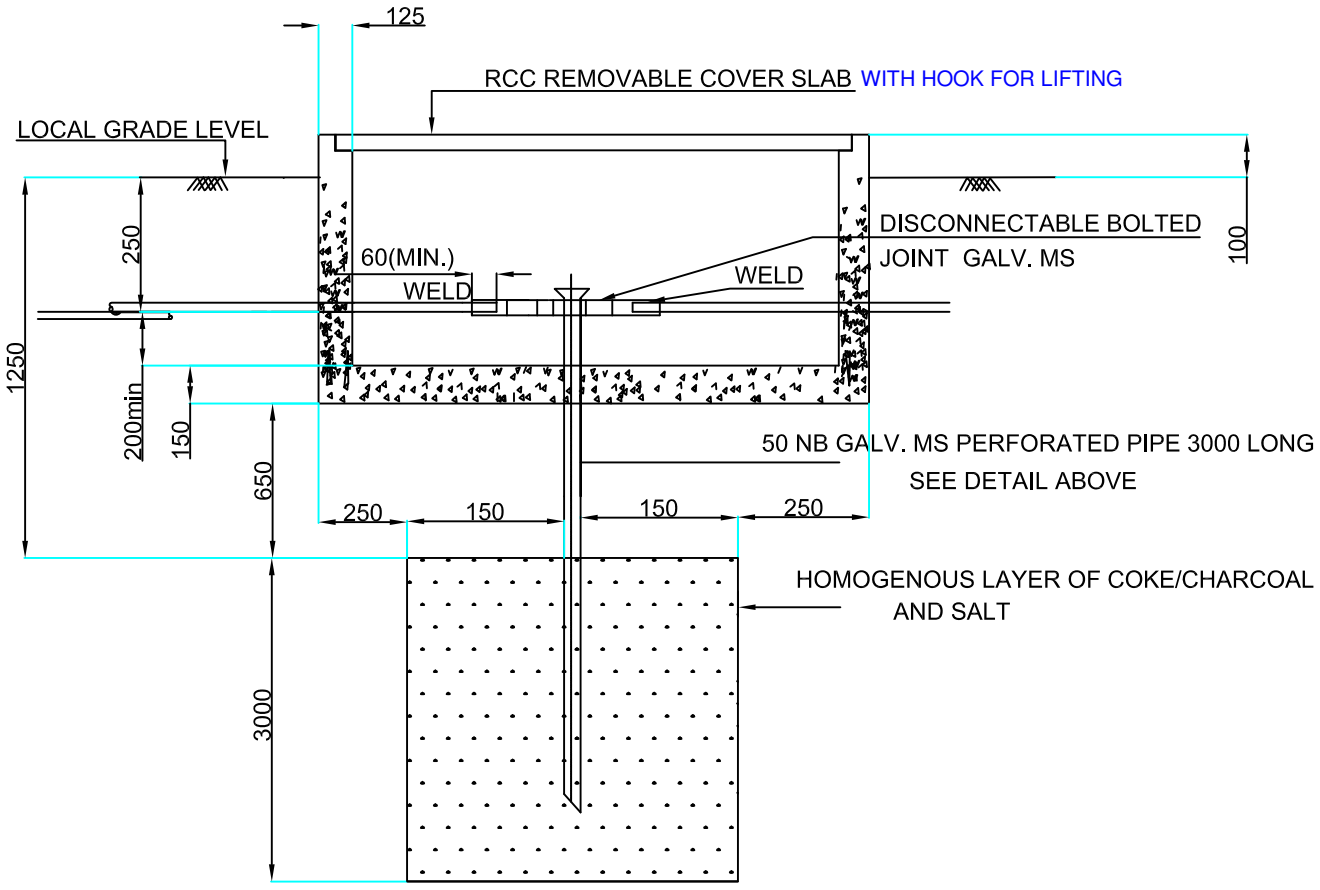


TITLE

TYPICAL BELOW GROUND EARTHING DETAILS



PERFORATED PIPE (50 NB GALV. MS)

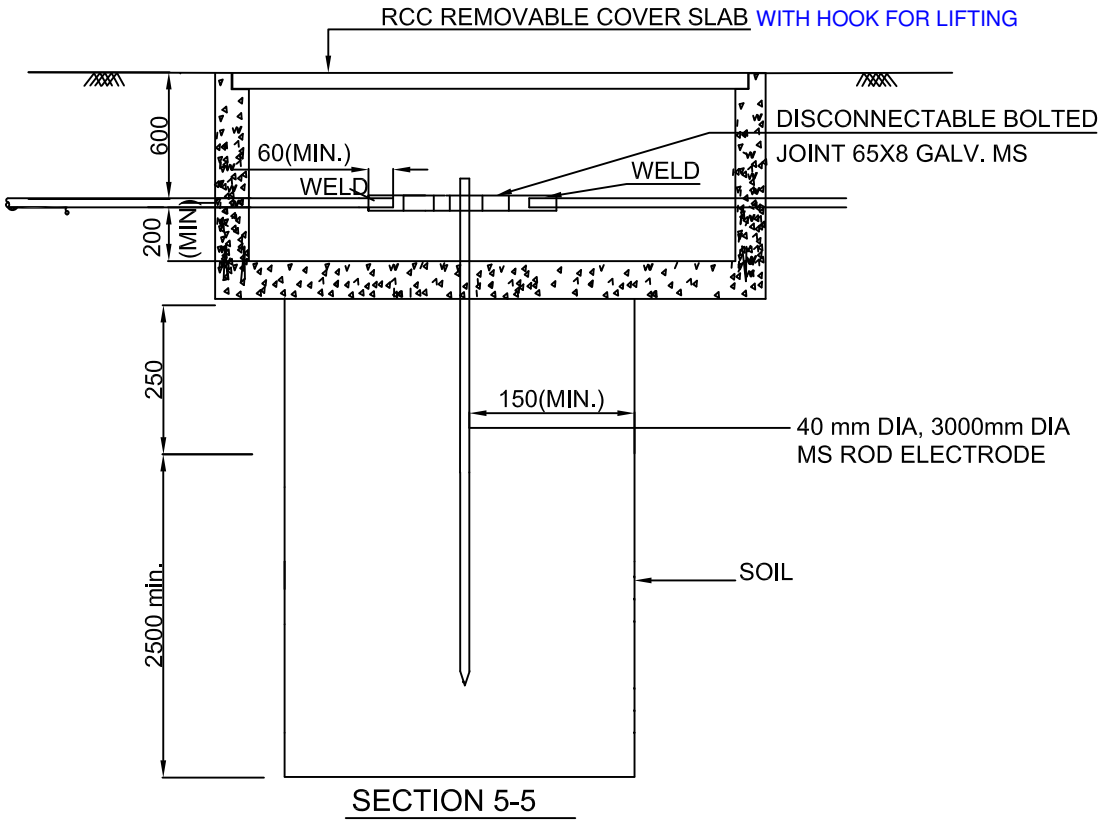


SECTION 5-5

TREATED EARTH PIT

TITLE

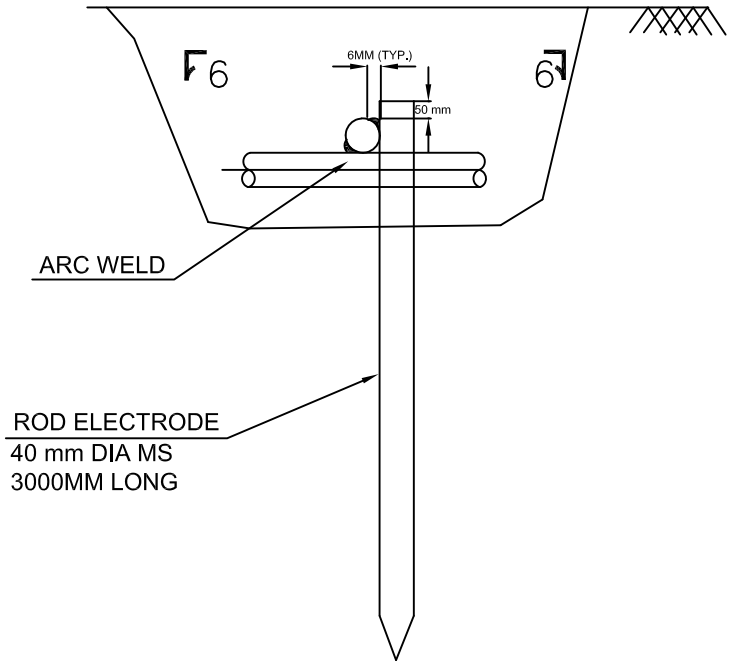
TYPICAL BELOW GROUND EARTHING DETAILS

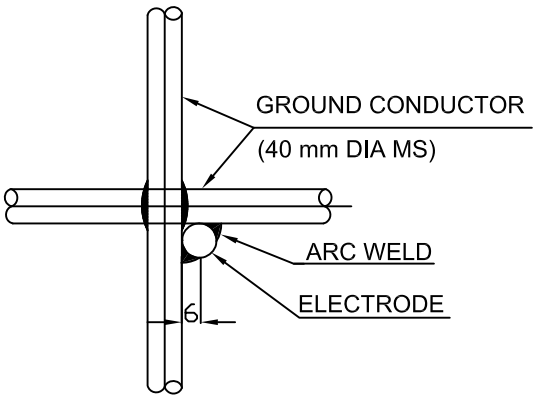


TEST EARTH PIT

TITLE

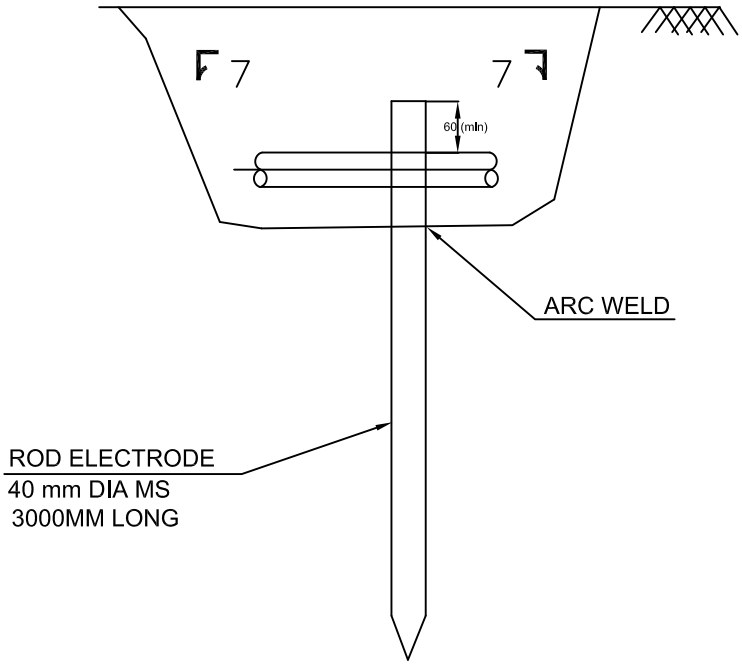
TYPICAL BELOW GROUND EARTHING DETAILS

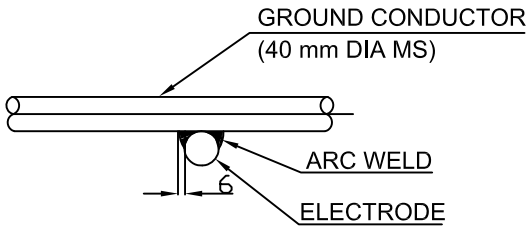




SECTION 6-6

ELECTRODE LOCATED AT JUNCTION OF GROUND CONDUCTORS





SECTION 7-7

ELECTRODES LOCATED ALONG PERIPHERAL GROUND CONDUCTOR

(FOR USE AS GROUND ELECTRODES OTHER THAN TEST PITS)

TITLE

TYPICAL BELOW GROUND EARTHING DETAILS

NOTES:–

1. THIS DRAWING COVERS TYPICAL INSTALLATION DETAILS FOR BELOW GRADE GROUNDING SYSTEM, AND SHALL BE READ IN CONJUCTION WITH RESPECTIVE GROUNDING LAYOUT DRAWINGS FOR DIFFERENT AREAS.

2. GROUND GRID OF MILD STEEL ROD MATERIAL DESIGNED TO LIMIT STEP AND TOUCH POTENTIALS WITHIN TOLERABLE LIMITS SHALL BE PROVIDED FOR THE MAIN POWER HOUSE AREA COVERING TRANSFORMER YARD, T.G. BUILDING, BOILER AREA, ESP, CHIMNEY AND CONTROL ROOM, AND AUXILIARY PLANTS COVERED WITHIN THIS ENVELOPE.

3. AUXILIARY PLANT BUILDINGS NOT COVERED BY THE MAIN GROUNDING GRID SHALL BE PROVIDED WITH RING ELECTRODE TYPE GROUNDING SYSTEM USING MILD STEEL ROD MATERIAL FOR LIMITING THE GROUND RESISTANCE BELOW 1 OHM.

4. POWER STATION GROUND GRID & SWITCHYARD GROUND GRID AND AUXILIARY PLANT GROUNDING SYSTEM SHALL BE INTERCONNECTED THROUGH AT LEAST TWO INTERCONNECTIONS WITH TEST FACILITY.

5. THE EARTH CONDUCTOR BELOW GRADE LEVEL SHALL BE BARE 40 mm DIA MILD STEEL (M.S.) ROD. & SHALL BE BURIED IN EARTH AT A MINIMUM DEPTH OF 600 MM BELOW GRADE LEVEL.

   EARTH CONDUCTOR SHALL BE ROUTED BELOW ROADS/ RAIL TRACKS/ TRENCHES WITH MINIMUM CLEARANCES AS UNDER :

   a) BELOW RAIL TRACK : MINIMUM 2000 MM
   b) BELOW ROAD/ CABLE TRENCHES/ PIPE TRENCHES : MINIMUM 300 MM.

6. EARTH RING CONDUCTOR AROUND THE OFFSITE BUILDINGS SHALL BE BURIED OUTSIDE THE BOUNDARY AT MINIMUM DISTANCE OF 1500 MM. FOR FENCE, THIS DISTANCE SHALL BE 2000 mm. EVERY ALTERNATE POST OF THE FENCES AND ALL GATES SHALL BE CONNECTED TO EARTHING GRID BY ONE LEAD.

7. EARTH ELECTRODE & TEST PIT ELECTRODE SHALL BE 40 MM DIA X 3000 MM LONG MILD STEEL ROD DRIVEN INTO THE GROUND AND CONNECTED TO THE GROUNDING GRID CONDUCTOR. EARTH ELECTRODE FOR TREATED EARTH PIT SHALL BE 50NB GALV. MS PIPE (PERFORATED). THE EARTH ELECTRODE FOR TEST PITS/TREATED EARTH PIT SHALL BE AS PER IS 3043.

8. RISERS / PIGTAILS FROM THE GROUNDING GRID / RING SHALL BE 40 mm DIA MILD STEEL ROD AND SHALL PROJECT 300 mm ABOVE GRADE/ CONCRETE FLOOR LEVEL UNLESS OTHERWISE SPECIFIED. ALL RISER PIGTAILS SHALL BE PAINTED GREEN FOR THE ABOVE GROUND PORTION.

9. THE INTERCONNECTING CONDUCTORS SHALL BE RUN PARALLEL TO AND AS CLOSE AS POSSIBLE TO THE INTERCONNECTING CABLE PATH ON PIPE CUM CABLE TRESTLE/ DUCT BANK/ TRENCH AS APPLICABLE.

10. ALL SYSTEM NEUTRALS, GROUNDING TERMINALS OF EHV SURGE ARRESTORS AND VOLTAGE TRANSFORMERS SHALL BE CONNECTED TO TWO TEST PITS, WHICH IN TURN ARE CONNECTED TO THE STATION GROUNDING GRID.

11. TEST PIT WITH RISER FOR SYSTEM NEUTRALS SHALL BE CONSTRUCTED AFTER COMPLETION OF RELEVANT EQUIPMENT FOUNDATION.

12. ALL LIGHTNING PROTECTION DOWN CONDUCTORS SHALL BE CONNECTED TO DEDICATED GROUND ELECTRODES THROUGH ISOLATING LINKS AND THEN TO THE GROUNDING SYSTEM.

TITLE

TYPICAL BELOW GROUND EARTHING DETAILS

NOTES:-

13 ELECTRONIC GROUNDING

FOR ELECTRONIC GROUNDING, 15 NO. ELECTRONIC GROUNDING PITS SHALL BE PROVIDED FOR EACH UNIT FOR MAIN PLANT & 8 NOS. FOR EACH AUXILIARY PLANT AREAS (WHERE ANY MAX DNA/PLC CONTROL PANELS ARE LOCATED).

ONLY ELECTRONIC GROUNDING CONNECTIONS SHALL BE BROUGHT TO THE EARTH PIT. NO OTHER GROUND CONNECTIONS (I.E. SYSTEM/ EQUIPMENT GROUND CONNECTIONS) SHALL BE PERMITTED. THE OTHER END CONNECTION FROM THE ELECTRONIC GROUNDING PITS SHALL BE MADE TO STATION GROUND. TWO CONNECTION SHALL BE MADE FROM EACH PIT TO STATION GRID. NO INTERCONNECTION SHALL BE DONE BETWEEN THE ELECTRONIC GROUNDING PITS. FOR FURTHER DETAILS OF ELECTRONIC GROUNDING FOR MAIN PLANT/DCS BASED SYSTEM, BHEL-EDN DOCUMENTATION SHALL BE REFERRED. FOR PLC BASED SYSTEM (IF APPLICABLE) DRG ATTACHED AS ANNEXURE-IV SHALL BE REFERRED.

14. WELDING:

BARE MS

a) ALL GROUND CONDUCTOR CONNECTIONS SHALL BE MADE BY ELECTRIC ARC WELDING USING LOW HYDROGEN ELECTRODES BY QUALIFIED AND EXPERIENCED WORKERS.

b) ALL WELDED JOINTS SHALL BE ALLOWED TO COOL DOWN GRADUALLY TO ATMOSPHERIC TEMPERATURE BEFORE PUTTING ANY LOAD ON THEM. NO ARTIFICIAL COOLING SHOULD BE ADOPTED TO COOL WELDED JOINTS

c) BEFORE WELDING, THE GROUND CONDUCTOR SHALL BE CLAMPED TIGHTLY TO ENSURE GOOD SURFACE CONTACT AT WELDING POINTS.

d) TWO COATS OF RED OXIDE PAINT, FOLLOWED BY A COAT OF BITUMEN COMPOUND SHALL BE APPLIED ON ALL BURIED WELDED JOINTS, FOR A MINIMUM LENGTH OF 100mm ON BOTH SIDE OF WELD LENGTH.

e) BENDING OF CONDUCTOR, WHERE EVER NECESSARY, SHALL BE DONE BY GA HEATING.

(B) GALVANISED MS

a) CLEANING OF WELD AREA WITH WIRE BRUSH AND REMOVAL OF GALVANISATION COATING IN THE WELD AREA SHALL BE CARRIED OUT BEFORE CARRYING OUT STEPS 14a) TO e) ABOVE.

b) ONE COAT OF ZINC RICH CHROMATE PRIMER & ONE COAT OF ZINC PAINT. THIS WILL BE APPLICABLE FOR BOTH GALV. MS TO GALV. MS AND BARE MS TO GALV. MS WELDING.

15. THE INSTALLATION OF BELOW GROUND EARTHING SYSTEM SHALL COMPLY WITH THE REQUIREMENTS OF IS : 3043 (CODE OF PRACTICE FOR EARTHING)

16. CIVIL DETAILS OF TEST PITS ARE INDICATIVE. ACTUAL DETAILS SHALL BE SHOWN IN CIVIL DRAWINGS.

17. ONE EARTH ELECTRODE-RISER TO BE PROVIDED ON EVERY CORNER OF THE CABLE VAULT/ SWGR ROOM LOCATED IN THE TG HALL 0 MTR/UPPER FLOOR.

18. ALL THE STREET LIGHTING POLES,LIGHTING MASTS,TRESTLE,CABLE TRAY RUNNING ON TRESTLE,TANKS, STRUCTURES ETC SHALL BE EARTHED TO THE MAIN GRID AND INDEPENDENT RISERS SHALL BE PROVIDED FOR THE SAME.

19. DEDICATED RISERS SHALL BE PROVIDED FOR ALL THE CRITICAL EQUIPMENT AT DIFFERENT ELEVATIONS OF TG /SG/ESP BUILDING. SAME SHALL BE INDICATED IN " BELOW GROUND EARTH MAT LAYOUT FOR MAIN PLANT AREA" (NTPC DRG NO. 4540-001-215-PVE-F-020).

20. DEDICATED RISERS REQUIRED FOR GENERATORS AND ITS NEUTRAL/TURBINE SHALL BE PROVIDED.

TITLE

TYPICAL BELOW GROUND EARTHING DETAILS

21. THE EARTH CONDUCTOR SHALL BE LAID AT APPROX 1000MM AWAY FROM COLUMN/FOOTINGS ETC TO AVOID FOULING.
22. ALL RISER, EARTH ELECTRODE-RISER SHALL BE PROVIDED CLEARING ANY PASSAGE WAY/ DOOR/ROLLING SHUTTER ETC.
23. EARTH RISER TO BE PROVIDED FOR EVERY COLUMN.
24. TWO NO OF RISER AND TWO EARTH ELECTRODE TO BE PROVIDED FOR EVERY MOTOR ON 0 MTR.
25. FOUR NO OF RISER AND TWO EARTH ELECTRODE TO BE PROVIDED FOR EVERY TRANSFORMER.
26. IF ADDITIONAL EARTH CONDUCTOR,ELECTRODES AND EARTHING CONNECTIONS IS REQUIRED TO SUIT THE SITE CONDITIONS,THE SAME MAY BE PROVIDED.
27. EARTHING SHALL BE CARRIED OUT IN ACCORDANCE WITH IS 3043, INDIAN ELECTRICITY RULES/ ACTS AND AS PER NTPC TECHNICAL SPECIFICATIONS
28. NO PART OF GS FLAT SHALL BE BURIED IN THE GROUND.
29. REFERENCE DRAWING :-

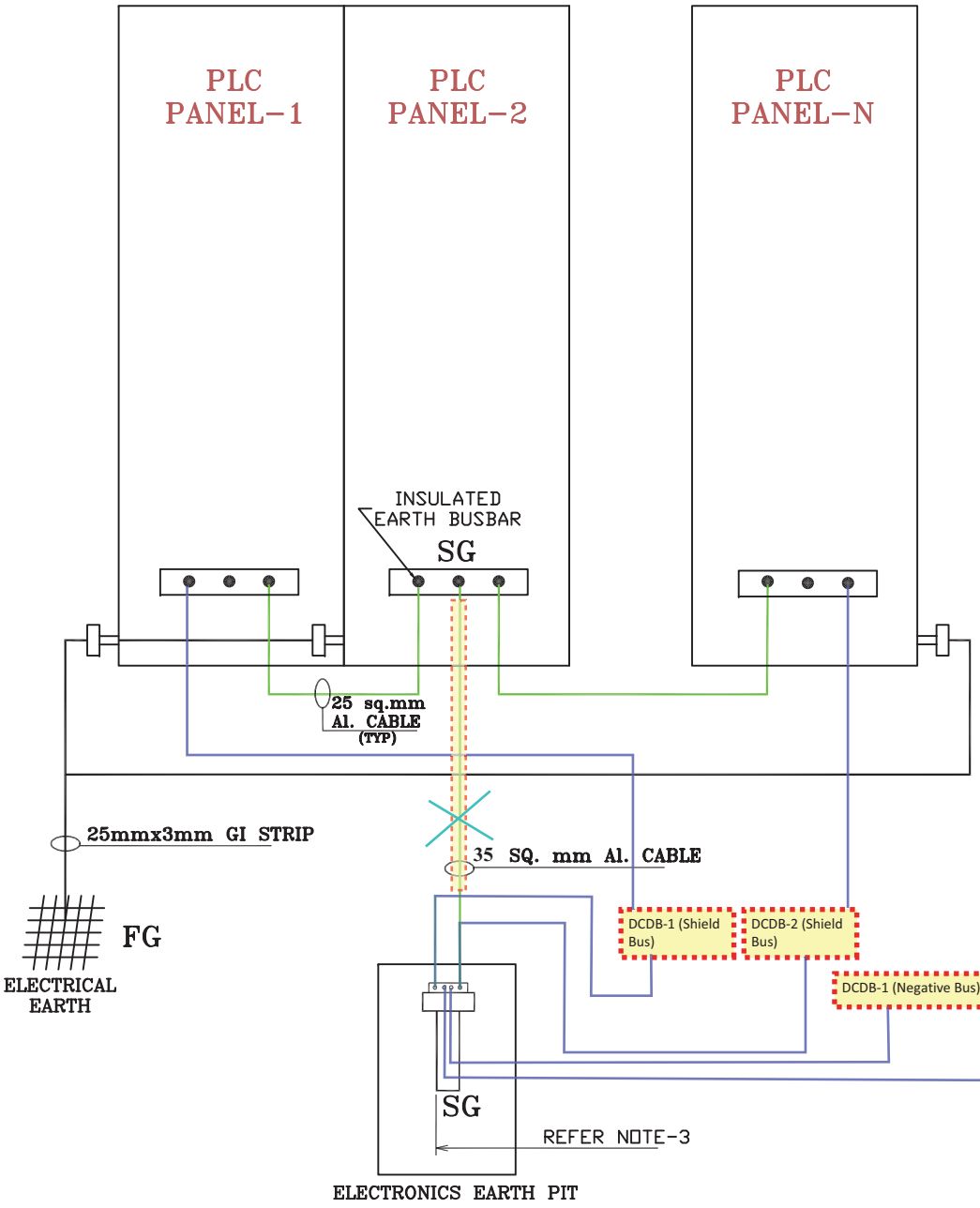
CHAPTER-6: Typical Above ground earthing details

TITLE

TYPICAL BELOW GROUND EARTHING DETAILS

ANNEXURE-V

SYSTEM GROUNDING DIAGRAM FOR PLC SYSTEM



NOTES :

1. DISTANCE BETWEEN PLC PANEL AND EARTH PIT SHOULD BE LESS THAN 100 Mtr, PREFERABLY.
2. EARTHING PITS SHALL BE PREPARED IN LINE ' EARTH PIT DRAWING (REFER SHEET-9 OF 10 FOR THE SAME).
3. NUMBER OF EARTH PITs SHALL BE SUCH THAT THE COMBINED EARTH RESISTANCE IS LESS THAN 1 OHM OR VENDOR RECOMMENDATION, WHICHEVER IS BETTER.
4. THIS SCHEME IS GENERAL GUIDELINE FOR EARTHING OF PLC. SCHEME SHALL BE MODIFIED AS PER RECOMMENDATION OF PLC VENDOR. with prior information.
5. EARTHING OF UPS/DC CHARGER SYSTEM, AS APPLICABLE, SHALL BE IN LINE WITH PLC VENDOR RECOMMENDATION.
6. EARTHING CABLEs SHALL BE MULTI STRAND TYPE.
7. SEPARATE EARTHING CABLE TO GI STRIP SHALL BE PROVIDED IN CASE EARTHING BOLT OF ADJACENT PANEL IS NOT CONNECTABLE.

LEGENDS :

Al.	-	ALUMINUM CABLE
Cu	-	COPPER CABLE
FG	-	FRAME GROUND/CHASSIS GROUND
SG	-	SIGNAL GND (ISOLATED FROM CABINET FRAME)

RECOMMENDED CABLE SPECIFICATION :(FOR SHIELD BUS EARTHING)

FROM	TO	DISTANCE (Mtrs)	Al. CABLE SIZE (Sqmm)	Cu. CABLE SIZE (Sqmm)
SG EARTH PIT Through DCDB	PLC PANEL	< 70	25	16
		> 70 & < 100	35	25

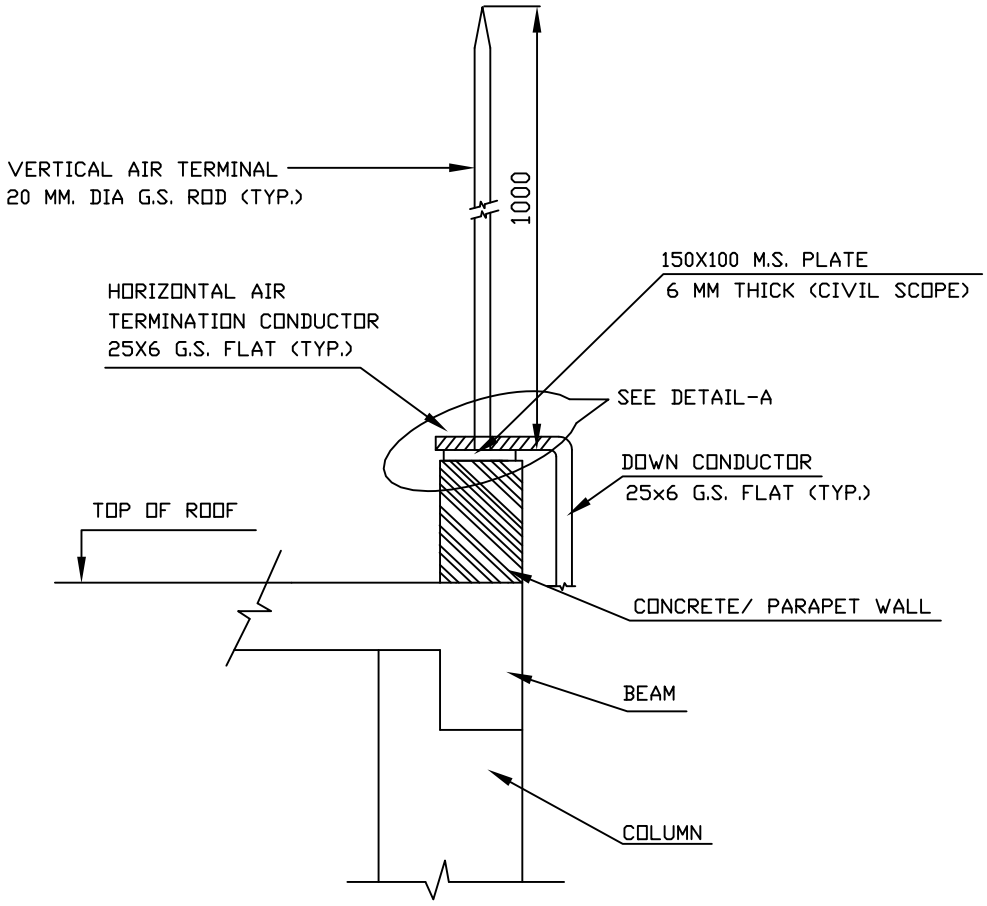
NOTE- 1. DCDB (NEGATIVE BUS) SHALL BE EARTHED IF RECOMMENDED BY PLC VENDOR THROUGH CABLE SIZE THUS RECOMMENDED.
2. THIS SCHEME IS FOR PANELS OF ONE FUNCTION GROUP ONLY. IF THERE IS SEPARATE FG, SEPARATE SET OF CABLES SHALL BE PROVIDED TO SHIELD BUS.

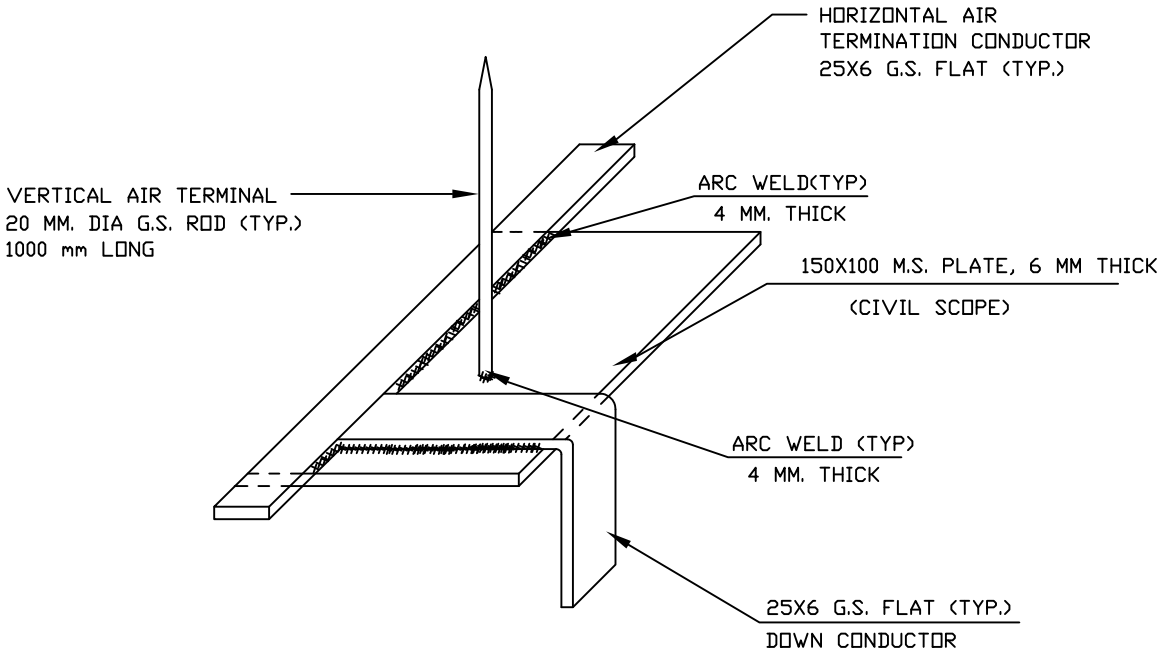
DATE	DRWN	DGN	CHD	APPD	RECOMMENDED GROUNDING SCHEME FOR PLC SYSTEM
15.01.15	GA	SSB	MAM/ SCS	DP	

Coal to 2000 TPD Ammonium Nitrate, LSTK-1

TYPICAL LIGHTNING PROTECTION DETAILS

BHARAT HEAVY ELECTRICALS LIMITED
INDUSTRIAL SYSTEM GROUP
BANGALORE-12



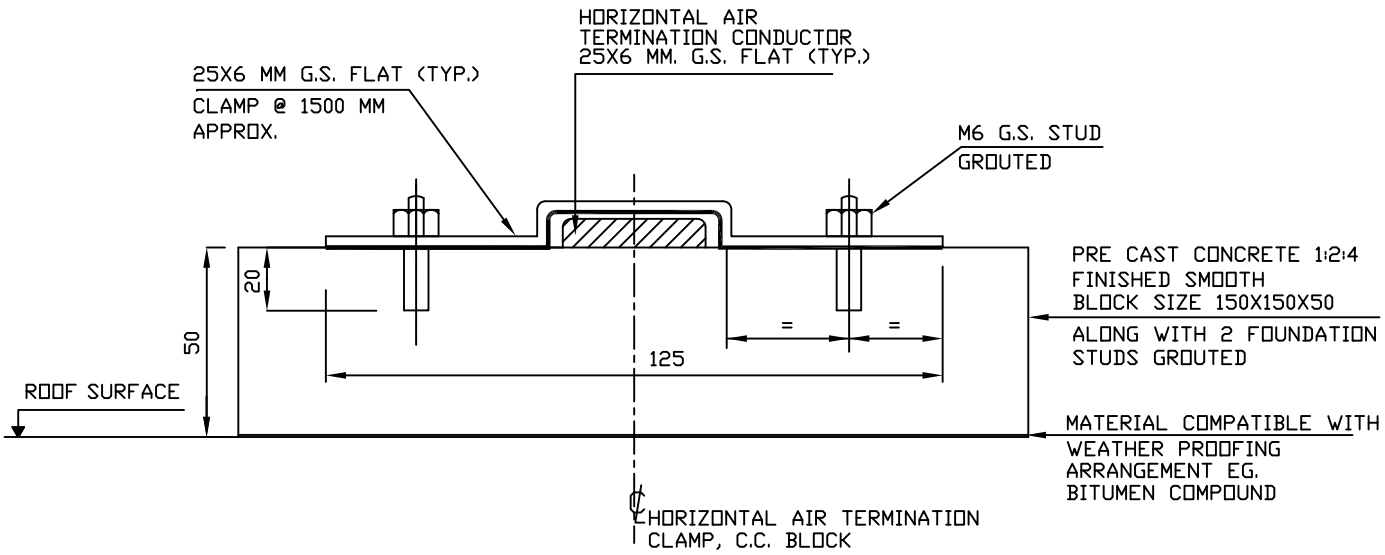


DETAIL-A

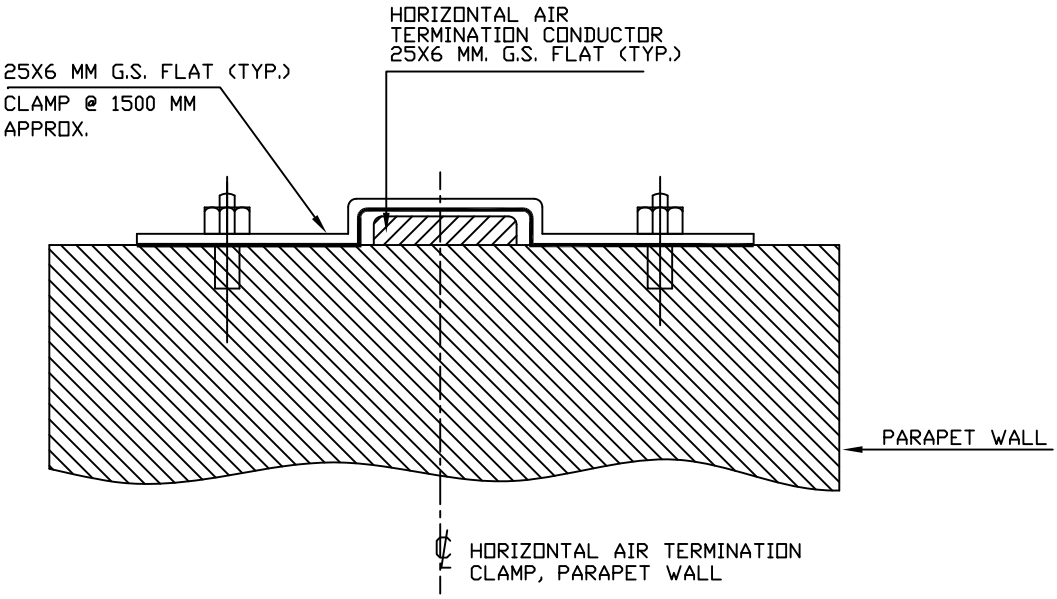
TYPICAL FIXING/CONNECTION DETAILS OF VERTICAL AIR TERMINAL ROD ON THE ROOF OF BUILDING

TITLE

TYPICAL LIGHTNING PROTECTION DETAILS



(A) OVER ROOF SURFACE



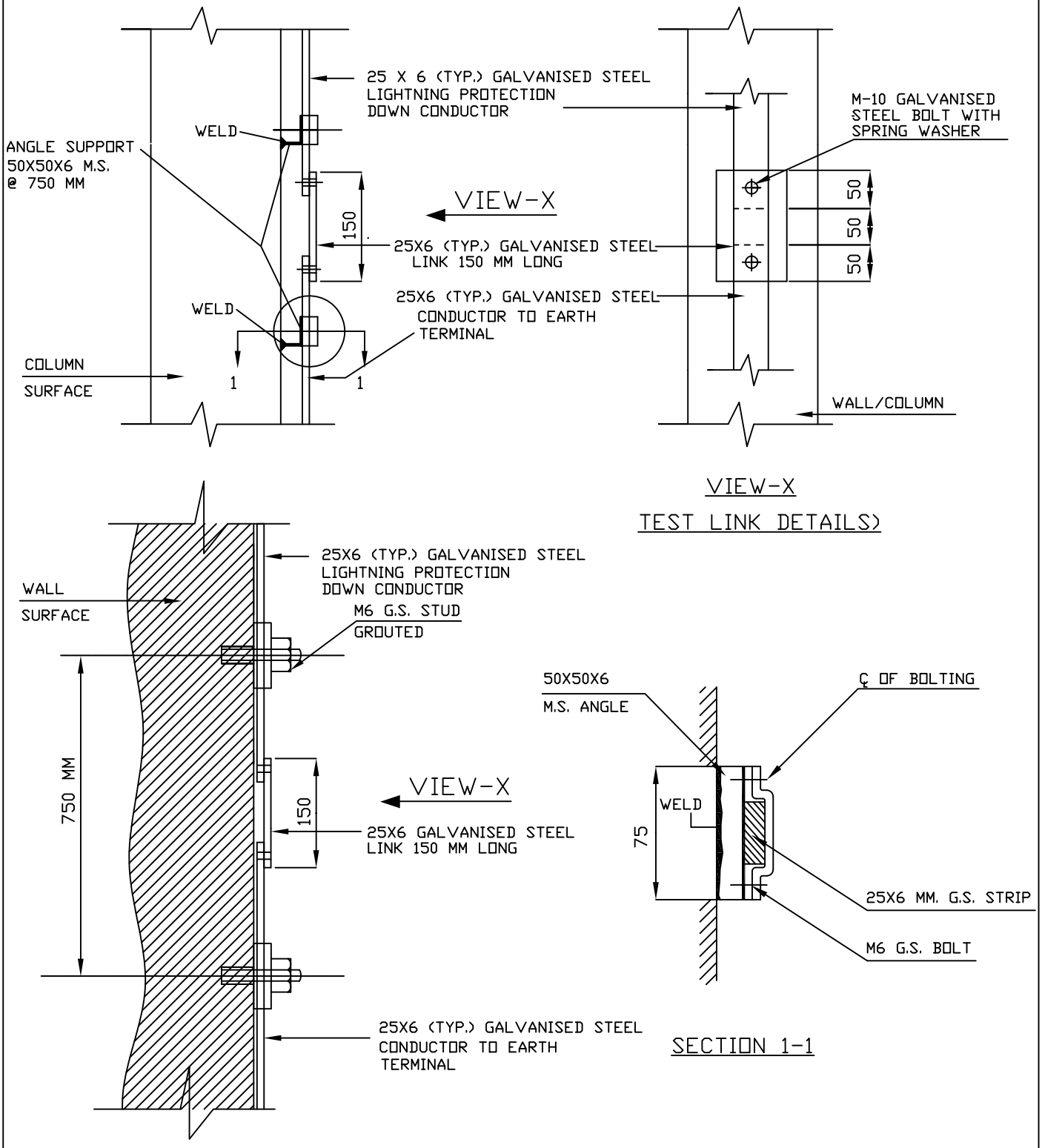
(B) OVER PARAPET WALL

TYPICAL DETAILS OF CLAMPING HORIZONTAL AIR TERMINATION

CLAMPING OVER ROOF

TITLE

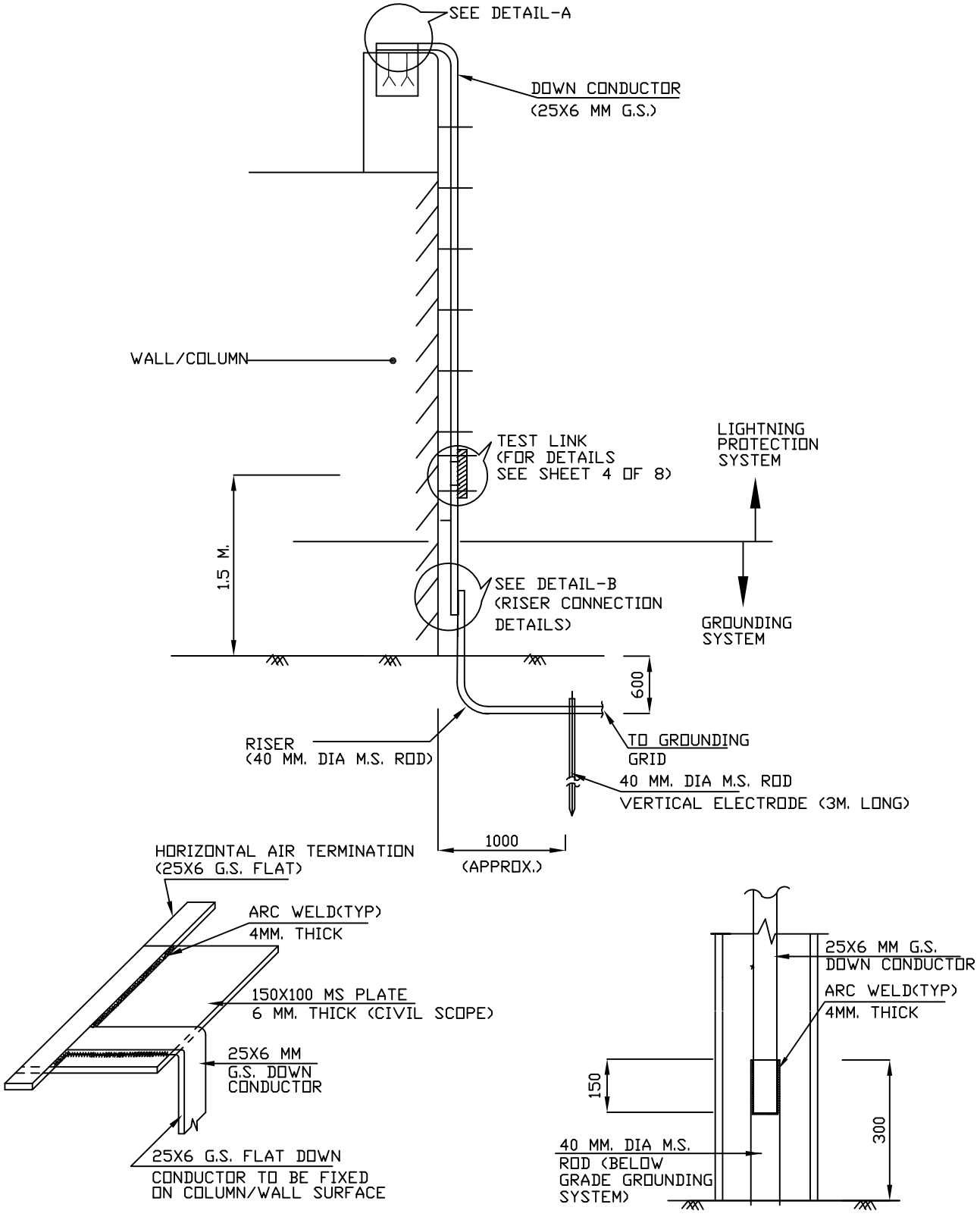
TYPICAL LIGHTNING PROTECTION DETAILS



TYPICAL DETAILS OF DOWNCONDUCTOR
FIXING AND TEST LINK

TITLE

TYPICAL LIGHTNING PROTECTION DETAILS



DETAIL-A

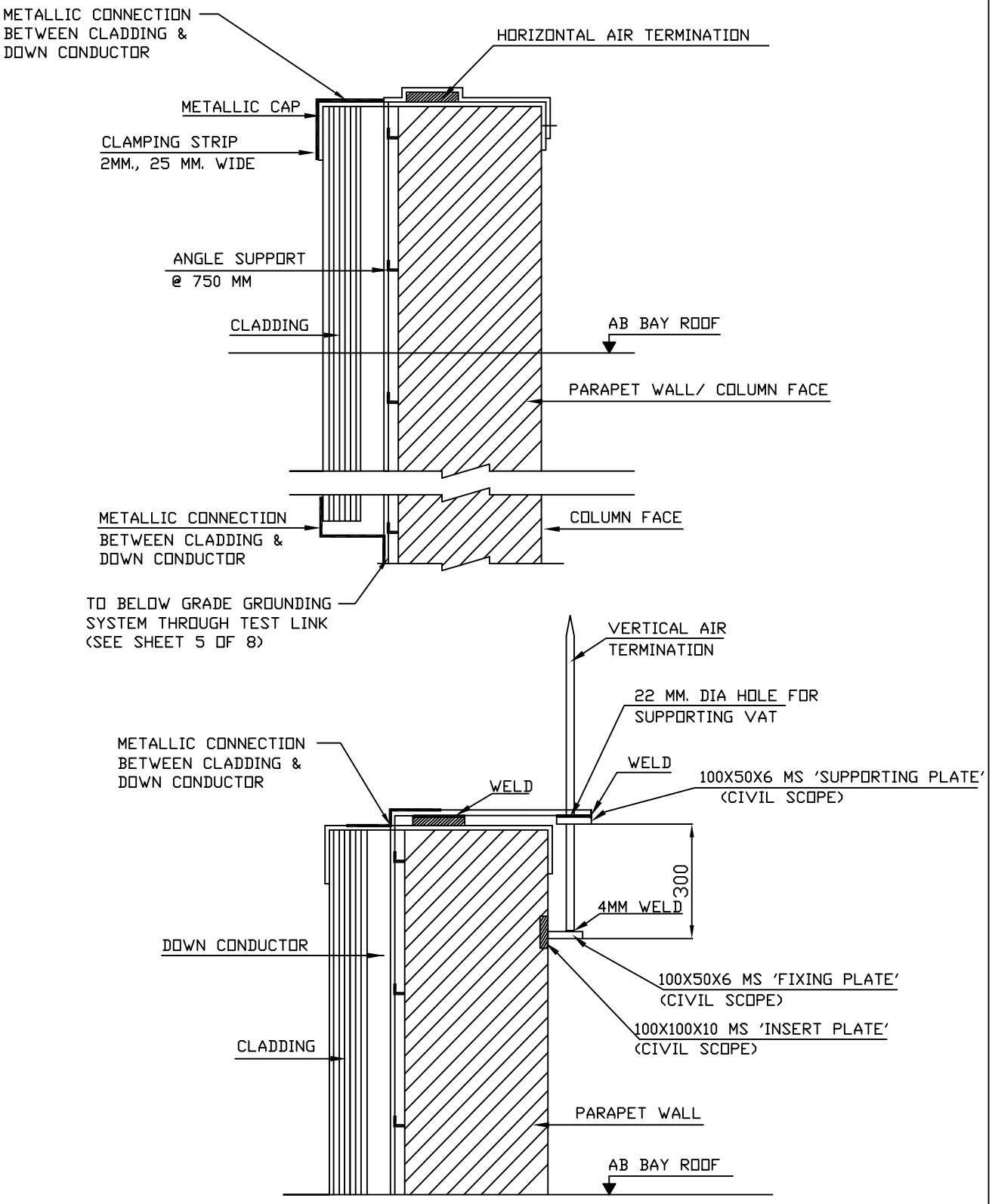
DETAIL-B

(RISER CONNECTION DETAILS)

TYPICAL DETAILS OF CONNECTION AMONG HORIZONTAL AIR TERMINAL, DOWN CONDUCTOR AND RISER

TITLE

TYPICAL LIGHTNING PROTECTION DETAILS



TYPICAL DETAILS OF CONNECTION AMONG

HORIZONTAL AIR TERMINAL, DOWN CONDUCTOR FOR 'A' ROW CLADDING

TITLE

TYPICAL LIGHTNING PROTECTION DETAILS

NOTES:–

1.0 AIR TERMINATIONS

1.1 HORIZONTAL/ VERTICAL AIR TERMINATION NETWORK WILL BE INSTALLED ON THE TOP OF ALL STRUCTURE/ BUILDINGS TO BE PROTECTED FROM LIGHTNING STROKES. THE INSTALLATION WORK SHALL BE DULY COORDINATED BY SITE WITH THE OTHER ACTIVITIES SUCH AS WEATHER PROOFING APPLICATION ON ROOF, ETC.

1.2 HORIZONTAL AIR TERMINATIONS SHALL BE OF 25MM x 6MM GALVANISED STEEL FLATS CLAMPED TO THE SURFACE AT EVERY 1500 MM. HORIZONTAL AIR TERMINATION SHALL NOT BE DIRECTLY CLEATED ON SURFACE OF ROOF. SUPPORTING BLOCKS OF PRE CAST CONCRETE 1:2:4 SHALL BE USED FOR CONDUCTOR FIXING AT AN INTERVAL OF 1500MM. VERTICAL AIR TERMINATION'S SHALL BE 20 MM DIA GALVANISED MILD STEEL ROD 1000 MM LONG.

1.3 THE VERTICAL AIR TERMINATION ROD WILL BE PROPERLY FIXED AS PER DETAILS GIVEN IN THE DRAWING ON THE TOP OF THE BUILDING/ STRUCTURE TO WITHSTAND VERY HIGH WIND PRESSURE. THE HORIZONTAL & VERTICAL AIR TERMINATIONS SHALL BE PROPERLY FIXED ON THE TOP OF ROOF OF THE BUILDINGS SUCH AS NOT TO MAKE ANY PENETRATION IN THE WATER PROOFING LAYER.

2.0 DOWN CONDUCTORS

2.1 THE DOWN CONDUCTORS SHALL BE 25MM X 6MM GALVANISED STEEL FLATS. ONE END OF THESE FLATS SHALL BE CONNECTED TO THE VERTICAL / HORIZONTAL AIR TERMINATION NETWORK ON TOP OF ROOF / STRUCTURE AND THE OTHER END TO THE NEAREST EARTH TERMINALS.

2.2 EACH DOWN CONDUCTOR WILL HAVE AN INDEPENDENT GROUND TERMINATION. IN NO CASE CONDUCTORS OF THE LIGHTNING PROTECTION SYSTEM WILL BE CONNECTED WITH THE CONDUCTORS OF THE GROUNDING SYSTEM ABOVE GROUND LEVEL. THE INDEPENDENT GROUND TERMINATION WILL COMPRISE OF A RISER CONNECTION FROM A 3000 MM LONG GROUND ELECTRODE WHICH IN TURN WILL BE CONNECTED TO THE BELOW GRADE GROUNDING SYSTEM. DETAILS OF THE ELECTRODE CONNECTION SHALL BE AS PER Chapter-7:–TYPICAL BELOW GROUND EARTHING DETAILS).

2.3 THE CONNECTION BETWEEN EACH DOWN CONDUCTOR AND EARTH TERMINAL WILL BE MADE VIA A TEST LINK LOCATED AT APPROXIMATELY 1500MM ABOVE GROUND LEVEL. THE TEST LINK SHALL BE ENCLOSED IN A PROTECTIVE GALVANISED MS BOX.

2.4 THE DOWN CONDUCTORS WILL BE LAID STRAIGHT AND SHARP BENDS WILL BE AVOIDED AS FAR AS PRACTICABLE. THESE WILL BE FIXED ON THE OUTSIDE OF THE BUILDING WALL AND OR COLUMNS/STRUCTURES AT INTERVALS OF ABOUT 750 MM, AS INDICATED IN THE DRAWINGS.

2.5 ALL EXPOSED METALLIC PARTS OF A BUILDING WILL BE BONDED TO THE DOWN CONDUCTORS. SUCH PARTS WILL INCLUDE LADDERS, BALCONIES, CONDUITS, METALLIC SHEET CLADDING, ETC.

2.6 ALL METALLIC STRUCTURES WITHIN A VICINITY OF TWO METERS OF THE CONDUCTORS SHALL BE BONDED TO CONDUCTORS OF LIGHTNING PROTECTION SYSTEM.

2.7 LIGHTNING CONDUCTORS SHALL NOT PASS THROUGH OR RUN INSIDE GI CONDUITS.

2.8 TESTING LINK SHALL BE MADE OF GALVANIZED STEEL OF SIZE 25X6 MM.

TITLE

TYPICAL LIGHTNING PROTECTION DETAILS

3.0 JOINTING

3.1 MINIMUM NUMBER OF JOINTS IN THE LIGHTNING CONDUCTORS WILL BE PROVIDED.

3.2 ALL THE JOINTS WILL BE DONE BY ARC WELDING PROCESS. OVERLAPPING OF CONDUCTORS AT STRAIGHT JOINTS WILL NOT BE LESS THAN 150MM. THE CONTACT SURFACES WILL BE PROPERLY CLEANED BEFORE JOINTING.

3.3 THOSE PORTIONS OF GALVANISED STEEL FLATS, WHICH HAVE BEEN WELDED AT SITE, SHALL BE COATED WITH TWO (2) COATS OF RED OXIDE PAINT FOLLOWED BY TWO COATS OF ZINC PAINT.

3.4 THE VERTICAL AIR TERMINATION RODS WILL BE COATED WITH WEATHER RESISTANT ANTI-CORROSIVE PAINT. (ZINC CHROMATE FOLLOWED BY TWO COATS OF ALUMINIUM PAINT)

4.0 LIGHTNING PROTECTION SYSTEM SHALL BE IN ACCORDANCE WITH IEC 62305.

5.0 AS PER IEEE : 142, STEEL TANKS (CONTAINING FLAMMABLE LIQUIDS OR GASES) WITH STEEL ROOFS OR FLOATING METAL ROOF HAVING STEEL THICKNESS OF 4.76 MM OR MORE ARE TO BE CONSIDERED SELF-PROTECTING TYPE AGAINST LIGHTNING, & SHALL BE PROVIDED WITH MINIMUM TWO EQUALLY SPACED CONNECTIONS TO THE NEAREST BELOW GRADE GROUNDING SYSTEM.

TITLE

TYPICAL LIGHTNING PROTECTION DETAILS

Coal to 2000 TPD Ammonium Nitrate, LSTK-1

TYPICAL INSTALLATION DETAILS FOR CABLE TRAY AND ACCESSORIES

BHARAT HEAVY ELECTRICALS LIMITED
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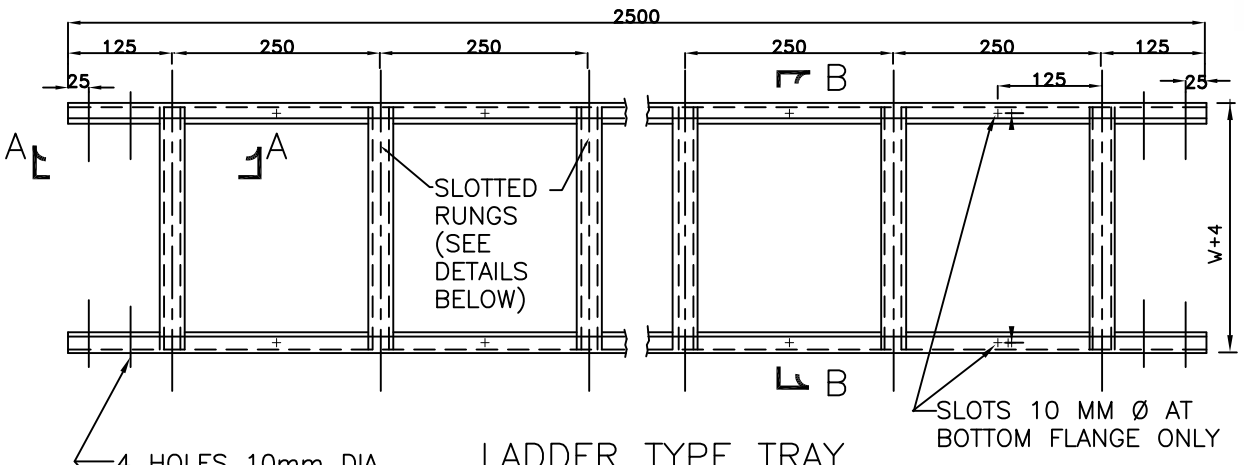
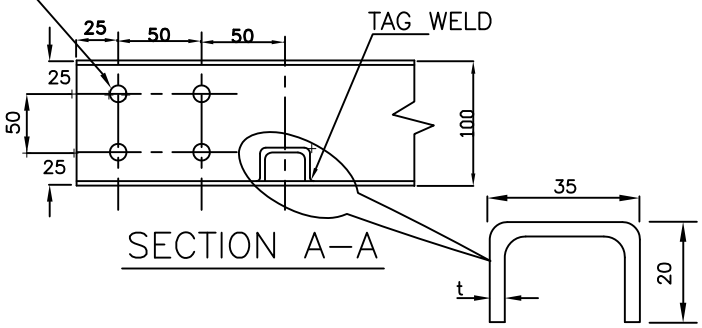
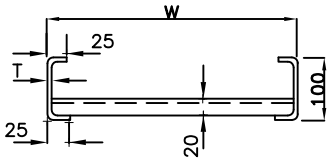
BANGALORE-12



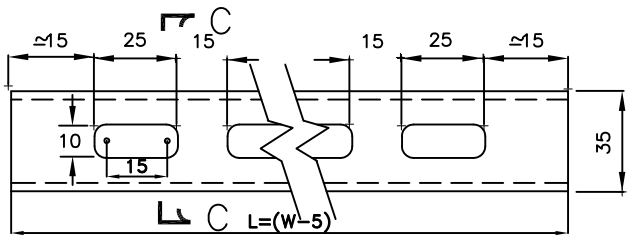
LADDER TYPE TRAY



SECTION A–A

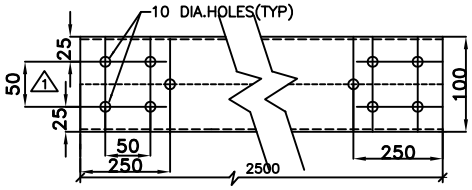


SECTION B–B

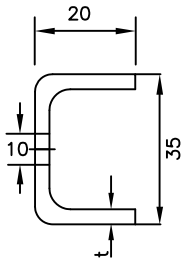


SLOTTED RUNGS

(TO SUIT TRAY WIDTH)



SIDE RUNNER

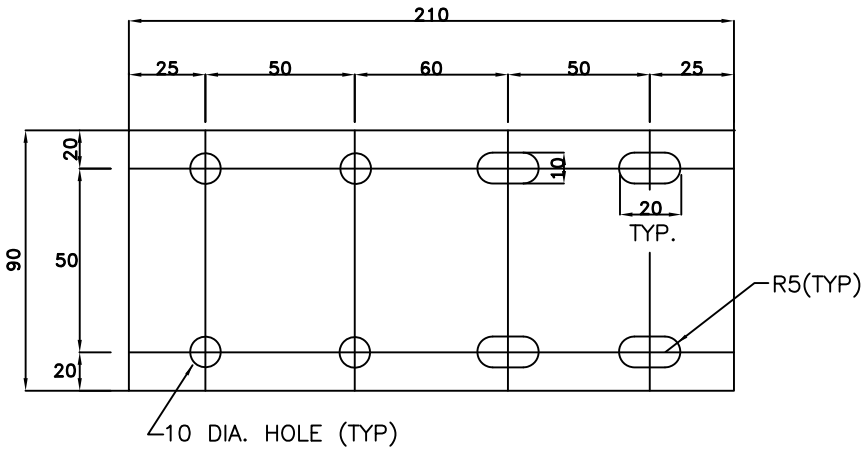


SECTION C–C

W	150	300	600
L	145	295	595
T	2	2	2
t	2	2	2

FOR GENERAL NOTES REFER SHEET 14 OF 14

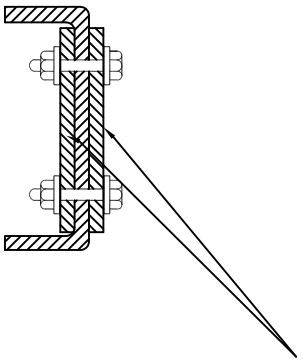
TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES



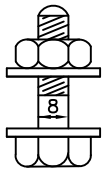
SIDE COUPLER PLATE FOR LADDER/PERFORATED TYPE TRAYS

(600/300/150W TRAYS)

QTY. REQUIRED/TRAY SECTION : 4 NOS.

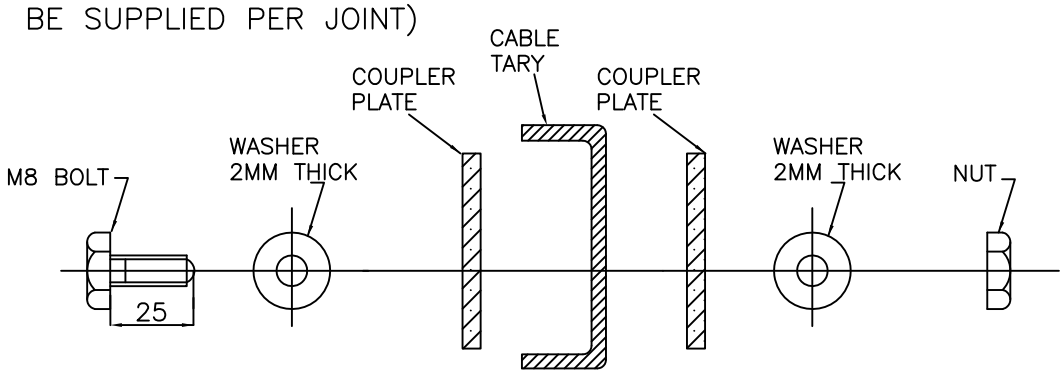


(2 NOS. COUPLER PLATES OF 3 MM THICKNESS TO BE SUPPLIED PER JOINT)



QTY. REQD/TRAY SECTION

A) 16 NOS. M8 BOLTS
B) 16 NOS. NUTS
C) 32 NOS. WASHERS

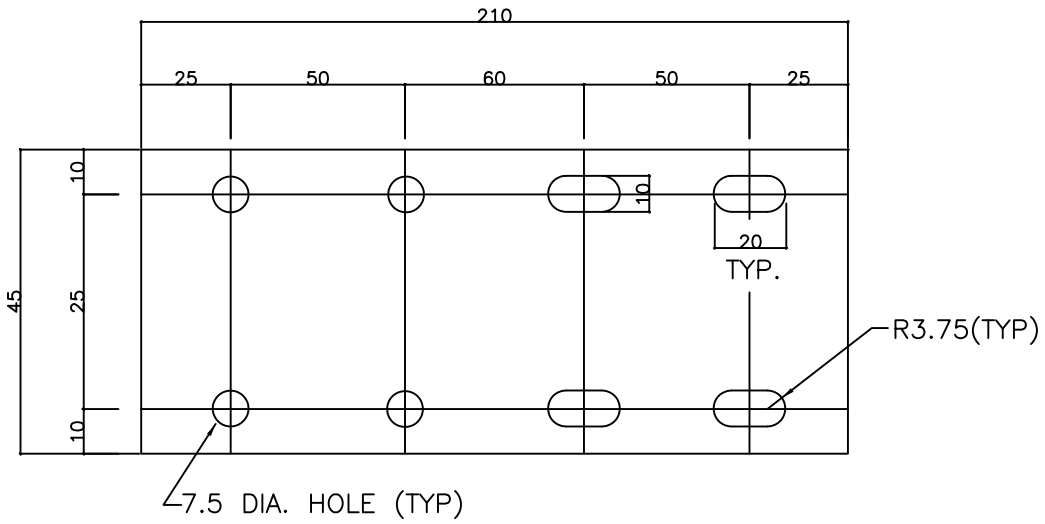


SEQUENCE OF M8 BOLT, WASHER, NUT, COUPLER PLATE & CABLE TRAY

FOR TYPICAL CABLE TRAY JOINT

FOR GENERAL NOTES REFER SHEET 14 OF 14

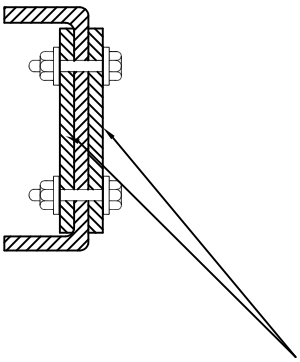
TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES



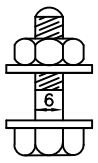
SIDE COUPLER PLATE FOR PERFORATED TYPE TRAYS

(100/50W TRAYS)

QTY. REQUIRED/TRAY SECTION : 4 NOS.

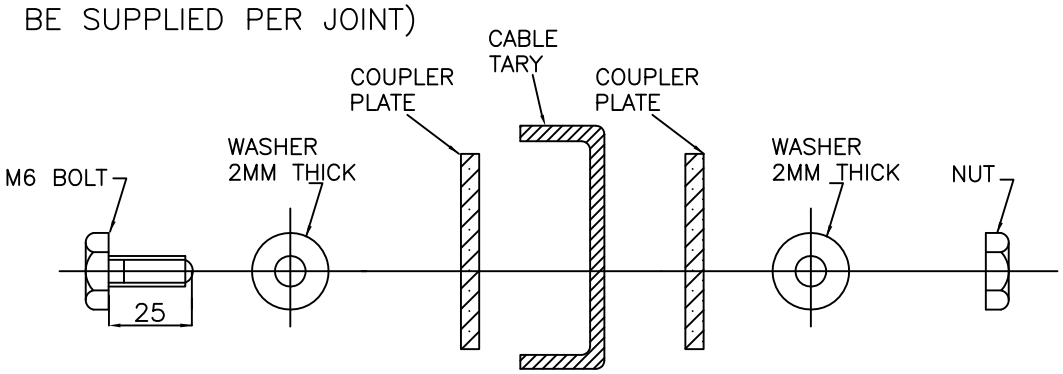


(2 NOS. COUPLER PLATES OF 3 MM THICKNESS TO BE SUPPLIED PER JOINT)



QTY. REQD/TRAY SECTION

A) 16 NOS. M6 BOLTS
B) 16 NOS. NUTS
C) 32 NOS. WASHERS

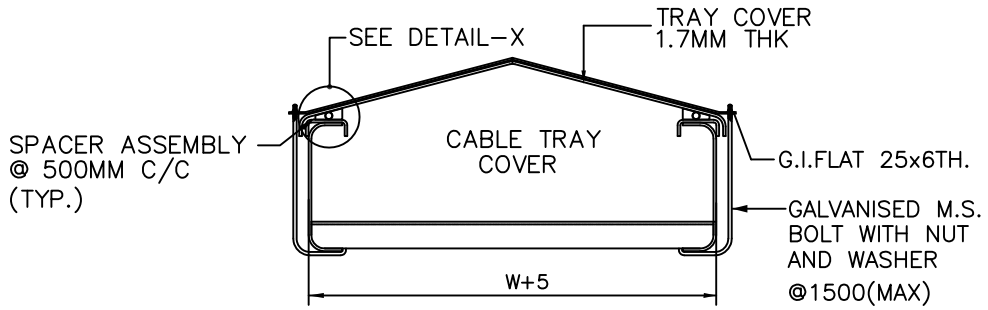


SEQUENCE OF M6 BOLT, WASHER, NUT, COUPLER PLATE & CABLE TRAY

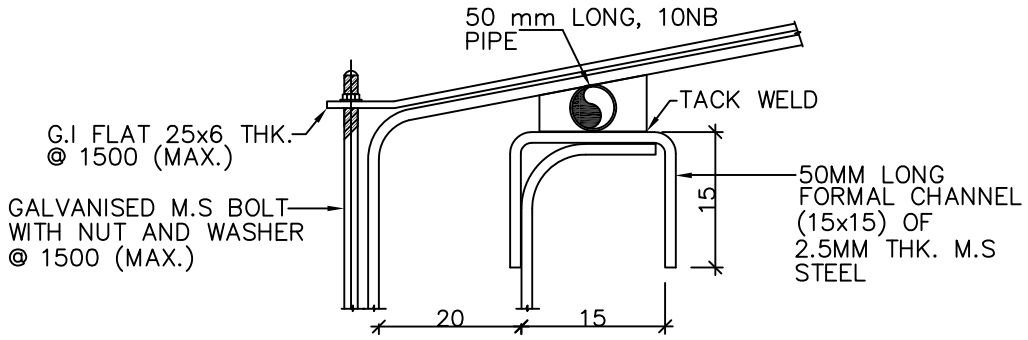
FOR TYPICAL CABLE TRAY JOINT

FOR GENERAL NOTES REFER SHEET 14 OF 14

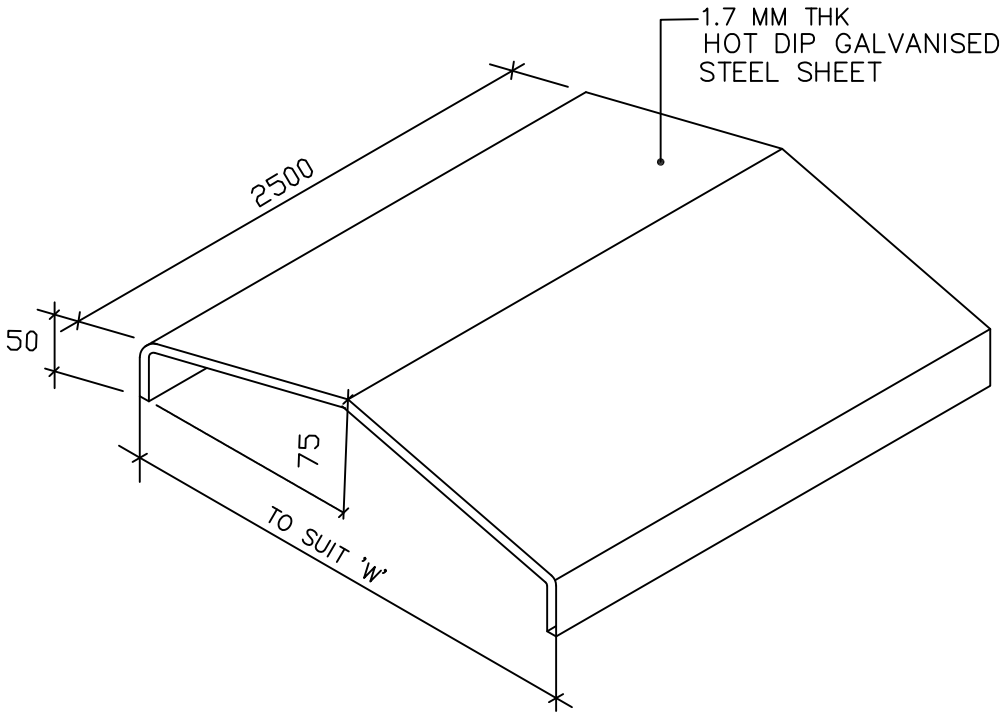
TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES



COVER FIXING (TYP.)



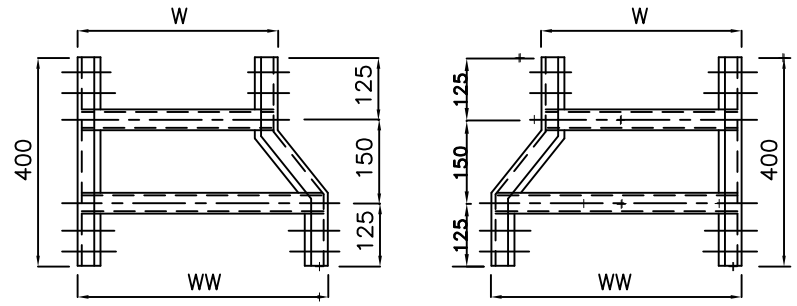
DETAIL–X



CABLE TRAY COVER

FOR GENERAL NOTES REFER SHEET 14 OF 14

TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES

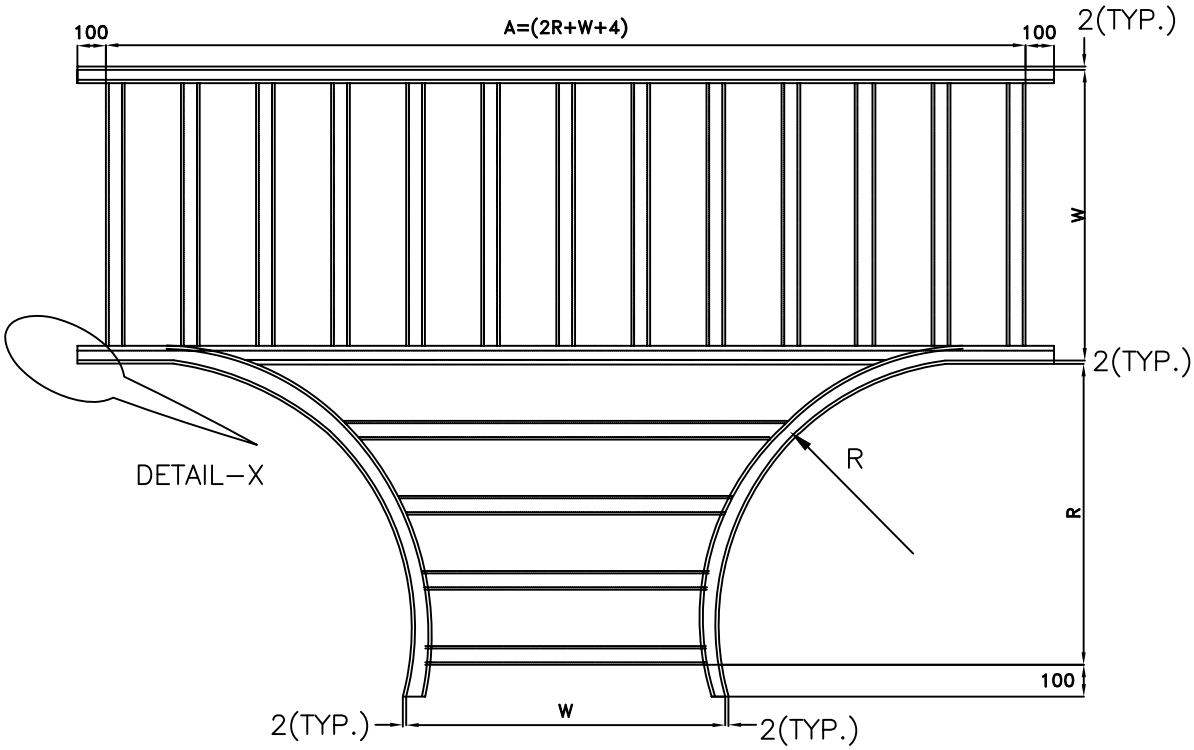


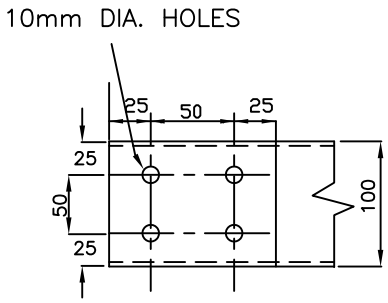
WW	W	DEPTH
600	300	100
600	150	100
300	150	100

LEFT HAND REDUCER

RIGHT HAND REDUCER

LADDER TYPE



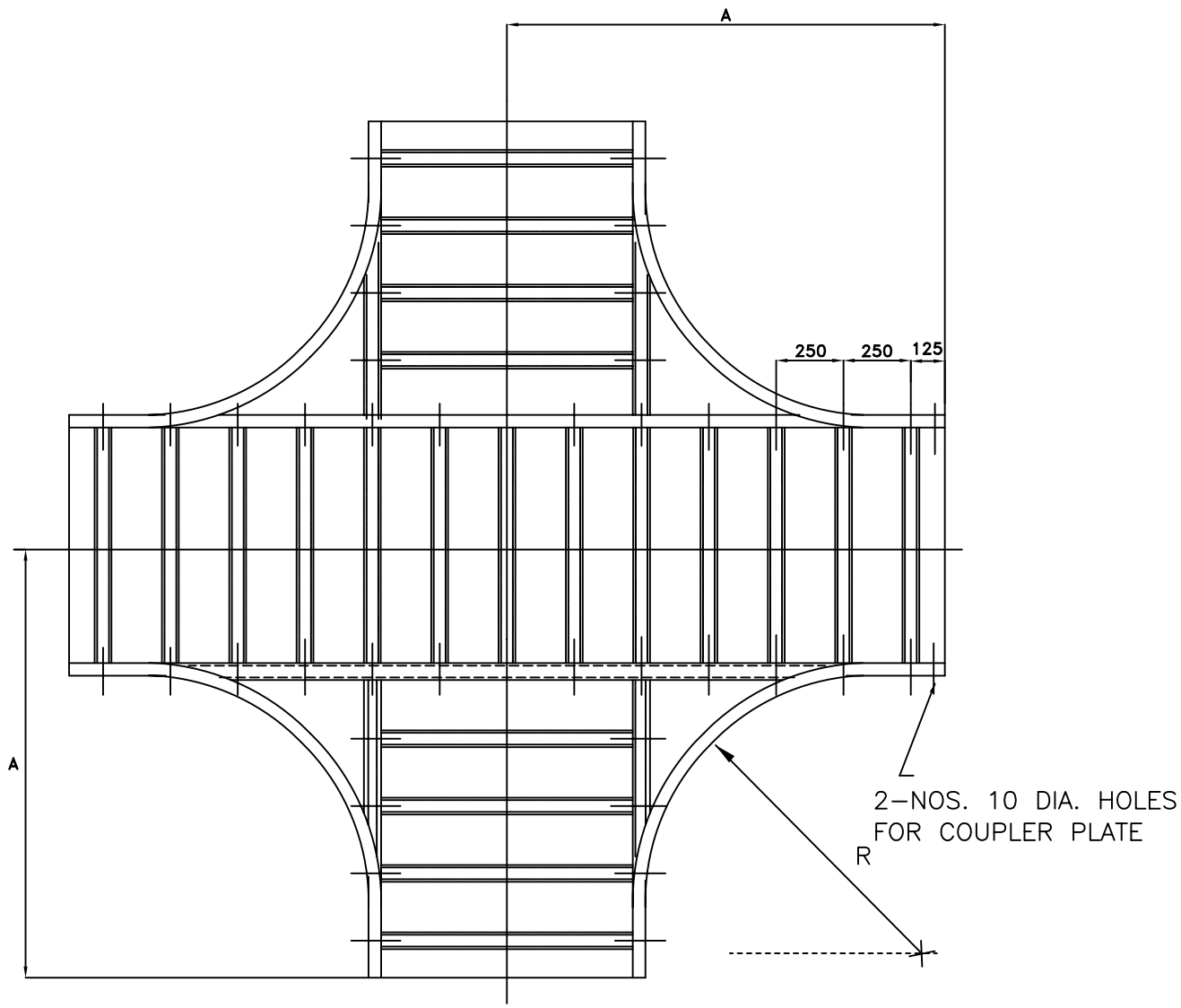


WIDTH W	BENDING RADIUS R	DEPTH	A		
			W		
			150	300	600
150, 300, 450 & 600	600	100	1354	1504	1804

LADDER TYPE

FOR GENERAL NOTES REFER SHEET 14 OF 14

TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES

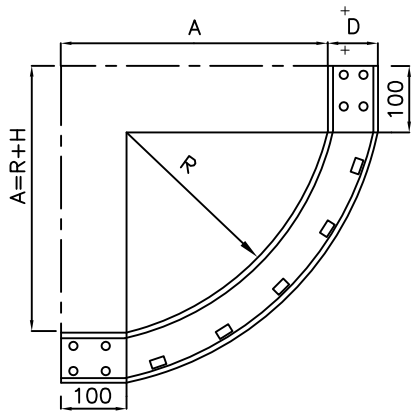


HORIZONTAL CROSS–PLAN

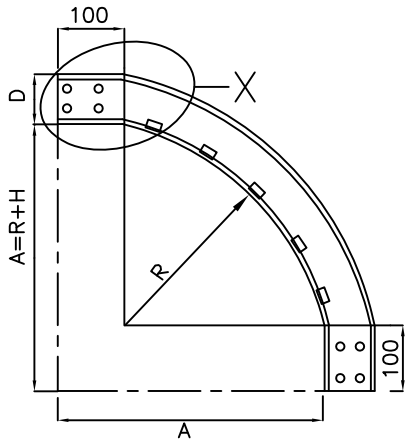
WIDTH W	BENDING RADIUS R	A=R+W/2+100
600	600	1000
300	600	850

FOR GENERAL NOTES REFER SHEET 14 OF 14

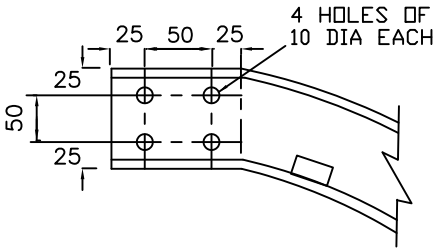
TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES



INSIDE TYPE



OUTSIDE TYPE

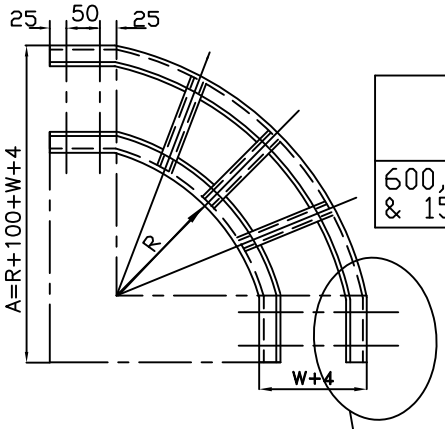


ENLARGED VIEW OF "X"

VERTICAL ELBOW 90 DEG UP/DOWN

INSIDE WIDTH W	BENDING RADIUS R	DEPTH	A
600, 300 & 150	600	100	700

90° VERTICAL BEND - LADDER TYPE



LADDER TYPE

X (AS ABOVE)

HORIZONTAL ELBOW 90 DEG

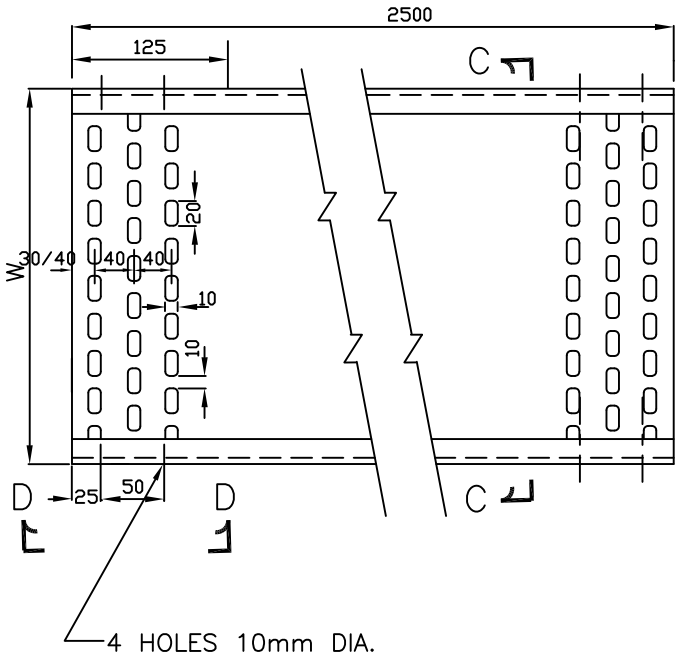
INSIDE WIDTH W	BENDING RADIUS R	DEPTH	A		
			W		
			150	300	600
600, 300 & 150	600	100	854	1004	1304

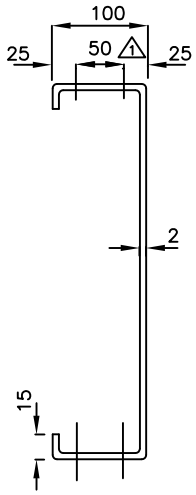
90° HORIZONTAL BEND - LADDER TYPE

LADDER TYPE ACCESSORIES

FOR GENERAL NOTES REFER SHEET 14 OF 14

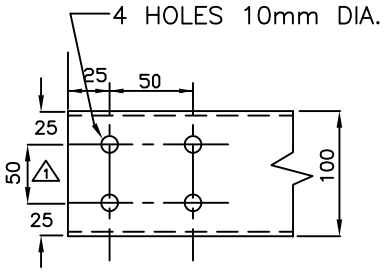
TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES





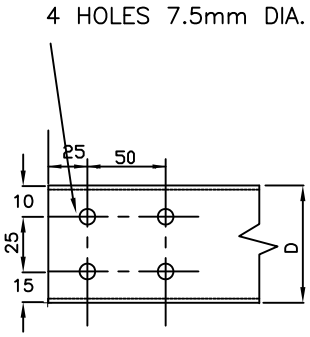
SECTION–CC

600/300/150 TRAYS



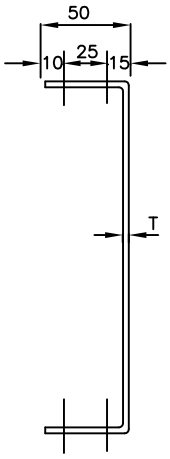
SECTION–DD

600/300/150 TRAYS



SECTION–DD

100/50 TRAYS



SECTION–CC

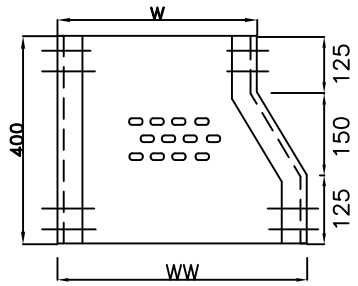
(100/50 TRAYS)

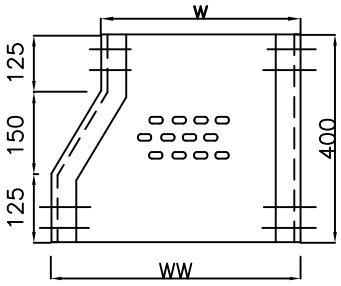
TRAY WIDTH W (mm)	600	300	150	100	50
TRAY DEPTH D (mm)	100	100	100	50	50
T (mm)	2	2	2	2	2

PERFORATED TYPE TRAY

FOR GENERAL NOTES REFER SHEET 14 OF 14

TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES

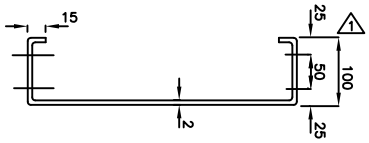




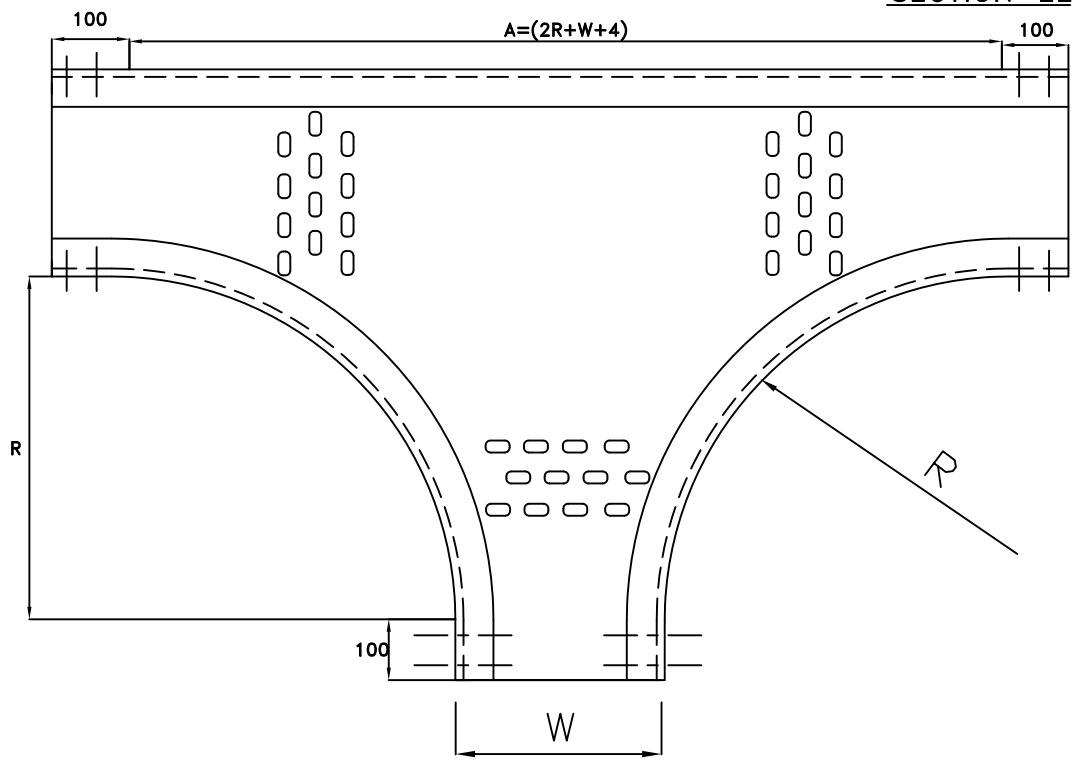
WW	W	DEPTH
600	300	100
600	150	100
300	150	100

LEFT HAND REDUCER RIGHT HAND REDUCER

PERFORATED TYPE



SECTION–EE



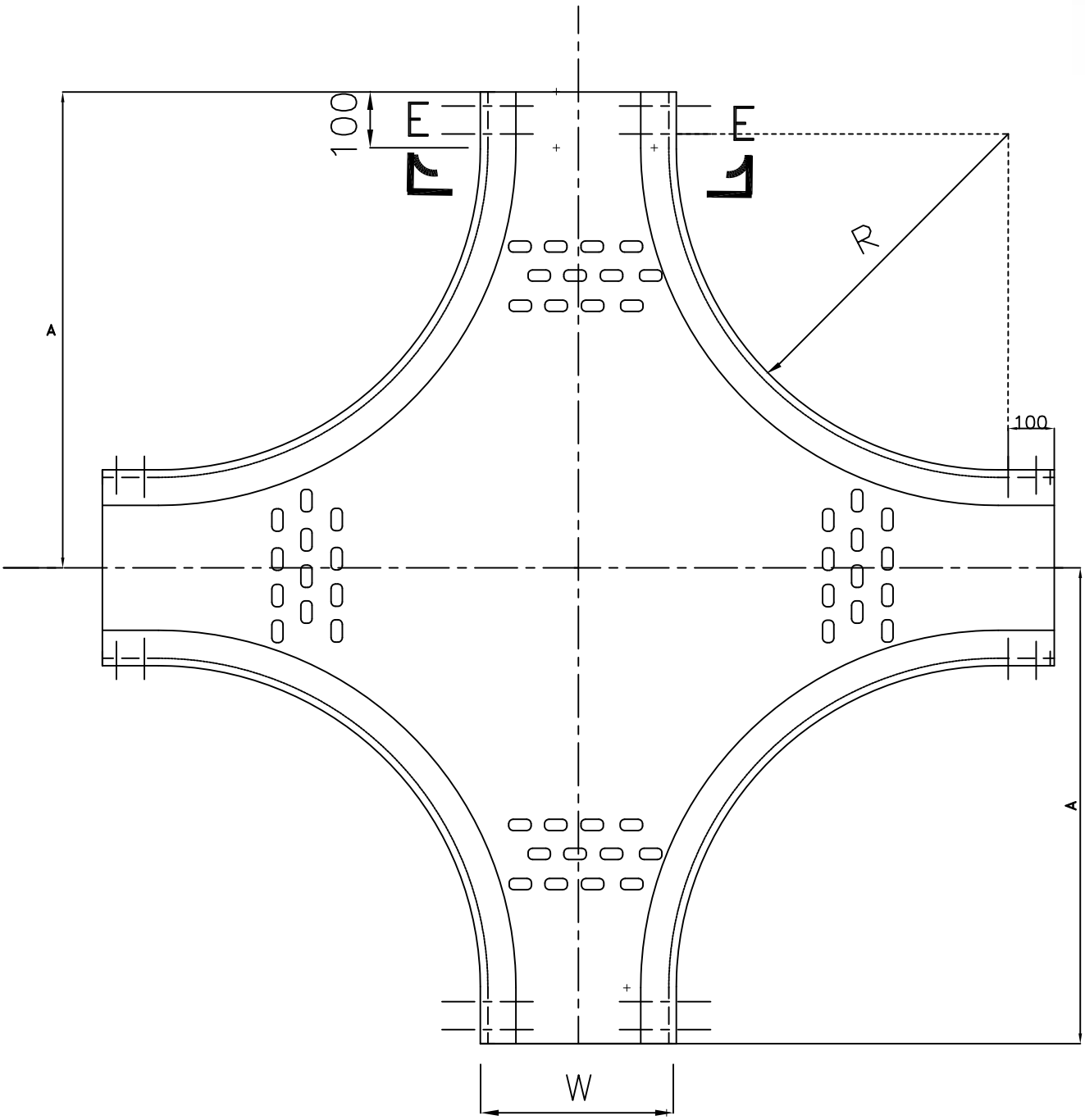
TEE

WIDTH W	BENDING RADIUS R	DEPTH	A		
			W		
			150	300	600
150, 300 & 600	600	100	1354	1504	1804

PERFORATED TYPE

FOR GENERAL NOTES REFER SHEET 14 OF 14

TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES

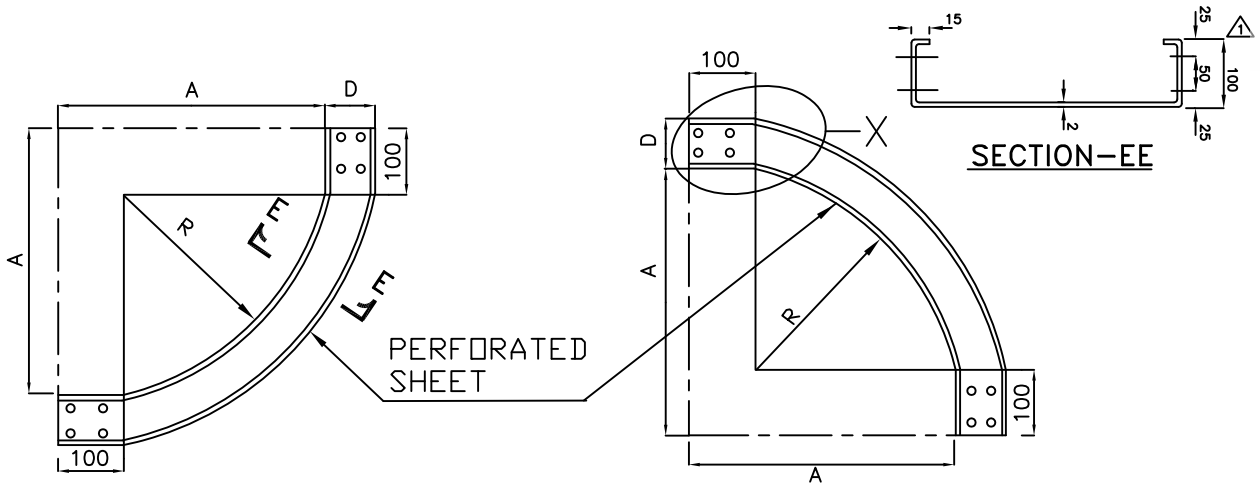


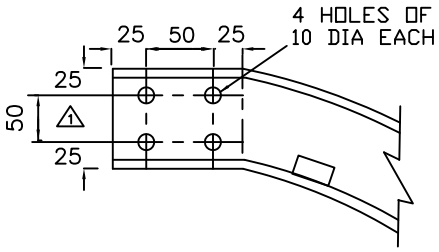
CROSS

WIDTH W	BENDING RADIUS R	A=R+W/2+100
600	600	1000
300	600	850

FOR GENERAL NOTES REFER SHEET 14 OF 14

TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES



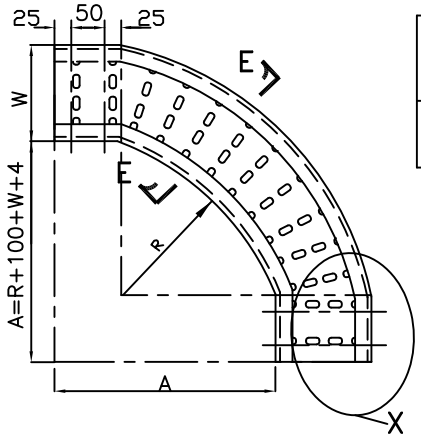


ENLARGED VIEW OF "X"

VERTICAL ELBOW 90 DEG UP/DOWN

INSIDE WIDTH W	BENDING RADIUS R	DEPTH	A
600, 300 & 150	600	100	700

90° VERTICAL BEND – PERFORATED TYPE



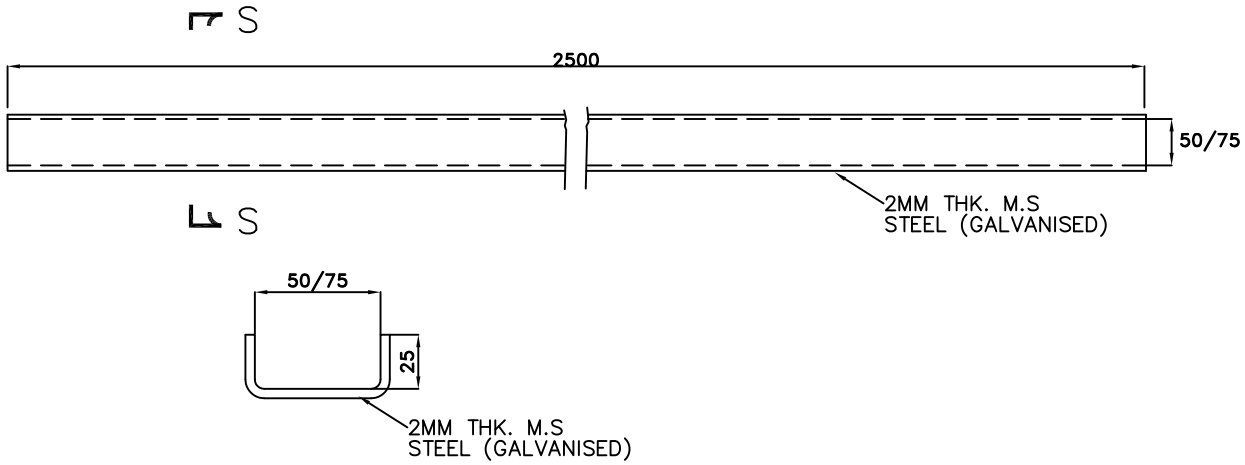
HORIZONTAL ELBOW 90 DEG

INSIDE WIDTH W	BENDING RADIUS R	DEPTH	A		
			W		
			150	300	600
150, 300 & 600	600	100	854	1004	1304

90° HORIZONTAL BEND – PERFORATED TYPE

FOR GENERAL NOTES REFER SHEET 14 OF 14

TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES



SECTION S–S

CABLE TROUGHS

FOR GENERAL NOTES REFER SHEET 14 OF 14

TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES

NOTES:–

1. THE CABLE TRAYS AND ACCESSORIES SHALL BE MADE OF 2mm HOT ROLLED M.S.SHEET CONFIRMING TO IS:1079. ALL THE COUPLER PLATE SHALL BE OF 3 MM THICK.
2. THE CABLE TRAYS AND ACCESSORIES SHALL BE HOT DIP GALVANISED AS PER IS 2629. THE MASS OF ZINC COATING SHALL BE 610 gm/sqm FOR 2MM THICK PRODUCT AND 460 gm/sqm FOR 1.7 MM THICK PRODUCT. THICKNESS SHALL BE 75 MICRONS (MINIMUM), 86 MICRONS (AVERAGE) FOR 2.0 MM THICK PRODUCT AND 55 MICRONS (MINIMUM), 65 MICRONS (AVERAGE) FOR 1.7 MM THICK PRODUCT .
3. FOR LADDER TYPE CABLE TRAYS AND ACCESSORIES, ALL RUNGS SHALL BE SLOTTED.
4. PERFORATED TRAYS SHALL BE FABRICATED OUT OF A SINGLE M.S. SHEET.
5. THE DIMENSIONS OF ALL BENDS, TEES, CROSSES, ETC. FOR PERFORATED CABLE TRAYS SHALL BE THE SAME AS FOR LADDER TYPE TRAY FITTINGS.
6. SIDE CHANNELS OF PERFORATED TRAY ACCESSORIES SHALL BE WELDED WITH THE PERFORATED SHEET AT INTERVALS OF 100mm.
7. LENGTH OF WELDING SHALL NOT BE LESS THAN 25mm. WELDING SHALL BE AS PER IS 9595.
8. PREFERABALY SINGLE MS PERFORATED SHEET SHALL BE USED AS BASE OF ALL PERFORATED TYPE TRAY ACCESSORIES. HOWEVER, IF USE OF PIECES OF PERFORATED SHEET IS UNAVIODABLE FOR BASE, PIECES SHALL BE WELDED WITH EACH OTHER IN LINE WITH THE ABOVE.
9. ALL TRAY CORNERS SHALL BE FREE OF SHARP EDGES & SMOOTH.
10. THE DEPTH, WIDTH AND LENGTH OF TRAYS AND ACCESSORIES SHALL BE WITHIN A TOLERANCE AS PER RELEVANT IS
11. TO FACILITATE ASSEMBLY, ALL ACCESSORIES AT ENDS SHALL HAVE 100mm STRAIGHT PORTION.
12. ALL NUTS, BOLTS, WASHERS ETC., SHALL BE HOT DIP GALVANISED AS PER IS 1367 FOR SIZES ABOVE 12MM AND ELECTROPLATED/ELECTROGALVANISED FROM SIZE BELOW 12MM.
13. ALL DIMENSIONS ARE IN mm UNLESS NOTED OTHERWISE.
14. TRAY ACCESSORIES SHOWN IN THIS DRAWING SHALL BE FACTORY FABRICATED FOR USE AT SITE AS PER APPROVED LAYOUT DRAWINGS. FOR SPECIFIC SITE REQUIREMENTS (E.G. IRREGULAR ANGLE BENDS SUCH AS 30°/60° BENDS, ETC) AS PER SITE LAYOUT CONDITIONS, TRAY ACCESSORIES SHALL BE FABRICATED AT SITE FROM THE STRAIGHT LENGHT OF RESPECTIVE SIZES AS REQUIRED. GALVANISATION DAMAGED DURING CUTTING/WELDING OPEARTIONS SHALL BE BRUSHED AND RED LEAD PRIMER, OIL PRIMER AND ALUMINIUM PAINT SHALL BE APPLIED BEFORE INSTALLATION OF THE ACCESSORIES.
15. WIDTH OF CABLE TRAYS PROPOSED TO BE USED FOR PROJECT ARE AS UNDER :
    LADDER TYPE CABLE TRAY (MM) : 600, 300 & 150.
    PERFORATED TYPE CABLE TRAY (MM) : 600, 300, 150, 100 & 50.
16. 600MM WIDE CABLE TRAY SHALL BE SUITABLE FOR WEIGHT OF 100KG/M INCLUDING LIVE LOAD OF RUNNING LENGTH OF CABLE TRAY.
17. CABLE TROUGHS OR 50/100MM WIDE PERFORATED TYPE TRAY SHALL BE USED FOR LOCAL CABLING/BRANCHING OUT FEW CABLES FROM MAIN ROUTE.

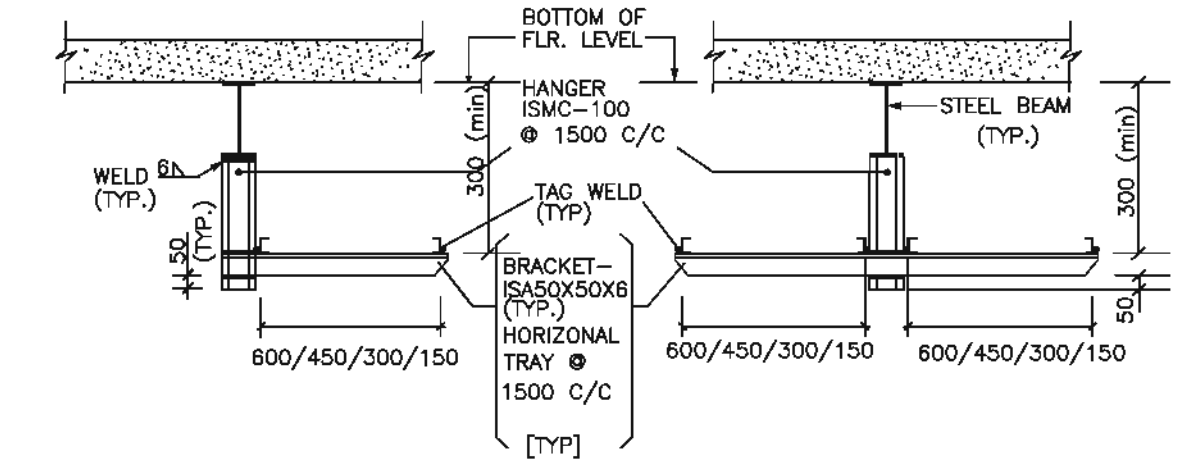
भा.प.इ.प्र.
BHEL

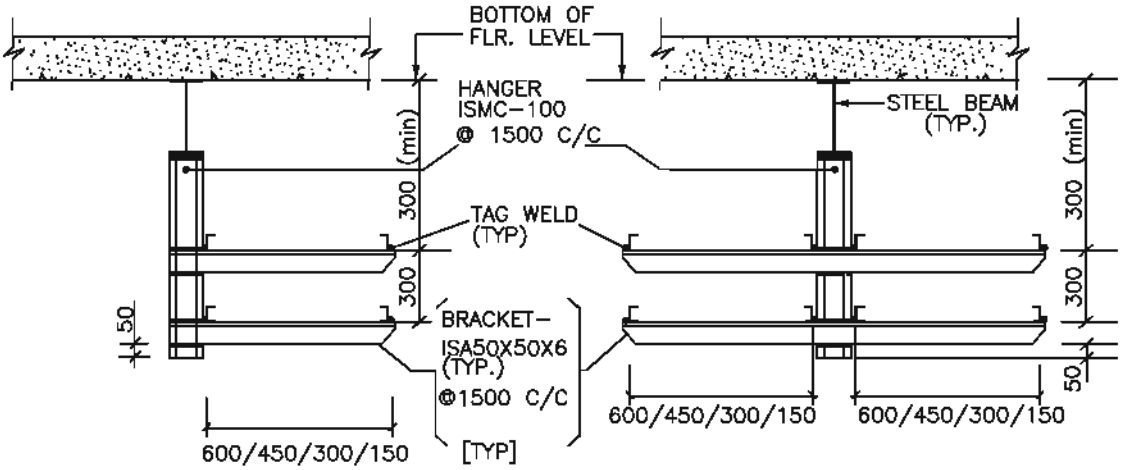
TYPICAL DETAILS OF CABLE TRAYS AND ACCESSORIES

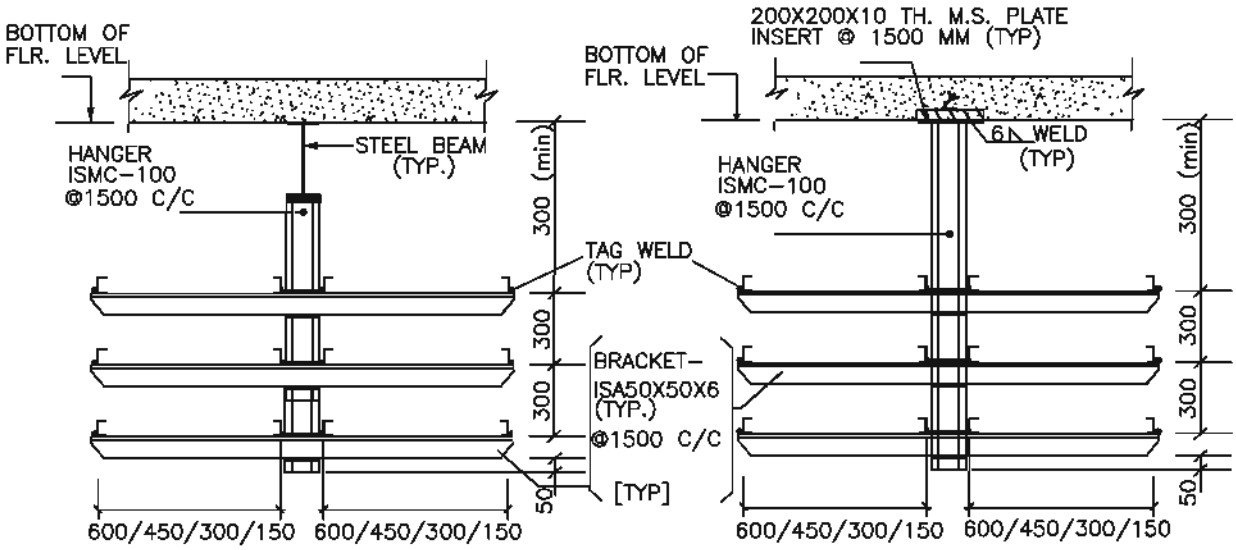
Coal to 2000 TPD Ammonium Nitrate, LSTK-1

TYPICAL INSTALLATION DETAILS FOR CABLE TRAY SUPPORT SYSTEM

BHARAT HEAVY ELECTRICALS LIMITED
INDUSTRIAL SYSTEM GROUP
BANGALORE-12





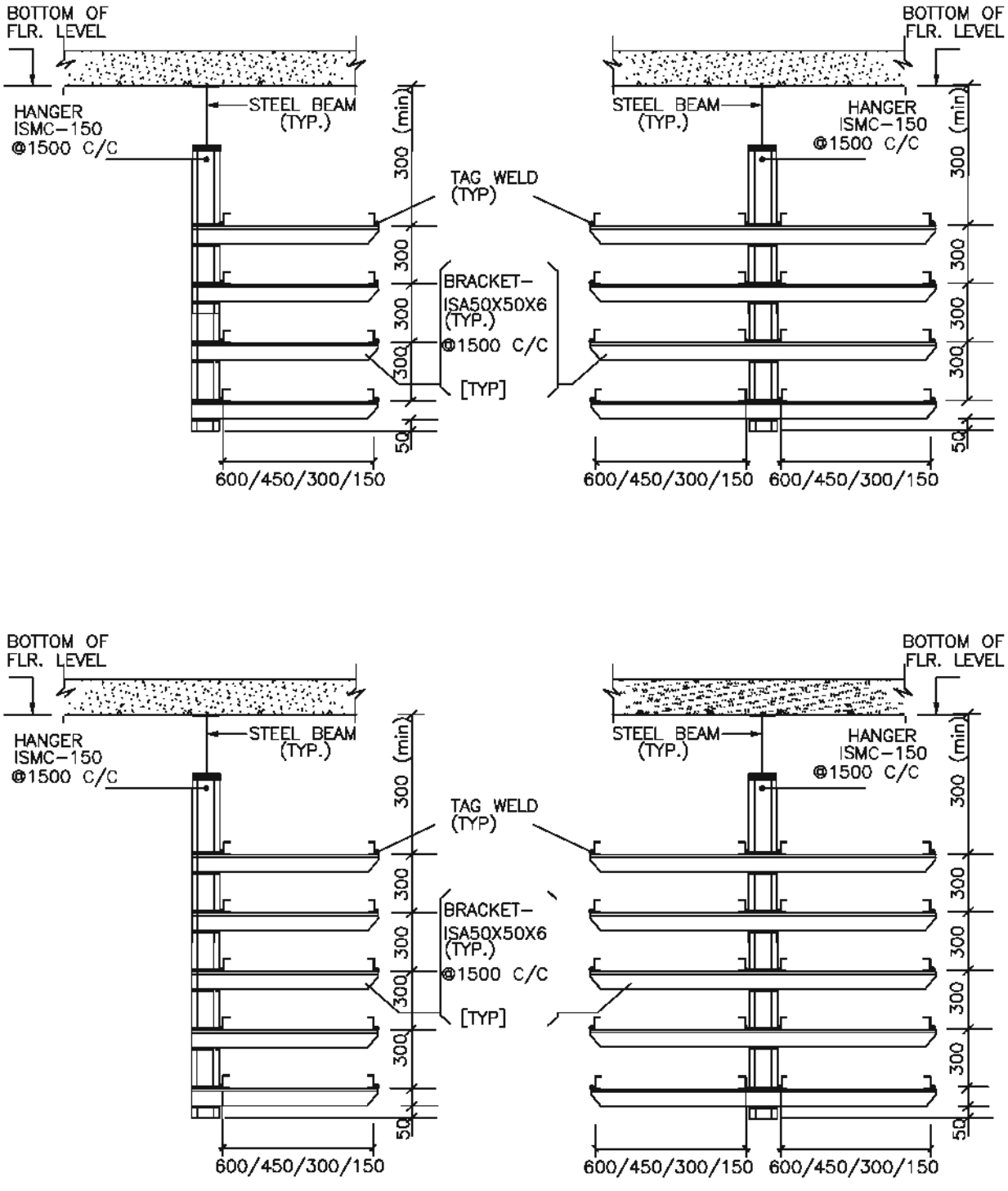


MOUNTING ARRANGEMENT
(FROM CEILING)

MOUNTING ARRANGEMENT (FOR UPTO & INCLUDING THREE TRAYS WITH TOP SUPPORT)

FOR GENERAL NOTES REFER SHEET 15 OF 15

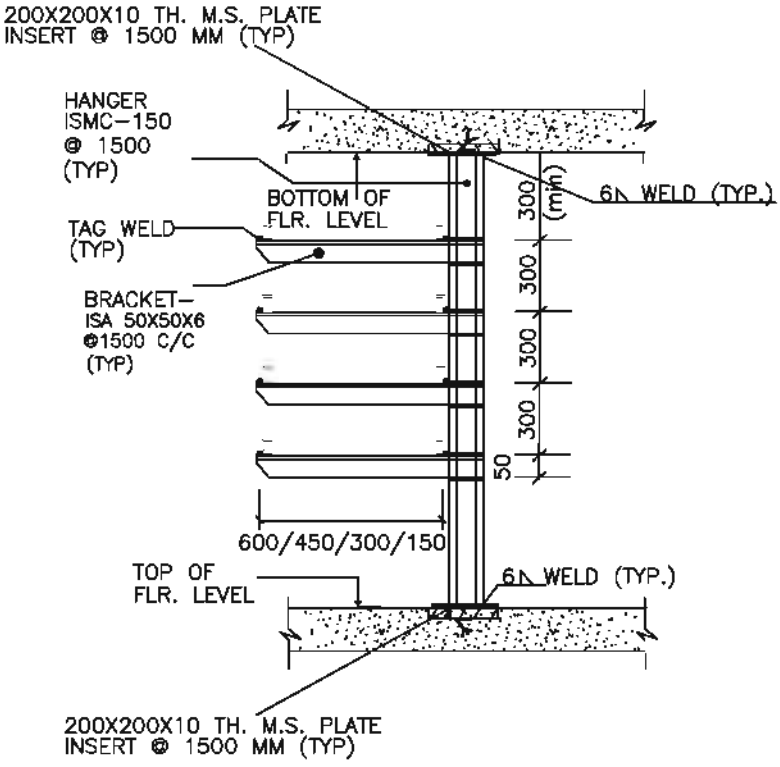
TYPICAL CABLING ARRANGEMENT DETAILS

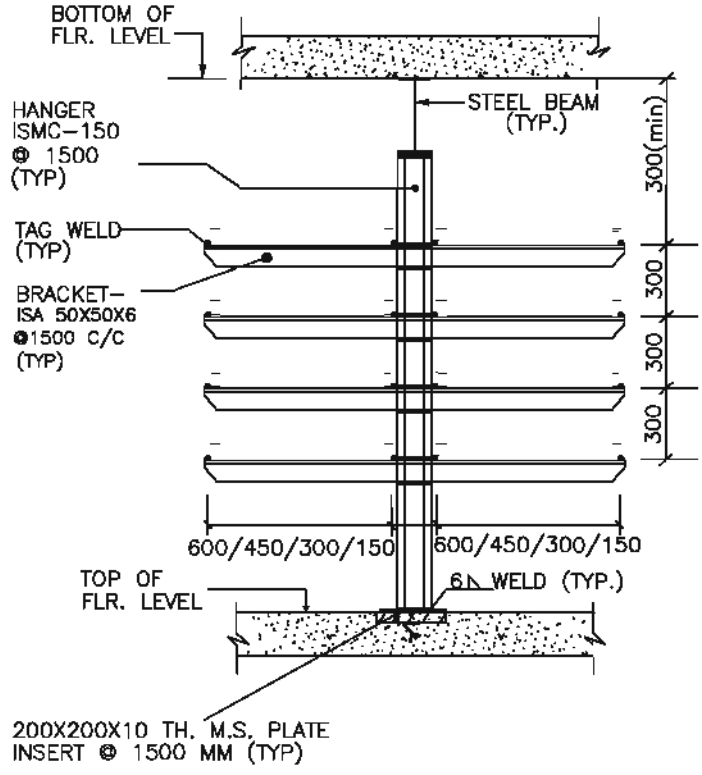


MOUNTING ARRANGEMENT (FOR MORE THAN THREE TRAYS WITH TOP SUPPORT)

FOR GENERAL NOTES REFER SHEET 15 OF 15

TYPICAL CABLING ARRANGEMENT DETAILS

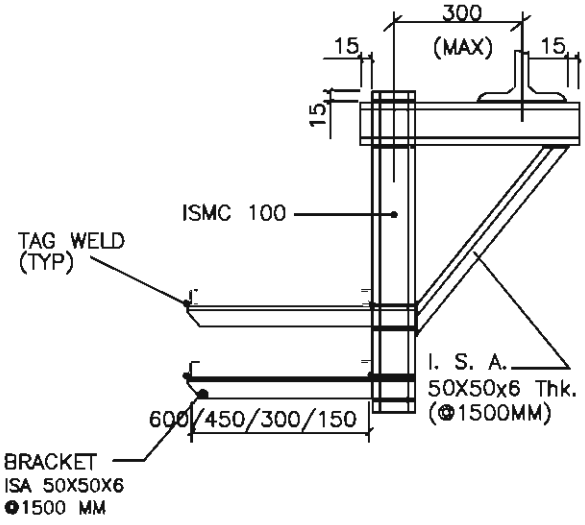




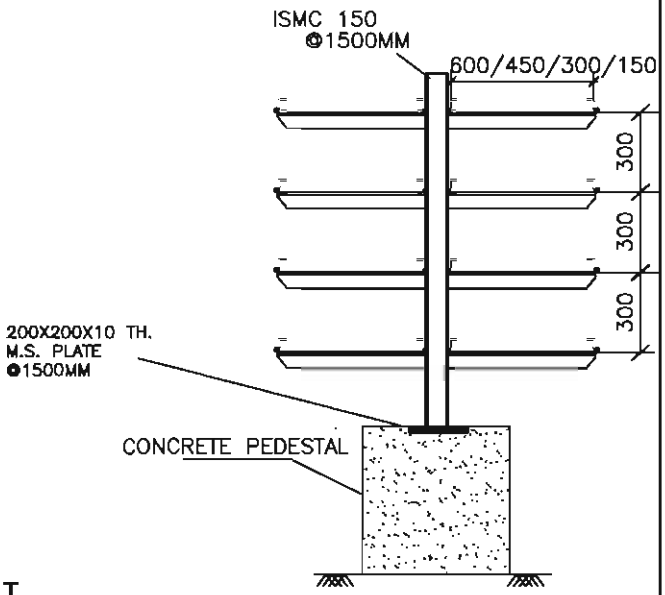
MOUNTING ARRANGEMENT (FOR MORE THAN THREE TRAYS WITH BOTH SIDE SUPPORT)

FOR GENERAL NOTES REFER SHEET 15 OF 15

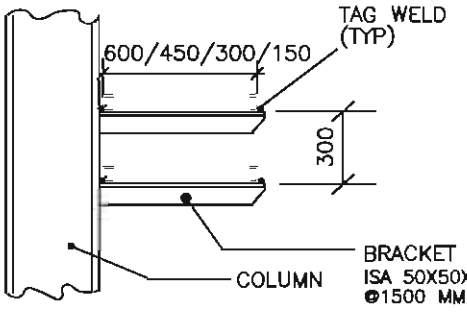
TYPICAL CABLING ARRANGEMENT DETAILS



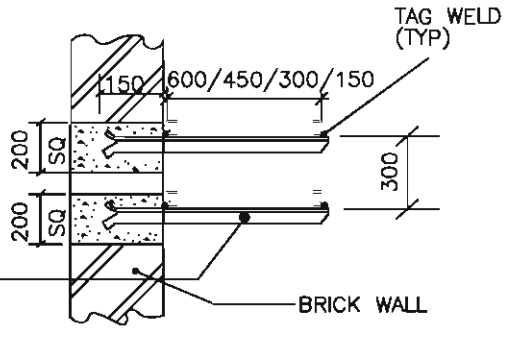
MOUNTING ARRANGEMENT
(FROM FLOOR BEAM)



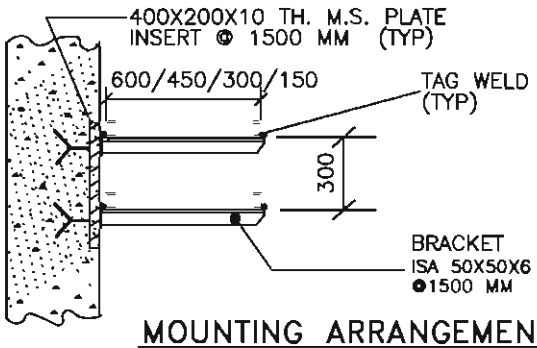
MOUNTING ARRANGEMENT
(ON PEDESTAL)



MOUNTING ARRANGEMENT
(FROM STEEL COLUMN)



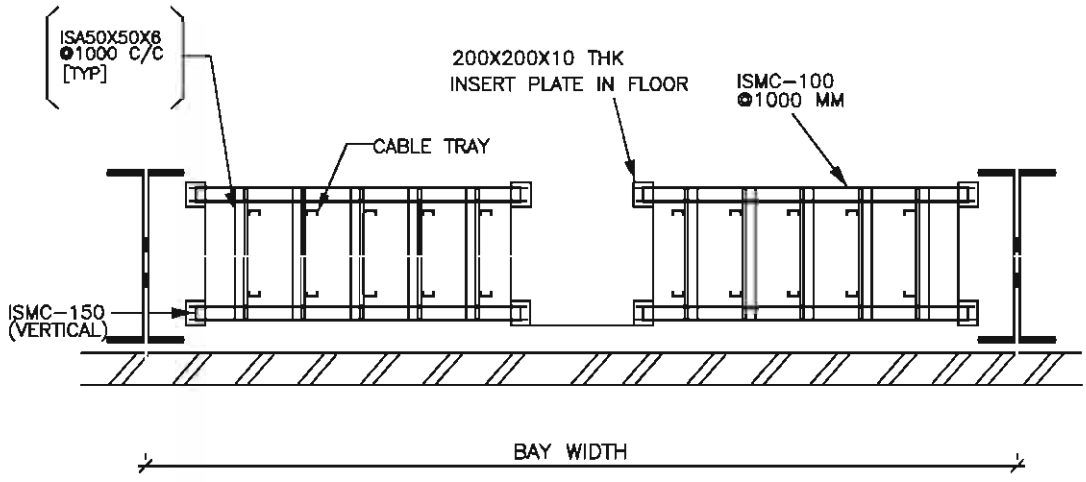
MOUNTING ARRANGEMENT
(FROM BRICK WALL)



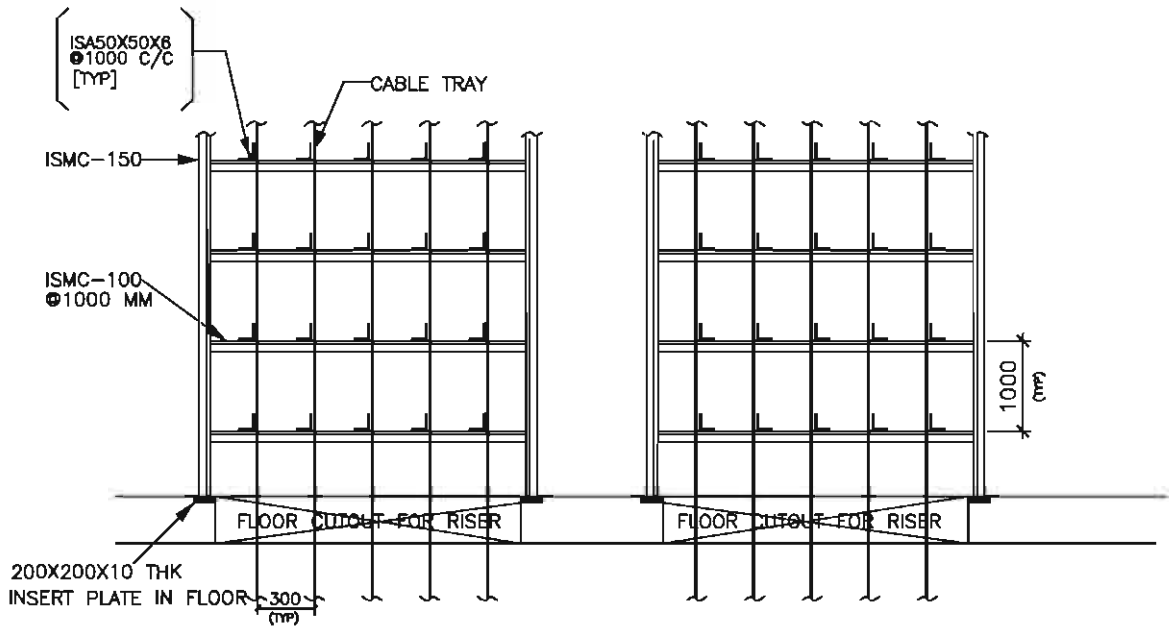
MOUNTING ARRANGEMENT
(FROM CONCRETE COLUMN)

FOR GENERAL NOTES REFER SHEET 15 OF 15

TYPICAL CABLING ARRANGEMENT DETAILS



PLAN

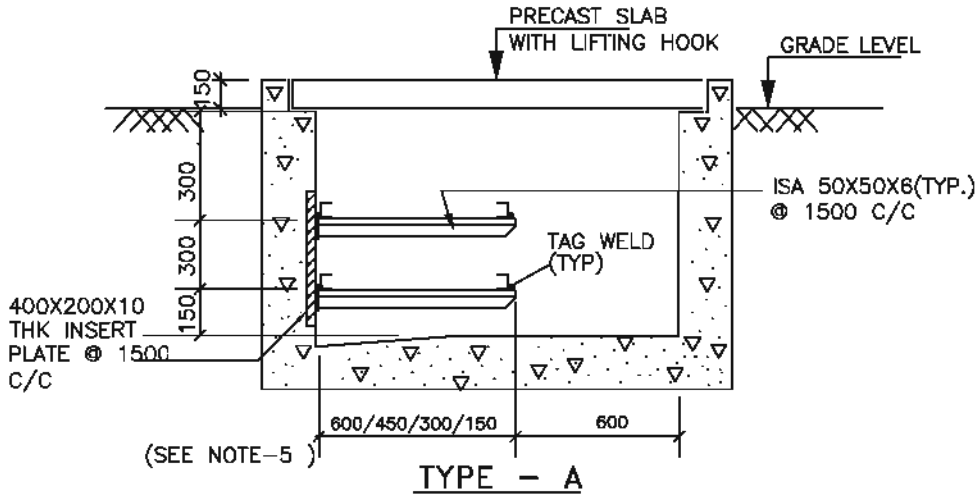


ELEVATION

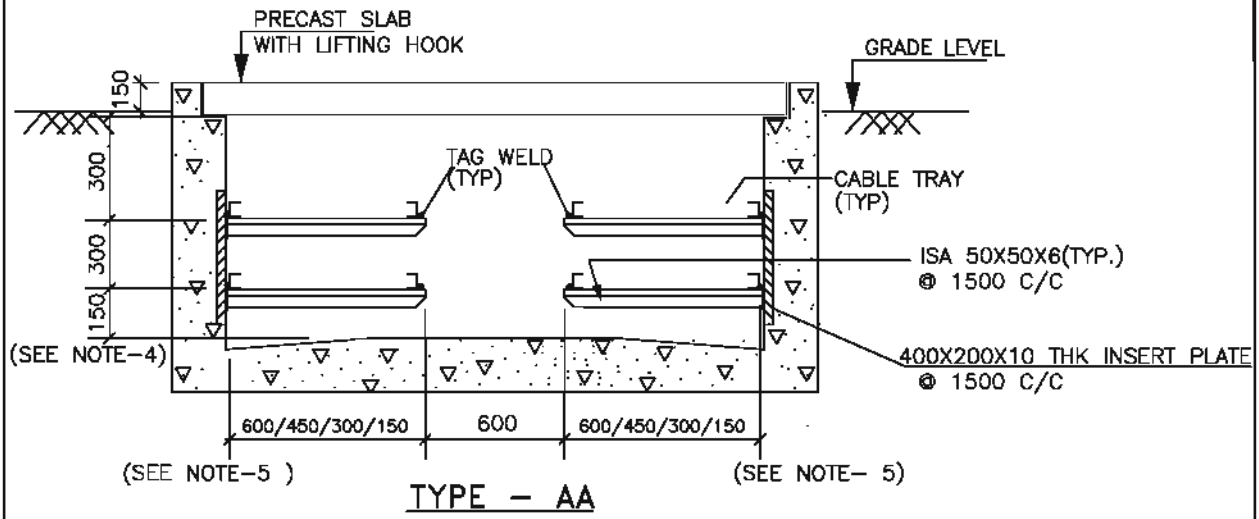
TYPICAL CABLE RISER IN MAIN PH BLDG

FOR GENERAL NOTES REFER SHEET 15 OF 15

TYPICAL CABLING ARRANGEMENT DETAILS



TYPE – A

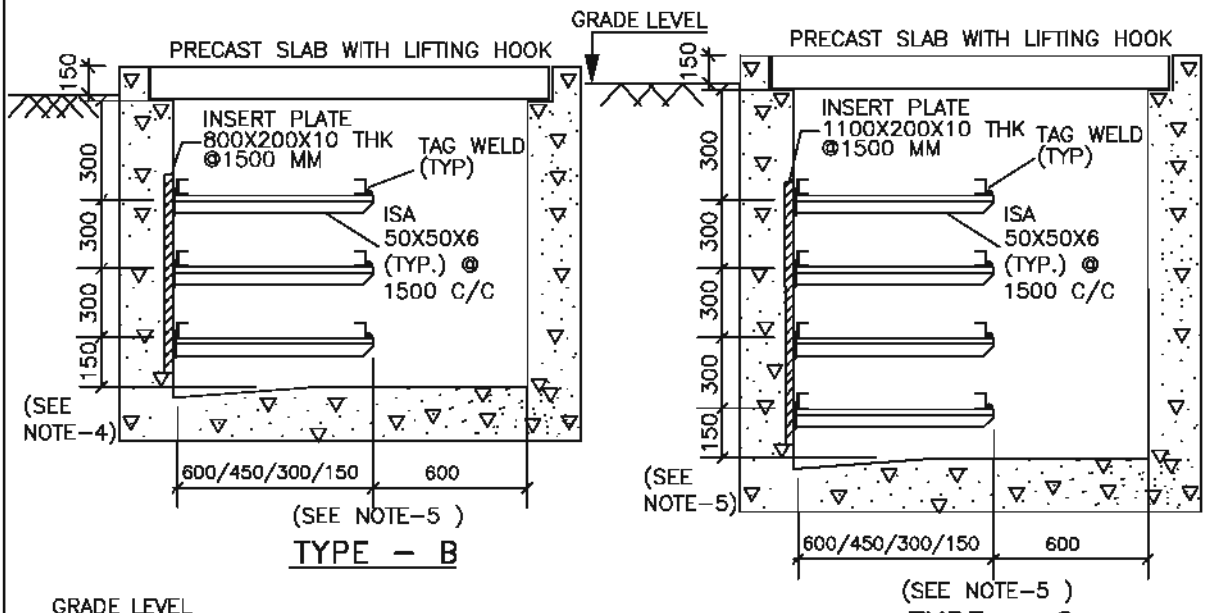


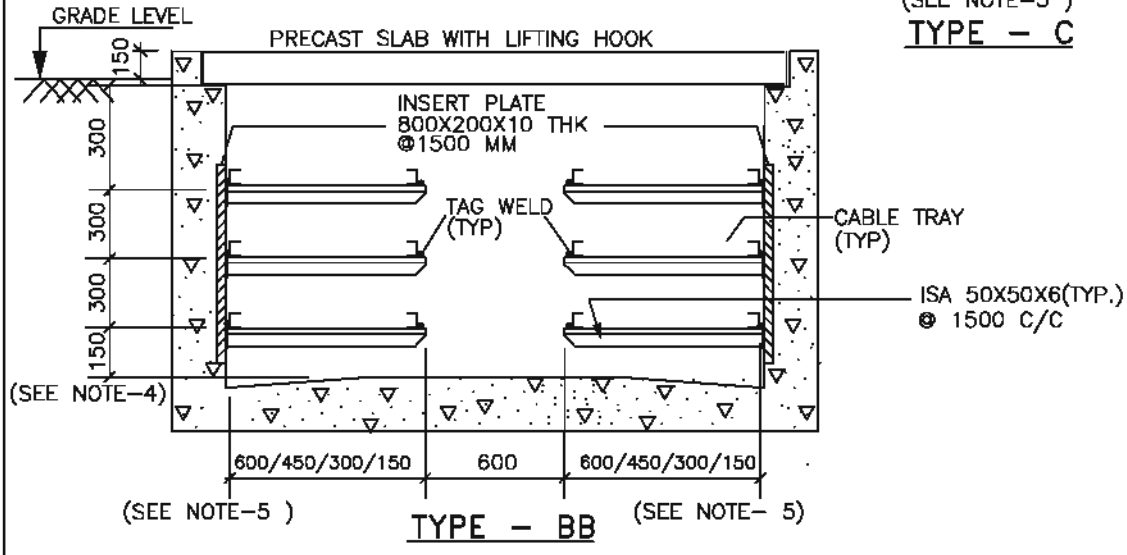
TYPE – AA

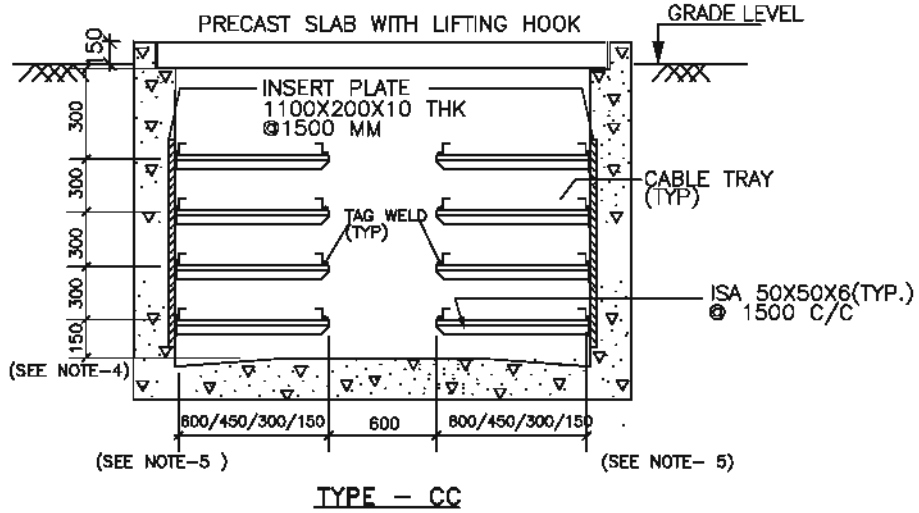
MOUNTING ARRANGEMENT IN CABLE TRENCH (SEE NOTE 5)

FOR GENERAL NOTES REFER SHEET 15 OF 15

TYPICAL CABLING ARRANGEMENT DETAILS



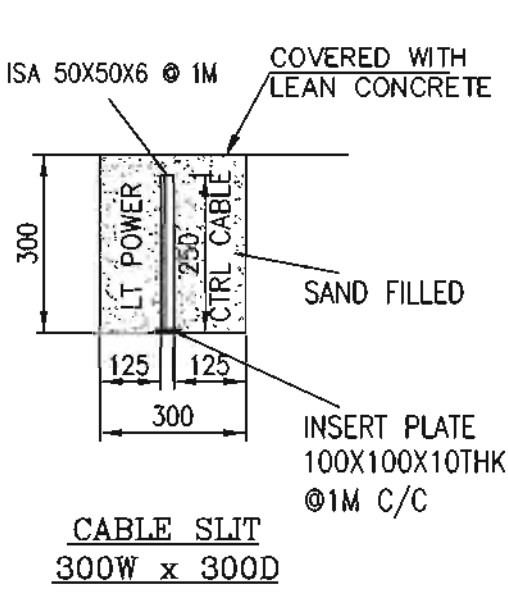




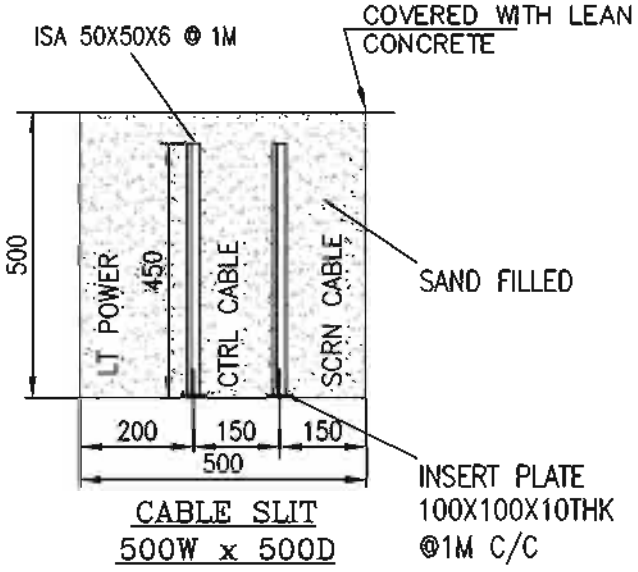
MOUNTING ARRANGEMENT IN CABLE TRENCH (SEE NOTE 5)

FOR GENERAL NOTES REFER SHEET 15 OF 15

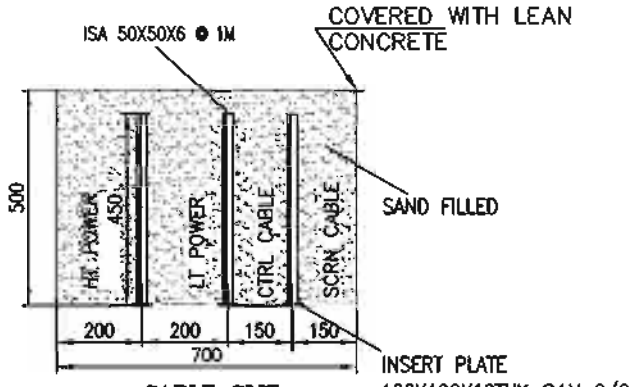
TYPICAL CABLING ARRANGEMENT DETAILS



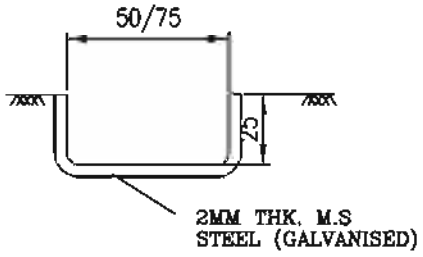
CABLE SLIT
300W x 300D



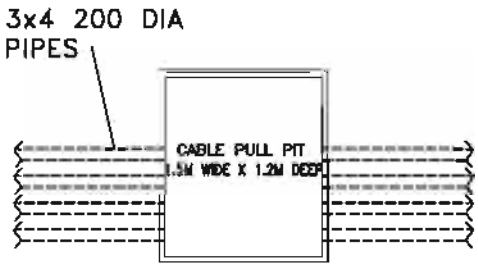
CABLE SLIT
500W x 500D



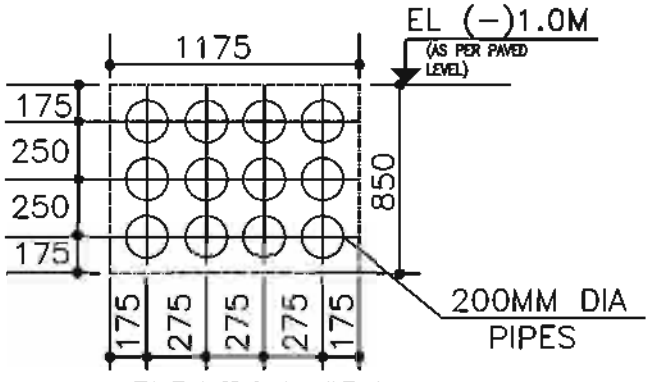
CABLE SLIT
500W x 500D



CABLE TROUGHS USED FOR BRANCHING OUT FROM MAIN CABLE ROUTE



PLAN VIEW

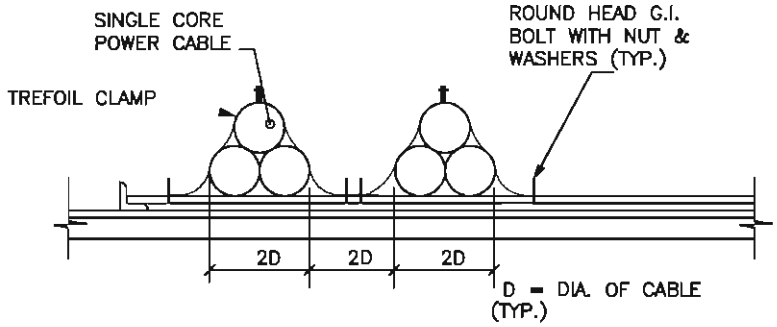


ELEVATION VIEW

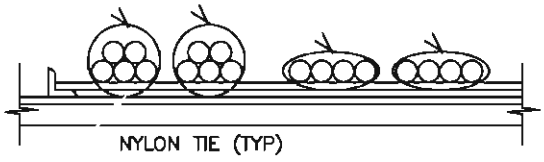
TYPICAL PULL PIT/DUCT BANK ARRANGEMENT AT ROAD CROSSING

FOR GENERAL NOTES REFER SHEET 15 OF 15

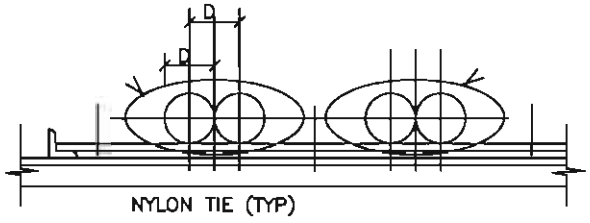
TYPICAL CABLING ARRANGEMENT DETAILS



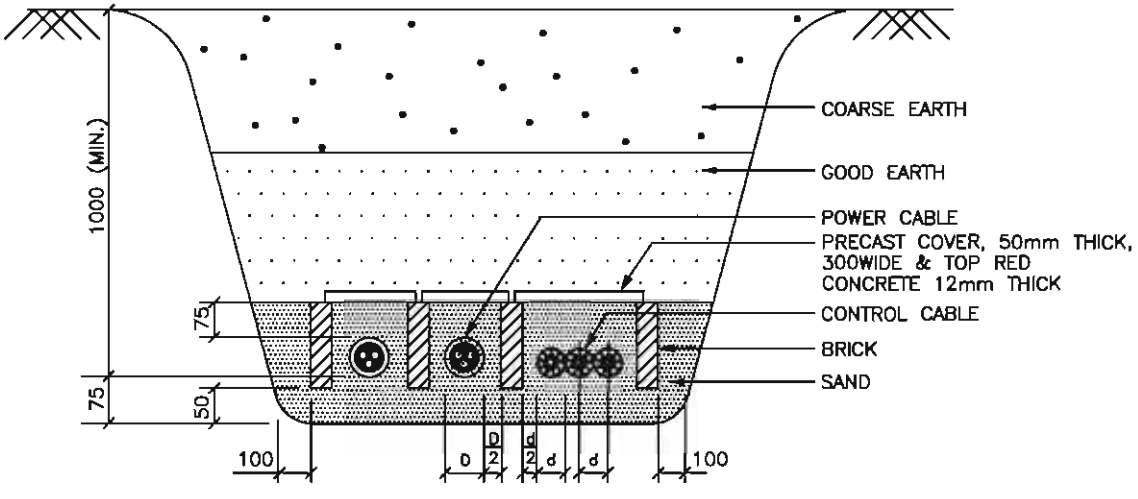
CABLE CLAMPS IN TREFOIL FORMATION
FOR SINGLE CORE POWER CABLES



CLAMPING ARRANGEMENT
OF POWER CABLES(MAX. EIGHT NOS)



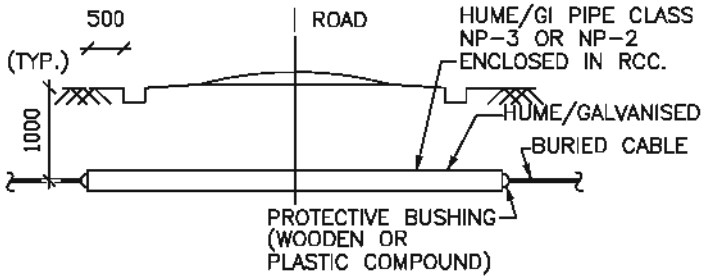
CABLE CLAMPS FOR
MULTICORE POWER CABLES
TOUCHING



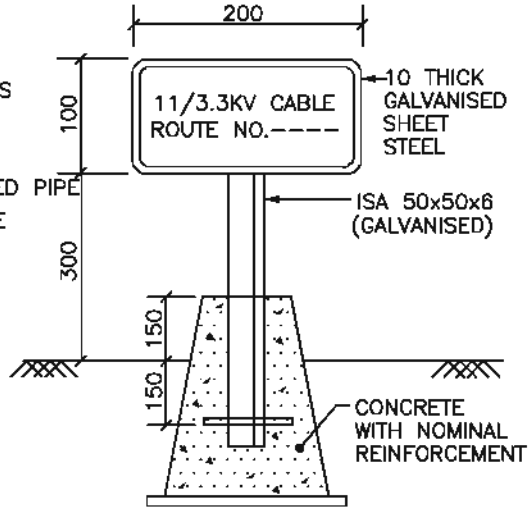
BURIED CABLE LAYING DETAILS

FOR GENERAL NOTES REFER SHEET 15 OF 15

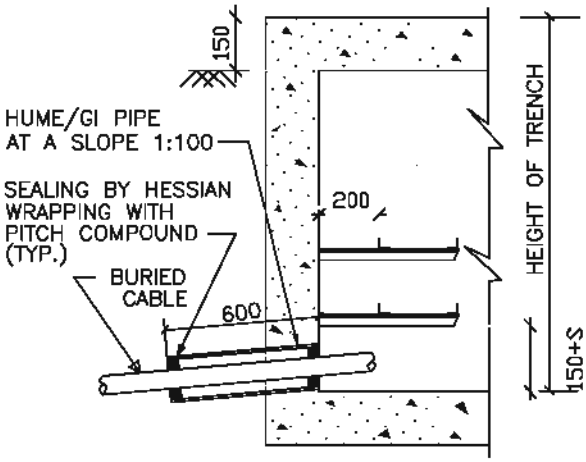
TYPICAL CABLING ARRANGEMENT DETAILS



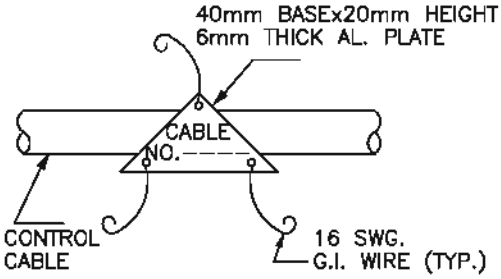
ROAD CROSSING
OF BURIED CABLE



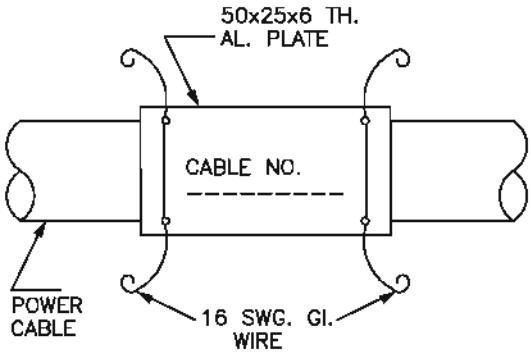
CABLE ROUTE MARKER



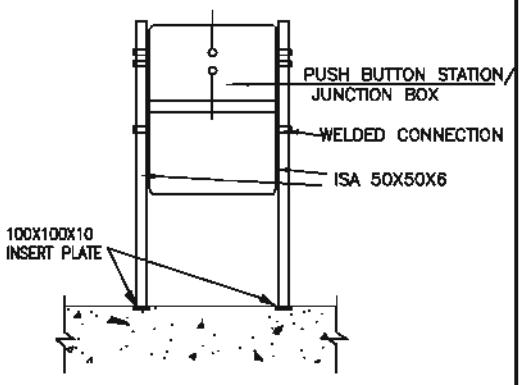
TYP. DETAILS OF BURIED CABLE
ENTRY TO BLDG. OR CABLE TRENCH



CABLE TAG
CONTROL CABLE



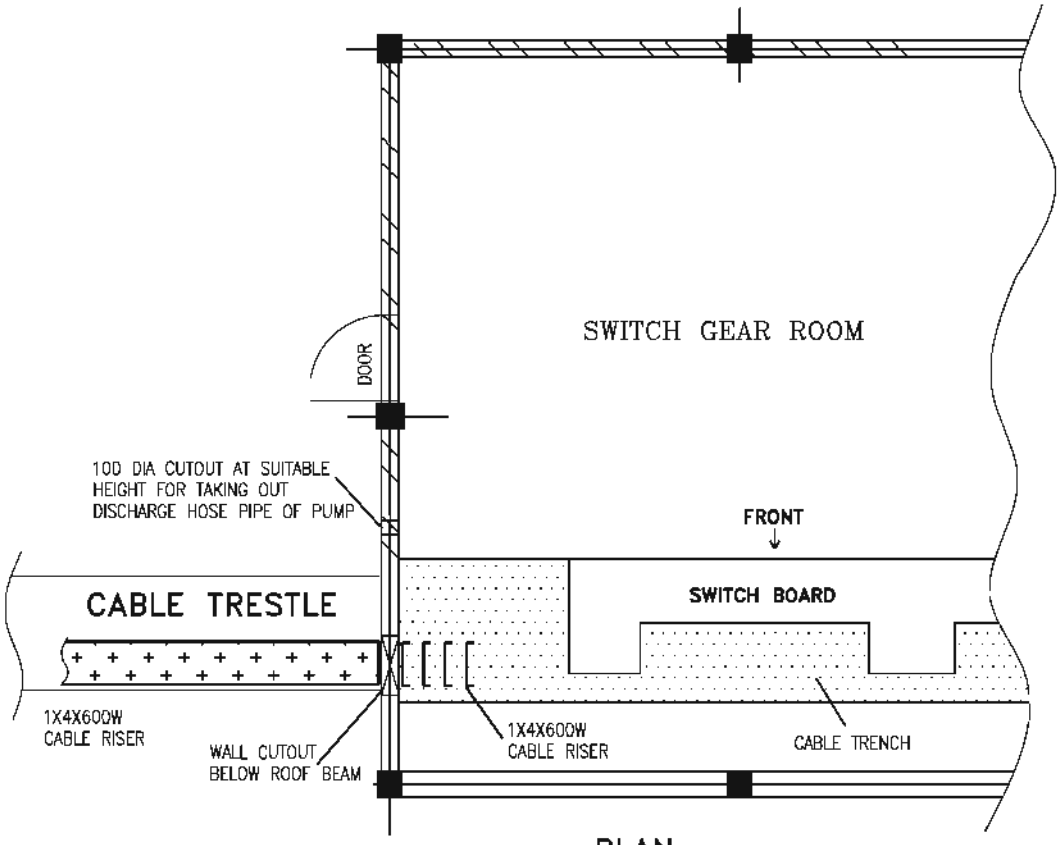
CABLE TAG
POWER CABLE



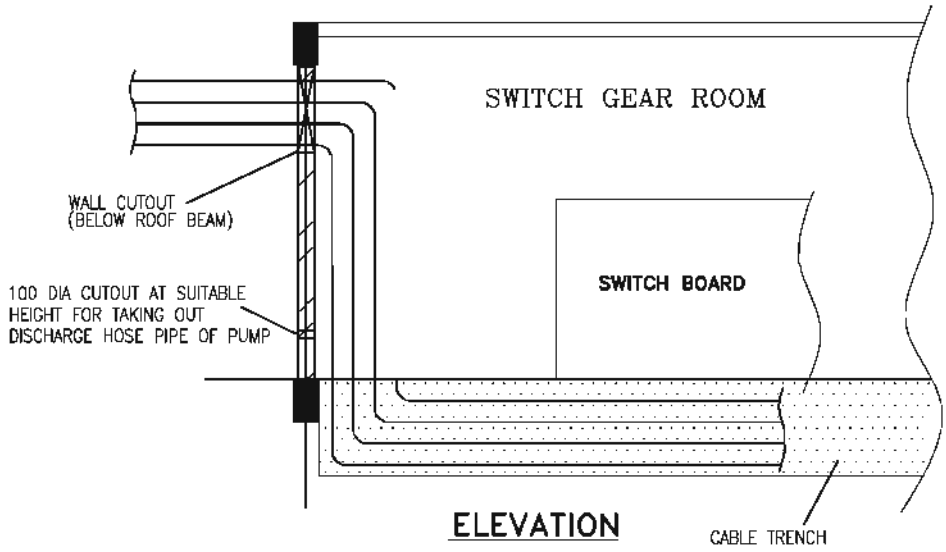
SUPPORT FOR PUSH BUTTON STATION

FOR GENERAL NOTES REFER SHEET 15 OF 15

TYPICAL CABLING ARRANGEMENT DETAILS



PLAN

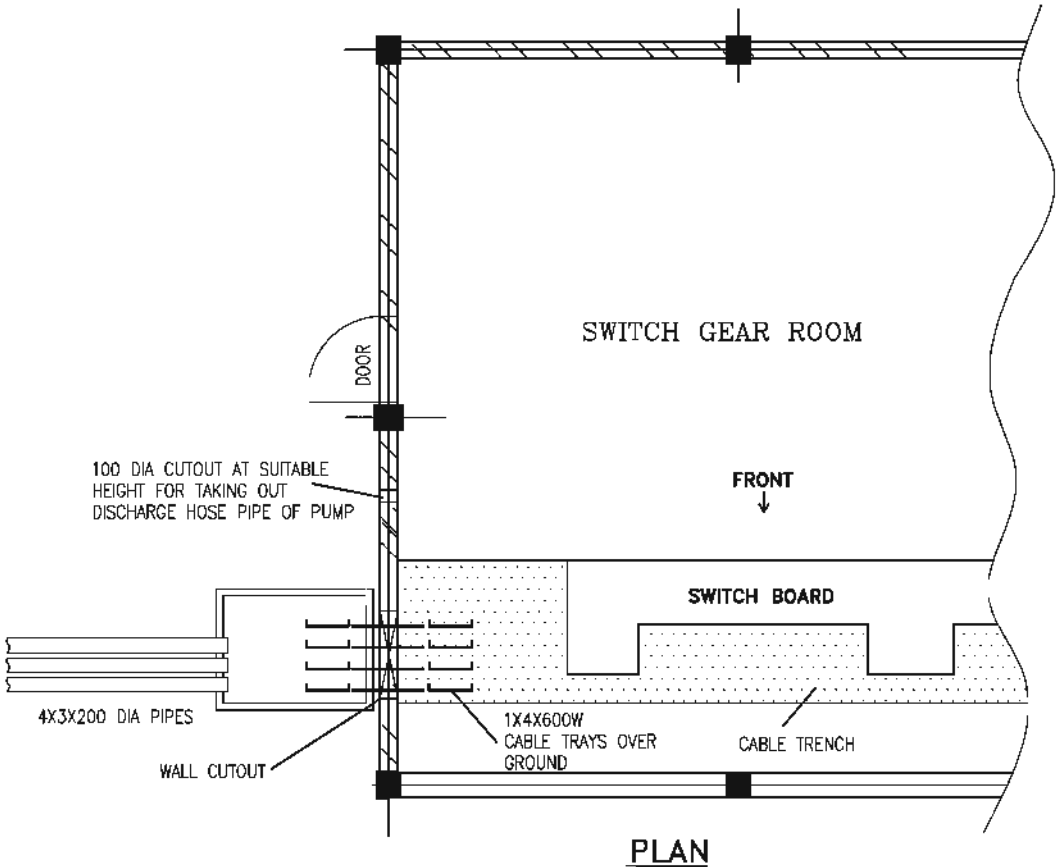


ELEVATION

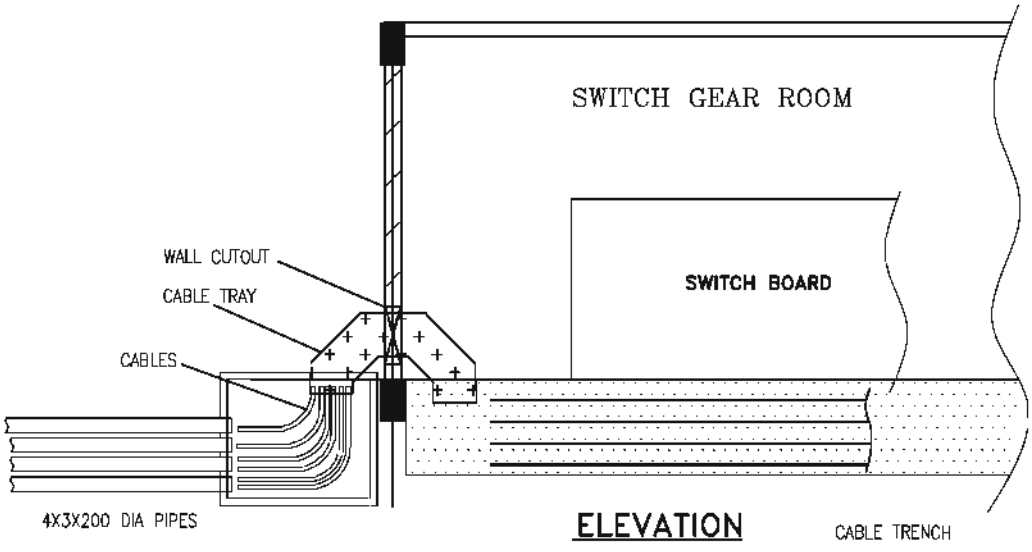
TYP. SECTION OF OVERHEAD CABLE ENTRY TO BOP AREA BUILDING

FOR GENERAL NOTES REFER SHEET 15 OF 15

TYPICAL CABLING ARRANGEMENT DETAILS



PLAN

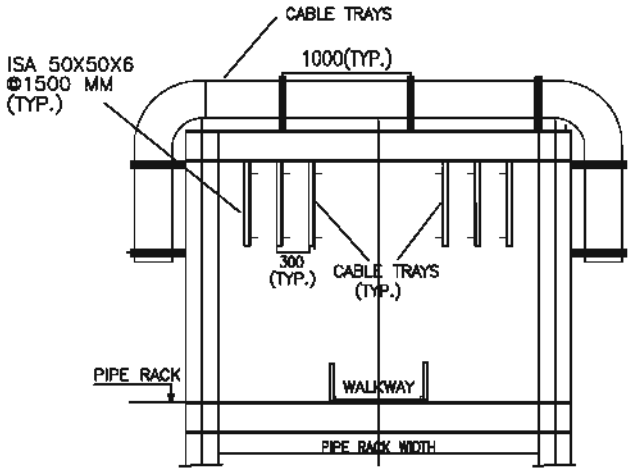


ELEVATION

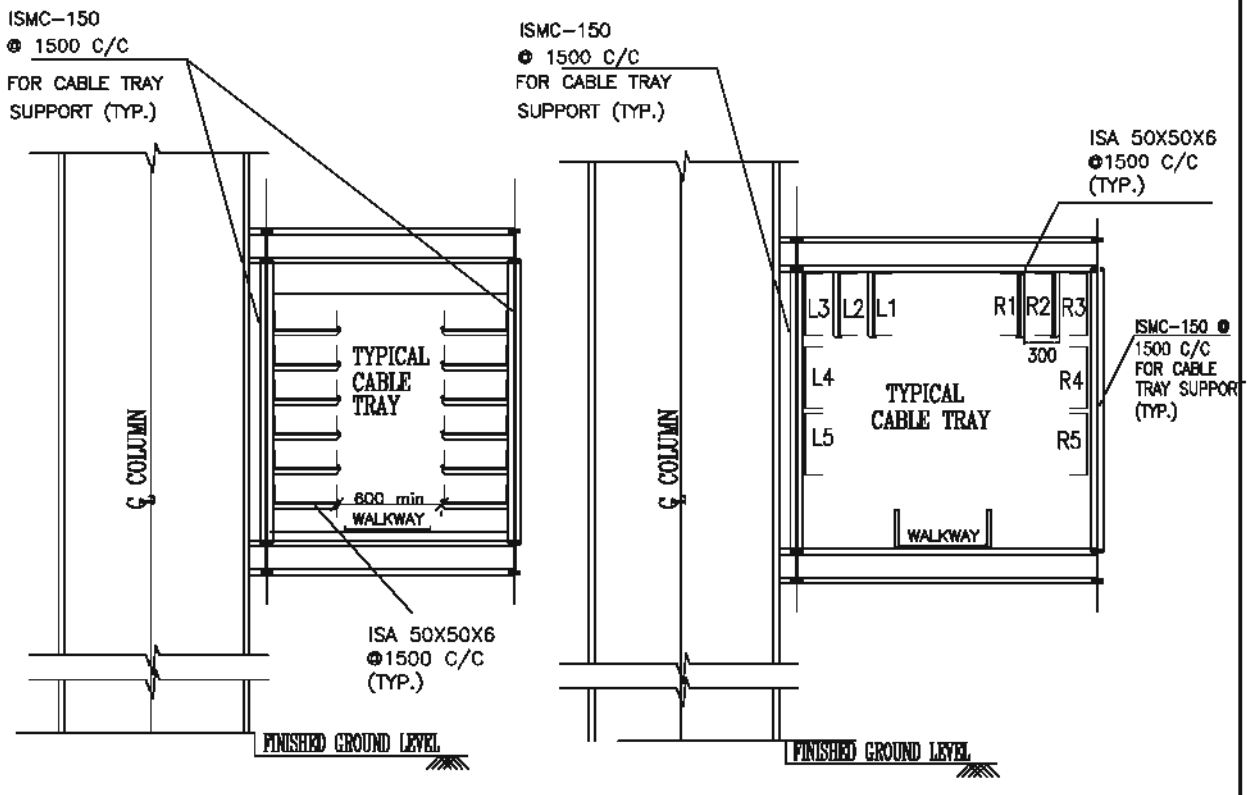
TYP. SECTION OF CABLE ENTRY FROM CABLE PULL PIT TO BOP AREA BUILDING

FOR GENERAL NOTES REFER SHEET 15 OF 15

TYPICAL CABLING ARRANGEMENT DETAILS



TYPICAL VERTICALLY ORIENTED TRAY
SUPPORT ARRANGEMENT ALONG PIPERACK



MOUNTING ARRANGEMENT FOR TRAYS ON TRESTLE

FOR GENERAL NOTES REFER SHEET 15 OF 15

TYPICAL CABLING ARRANGEMENT DETAILS

NOTES:–

1. ALL DIMENSIONS SHOWN ARE IN MM.
2. CABLE TRAYS SHALL BE SUPPORTED @ 1.5M FOR HORIZONTAL RUNS & @ 1M FOR VERTICAL RUNS I.E. CABLE TRAY RISERS.
3. CABLE TRAYS SUPPORTING STRUCTURE SHALL BE FABFRICATED AT SITE OUT OF HOT–DIP GALVANISED STRUCTURAL MEMBERS (ISMC/ISA) AS PER REQUIREMENT. AND SHALL BE WELDED TO STRUCTURAL STEEL(WHERE AVAILABLE), OR INSERT PLATES PROVIDED ALONG FLOOR SURFACES/WALLS/BOTTOM OF CEILING.
4. MINIMUM DEPTH REQUIREMENTS FOR TRENCHES ARE INDICATED. SLOPE DETAILS SHALL BE TAKEN CARE OF IN CIVIL DRAWING.
5. CABLE TRENCH TYPES SHALL BE AS UNDER:–

   a)TYPE–A – DOUBLE TRAYS, SINGLE SIDE
   b)TYPE–AA – DOUBLE TRAYS, BOTH SIDES
   c)TYPE–B – THREE TRAYS, SINGLE SIDE
   d)TYPE–BB – THREE TRAYS, BOTH SIDES
   e)TYPE–C – FOUR TRAYS, SINGLE SIDE
   f)TYPE–CC – FOUR TRAYS, BOTH SIDES

6. GALVANISATION DAMAGED DUE TO WELDING SHALL BE MADE GOOD WITH APPLICATION OF COLD GALVANISING PAINT.
7. NUMBER OF TIERS ARE VARIABLE AS PER THE REQUIREMENT & SHALL BE SHOWN IN RESPECTIVE CABLING LAYOUT DRAWINGS.
8. CABLE TRAYS SHALL GENERALLY BE INSTALLED IN HORIZONTAL ORIENTATION.
   IN AREAS SUSCEPTIBLE TO COAL/ASH DUST DEPOSITION (E.G OVERHEAD CABLING PATHS IN BOILER AREA, TRAYS BELOW BOILER PLATFORMS ETC.) CABLE TRAYS SHALL BE INSTALLED IN VERTICAL ORIENTATION.
9. CABLE TRAYS SHALL BE TAG WELDED TO SUPPORTING HORIZONTAL ARM BRACKET ISA 50X50X6.
10. CABLE TAGS SHALL BE FIXED AT TERMINAL ENDS, AT TRAY INTERSECTION / BEND AND AT EACH SIDE OF FLOOR/WALL/DUCT CROSSINGS ETC. AND AT EVERY 30M IN CABLE TRENCH/TRAY OR BURIED RUN.
11. BURIED CABLE ROUTES SHALL HAVE MARKER PROJECTING 150MM ABOVE GROUND AND SHALL BE SPACED AT AN INTERVAL OF 30M ALONG THE ROUTE & AT EVERY BEND.
12. IN CASE OF BURIED CABLES, CABLE MARKERS SHALL ALSO BE PROVIDED AT THE LOCATION OF CABLE JOINTS WITH AN INSCRIPTION "CABLE JOINT"

TYPICAL CABLING ARRANGEMENT DETAILS

Coal to 2000 TPD Ammonium Nitrate, LSTK-1

DESIGN MEMORANDUM FOR LIGHTING SYSTEM

BHARAT HEAVY ELECTRICALS LIMITED
INDUSTRIAL SYSTEM GROUP
BANGALORE-12

1.0 SCOPE:

The purpose of this design document is to cover basic approach for designing lighting system for CHP, LHP and AHP area. The document covers various types of lighting system, lighting system design, illumination levels for various areas, luminaries' type and low voltage power services for various areas of the power plant.

2.0 LIGHTING SYSTEM DESIGN:

2.1 The illumination system shall be designed to ensure uniform, reliable, aesthetically pleasing and glare free illumination. The lighting fixtures shall be designed for minimum glare. The design shall prevent glare/luminous patch seen on VDU/ Large video screens, when viewed from an angle. The finish of the fixtures shall be such that no bright spots are produced either by direct light source or by reflection. The diffusers/ louvers used in fixtures shall be made of impact resistant polystyrene sheet and shall have no yellowing property over a prolonged period. The Lux levels to be adopted for various area are indicated at Annexure - A.

2.2 All fixtures shall be of a proven design for applications in power plant environment and process plant.

LED Luminaires shall be used for the lighting of all the indoor & outdoor areas. However, for hazardous areas lighting etc. LED luminaires shall be used. In the hazardous areas like fuel oil handling area or any other gasification areas, lighting shall be flameproof. In battery room fixtures shall be corrosion proof.

In false ceiling area LED luminaires shall be recessed mounting type & in non-false ceiling area the LED luminaires shall be surface mounting type.

The individual lamp wattage for LED shall be 3-5 watt. Fractional wattage LEDs can also be provided. The LED chip efficacy shall be min 120 Lm/W. The luminaire efficacy shall be not less than 100 Lm/W. Suitable heat sink shall be designed & provided in the luminaire. The LED used in the luminaires shall have colour rendering index (CRI) of Min 80. Colour designation of LED shall be "cool day light" (min 5700K) type for indoor areas. However, for outdoor areas, the colour temperature of LED shall be min. 4000K, including rough & dust prone areas. LED shall conform to the LM 80 requirements.

The max. junction temperature of LED shall be 85 deg C. Further the lumen maintenance at this temperature shall be min 90%. The THD of LED Luminaires shall be less than 10%. Further the EMC shall be as per IS 14700. The power factor of the luminaire shall not be less than 0.95. The marking on luminaire & safety requirements of luminaire shall be as per IS standards. Suitable heat sink with proper thermal management shall be designed & provided in the luminaire. Min. efficiency of LED driver: The minimum efficiency of LED driver shall be 85% for driver power output rating <=40W and 87% for driver power output rating> 40W.

The connecting wires used inside the system, shall be low smoke halogen free, fire retardant type and fuse protection shall be provided in input side specifically for LED luminaire.

Care shall be taken in the design that there is no water stagnation anywhere in the housing of the luminaire. The entire housing shall be dust and water proof protection as per IS 12063.

LED drivers shall have following control & protection:
(i) Suitable precision current control of LED
(ii) Open circuit protection
(iii) Short circuit protection
(iv) Over temperature protection
(v) Overload protection
(vi) Surge Protection(3 kV)

2.3 LED fixtures shall be used for DC lighting.

2.4 Aviation light in Lighting Mast shall be of LED type.

2.5 The lighting fixtures shall be group controlled from lighting panel. The lighting fixtures in office areas, control

rooms etc. shall be controlled by switches. Each switch shall control a maximum of three fluorescent fixtures.

2.6 Lighting panel (LP) for controlling lights with additional provision for manual/bypass control shall be provided:

Indoor lighting panel: Without Timer
Outdoor lighting panel: With Timer. All outdoor lighting system shall be automatically controlled by synchronous timer. Provision to bypass the timer shall be provided in the panel. All areas except MCC buildings shall be considered as Outdoor areas.

2.7 Outdoor areas shall have flood light fixtures mounted on flood light poles.

2.8 All outdoor fixtures shall be weather proof and of min. IP65 degree of protection.
(In CHP, LHP & AHP – TP's, Crusher House, Conveyor Galleries etc) to be considered as outdoor.

(ii) For Indoor type of fixtures: -
(a) Surface/Pendent mounting: - IP 54 class of protection.
(b) Recess Mounting (False ceiling): - IP 20 class of protection

2.9 Junction box for lighting shall be made of GI type
Junction boxes for street lighting poles and lighting mast shall be deep drawn or fabricated type made of min 1.6mm thick CRCA sheet, hot dip galvanized min 50micron thick. The degree of protection shall be IP 65. The thickness for Zinc in Junction Boxes is in line with IS:4759.
For octagonal type poles, junction boxes are integral to the poles and separate junction boxes will not be required.

3.0 ILLUMINATION DESIGN CALCULATION:

3.1 Lighting design for indoor areas will be done by LUMEN method only. For a given indoor area, number of

luminaires is calculated as follows:
Number of Luminaires =

Where,

$$\frac{L \times W \times \text{LUX LEVEL (Average)}}{\text{LUMEN} \times \text{COU} \times \text{MF}}$$

L= Length of room W= Width of room
LUMEN= Lumen output of each lamp
COU= Coefficient of Utilisation
MF= Maintenance Factor

Coefficient of Utilisation (COU) is determined from the COU chart for a particular luminaire of the manufacturer, corresponding to selected reflection factors and calculated Room Index.

The working plane from the floor level considered at: 0.85 meter

The Room Index is calculated by the following formula:
Room Index: $\frac{L \times W}{\{(L+W)XMH\}}$
Where, MH = Mounting height of luminaire.
The Reflection factor (RF) will be considered as given below:
Ceiling : 0.8
Wall : 0.5
Floor : 0.2
Reflectance factor for CHP areas such as Bunker floor, TPs etc. and AHP outdoor areas: -
Ceiling : 0.3
Wall : 0.3

Floor : 0.1

Values of Maintenance Factor (MF), which includes the luminaire depreciation factor, will be

Dust prone indoor/outdoor area	0.6
Control room & air conditioned area	0.8
Indoor area non-AC (Except fluorescent fixture)	0.7
Coal Handling area, Ash Handling, Conveyor/Transfer Points etc.	0.5

Apart from maintenance factor as given above, Temperature correction factor shall be considered in the lighting design for fixtures located in non-air-conditioned area.

3.2 Lighting design for outdoor area, open area shall be done by computer programme as per standard norms for lighting design to meet the specified lux level. Average maintenance factor for outdoor and road lighting (including CHP, AHP & LHP areas roads): 0.6

4.0 LIGHTING SYSTEM DESCRIPTION

Lighting system will be provided with AC normal and DC as listed against various areas as per Annexure-B enclosed.

The sources of power lighting are as below:

(i) 415V AC Normal (ACN) Supply from lighting distribution boards / switchboard MCCs

(iii) DC Supply from DC Distribution Board

(v) DC lighting is to be provided, through self-contained DC fixtures with four hours back-up duration, at strategic locations, in auxiliary/offsite buildings wherever DC lighting is not available. The fixtures shall be switched 'ON' automatically in case of failure of AC supply.

AC Normal lighting will provide 100% illumination level and normally all AC lighting fixture shall remain ‘ON’ as long as normal AC supply is available.

For CHP, AHP & LHP

The supply to the DC lighting panels shall be automatically switched on in case of loss of AC supply. The DC supply will be automatically switched off after 3 minutes following the restoration of AC lighting system

18W, 220 V DC lighting fixtures shall be provided as follows:

- One (1) no in each local control area (RIO ROOM) & PLC Room
- Three (3) nos. in each MCC/Switchgear room
- Min. Three (3) nos. or avg lux level of 20 in each control room
- One (1) no in each Office room and each pump House.
- One (1) no in each battery room
- Six (6) nos in Limestone shed
- Two (2) nos in each underground portion of TPs.
- One (1) no at every 5.0 m height interval in the staircases of various TPs & Buildings
- One (1) no in each drive floor in each TP and Crusher House
- One (1) no at every 20m interval in underground conveyor gallery

Lighting level by DC lighting will be provided to meet functional/ operational requirements. DC fixtures will be located at strategic locations such as near entrance, staircase, landings etc. for safe personnel movement during emergency.

4.1 AC Normal Lighting Systems:

AC Normal lighting fixtures are fed through a number of conveniently located AC Lighting panel (ACLP) which are fed from Lighting Distribution Board (LDB). Each Lighting DB shall have 2x100% transformers.

LDBs consisting of dry type isolation transformer housed in LDB with proper separation from distribution panels as per details indicated below is envisaged:

The no. of LDB shall be as per loading based on the lighting layout for different areas (governed by the minimum lux level defined in Annexure-A)

Transformer rating:	**50 / 100/150 kVA**
Transformer voltage ratio:	415 / 415 Volt, taps of +5% to -5% in steps of 2.5%.
Transformer type:	Non- Encapsulated
Distribution Panel type:	Single front/Double front fixed type
LDB Configuration:	Two incomers
Incomer & Bus coupler type:	TPN MCCB
Incomer & Bus coupler rating:	As per lighting transformer rating
Outgoing feeder type:	TPN MCCB
Outgoing feeder rating:	63A

Cable termination in the cable alley of LDB shall confirm to Form IVb design. 20% spare outgoing feeders will be provided for both LDB and lighting panels.

AC normal lighting panel as per details given below is envisaged:

Incomer type:	TPN MCB
Incomer rating:	63A
Outgoing feeder type:	RCBO
Outgoing feeder rating:	20A
Short circuit rating:	10kA
No. of outgoing feeders:	6/12/18 (as per loading requirement of the area where LP is installed)
On/off control:	With timer (for outdoor LP)

Street lighting panel as per details given below is envisaged:

Incomer type:	TPN MCB
Incomer rating:	63A
Outgoing feeder type:	TPN RCBO
Outgoing feeder rating:	20A
Short circuit rating:	10kA
ON/ OFF control	With Timer
No. of outgoing feeders:	6

4.2 DC Lighting Systems:

DC lighting fixtures fed through suitable numbers of conveniently located DC Emergency Lighting panel (DCELP) which are fed through DC Lighting Distribution Board (DCELDB).

DCELDBs as per details given below is envisaged:

Distribution Panel type:	Single front fixed type
DC Incomer type:	MCB with contactor
DC Incomer rating:	16/32/63A
Outgoing feeder type:	MCB

Outgoing feeder rating: 6/10/16/32A

DCELPs as per details given below is envisaged:

Incomer type: DP MCB

Incomer rating: 32A

Outgoing feeder type: DP MCB

Outgoing feeder rating: 16A

DC lighting fixtures shall be provided at strategic locations to enable safe movement of operating personnel and access to important control points during an emergency, when both the normal AC & Emergency lighting system fail.

TPs and buildings and each local control area. DC lighting fixtures shall be fed from DC LDB which in turn will be fed from CHP DC system. The supply to the DC lighting panels shall be automatically switched ON in case of loss of normal AC supply.

Lighting fixtures shall be fed from DC lighting panels which in turn shall be fed from DC LDB OR DCFB.

4.3 The LDBs shall be made of sheet steel (CRCA) of 2 mm thickness for load bearing members and 1.6 mm for other members and shall be provided with voltmeter and ammeter along with selector switch, supply ON indicating lamps etc. All indicating lamps will be cluster LED type. The DOP for LDB will be IP-54 for indoor and for transformer cubicle IP-42. DOP for LP shall be IP-65. Lighting distribution boards & panels shall be powder coated with colour shade RAL9002.

Lighting panels shall have 20% spare outgoing feeders.

4.4 Emergency EXIT lamps:

Emergency exit lamps backed up by battery shall be provided at strategic locations of the building for safe exit of personnel. These exit lamps will remain ON all the time and normally receive power supply from ACNLP.

Exit lamp unit shall contain maintenance free Ni-Cd battery with 0.5 hours backup capacity.

5.0 STREET LIGHTING / OUTDOOR LIGHTING

5.1 The roads within BHEL scope as per contract will be considered for lighting.

5.2 Street lights / outdoor lighting will be fed from separate panel located at suitable places. Automatic switching ON/OFF of these circuits shall be done from street light panel.

5.3 For street lighting, street light pole will be used. For outdoor area lighting if required flood light pole will be used. Pole type shall be as below:

Pole height: 9/11 meters
Pole construction type: Steel tubular/ Octagonal poles
Pole type: Hot dip galvanized.

Coating thickness of galvanizing shall be min 70 micron.

The pole shall be mounted above ground using base plate and minimum height of pole shall be 8 meters.

High mast tower will be 30 meters high, hot dip galvanised and tapered polygonal shaped. The location of high mast will be decided during detailed engineering. Supply to high masts shall be fed from feeder pillar panels. Each feeder shall consist of TPN MCB, timer circuit, contactor, MCB and other necessary accessories for its operation. Also, the protection of mast and fixtures shall be provided.

A separate spike electrode of suitable height shall be provided to individual lighting mast for protection from lightning.

6.0 LOW VOLTAGE POWER SERVICES

6.1 Different type of receptacles as per details below will be provided:

(i) Decorative receptacle:

At least 02 number 6/16A, 6-Pin, 240V AC decorative socket with switch will be provided in control room, office area, store room, cabin etc.

In office area, suitable number of decorative sockets with switch to be provided for IT requirements.

(ii) Industrial receptacle: At least 01 number 20A, 3-Pin, 240V AC industrial type receptacles with switch will be provided at suitable location in industrial area.

Two number 20A, 3-Pin, 240V AC industrial type receptacles with switch will be provided at suitable location (not more than 50 meters) in Switchgear rooms, control room and pump houses only. For all TP's & Crusher House 1 no. will be provided in each operating floor. Same is not applicable for conveyor gallery.

Maximum 4 no's will be loop in & loop out in a circuit wherever 20A receptacle is provided.

(iii) Welding receptacle: 63A, 3-phase, 415V AC welding receptacles with isolating switch will be provided at specific points near all major equipment and at an average distance of 50m (location will be decided during detailed engineering. Maximum 04 nos. receptacles will be fed through one feeder. At least one no. 63A 3 phase 415V AC receptacle shall be provided in each off-site area.

The welding receptacles shall be provided with RCCB/RCD of 30mA sensitivity having facility for manual testing/ checking of operation of RCCB/RCD.

6.2 Maximum Transformer rating for welding distribution board shall be 150kVA. Other construction details shall be identical to AC LDB.

For CHP/LHP area 63A welding receptacles shall be provided in equipment floors of TPs, crusher house, Lime Shed, Gypsum Shed, Pump House etc at every 50 meters. For conveyor gallery, welding receptacles at 50 m interval on one side of the gallery shall be considered. In AHP areas like pump houses, compressor house, Silo unloading floor, clarifier areas one welding receptacle shall be provided. For offsite areas, welding receptacles shall be fed directly from nearest ACDB.

6.3 Based on room size, suitable nos. of ceiling fans (1200mm sweep) with Stepped electronic regulator finished in stove enamelled white or with electro static powder coating shall be provided in office rooms/control room which are not covered by air-conditioned and ventilation system. Power factor of fans shall not be less than 0.9 except for hazardous and flameproof areas.
Tentatively one (1) no. of ceiling fan shall be provided for 10 sq. m area at suitable mounting height. The ceiling fans shall be suitable for operation on 240V +/-10%, 50Hz, AC supply comprising of class 'E' or better insulated copper wound single phase motor, aerodynamically designed well balanced Al blades (3 nos.), down rod, BEE 5 star rated, die cast aluminium housing, capacitor, suspension hook, canopies etc. Fan regulators shall be stepped electronic type suitable for operation on 240V +/-10% AC supply.

6.4 For the maintenance of lighting fixtures, 1 no. free standing adjustable aluminium ladder, adjustable from 05M to 10M shall be provided.

7.0 WIRING / CONDUITS

7.1 Wiring of lighting system will be done as follows:
(i) Wiring installation will be done by multi-stranded, PVC insulated, unsheathed, copper, colour coded wires laid in GI conduits of 20 mm dia size (minimum) conforming to IS-9537. The thickness of conduits up to & including

25 mm dia will be 1.6 mm and conduits above 25 mm will be 2.0 mm. Colour of the PVC insulation of wires shall be Red, Yellow, Blue, black for R, Y, and B phases & neutral respectively and white & grey for DC positive & DC negative circuits respectively.

(ii) Conduits will be heavy-duty type hot dip galvanised steel conforming to IS-9537. Conduit accessories will be hot dip galvanised. In corrosive area, conduits will have suitable epoxy coating additionally.

(iii) Flexible conduits shall be PVC-coated galvanized steel flexible conduit.

(iv) Concealed conduits shall be GI conduits. Conduits in office rooms, control room and other air-conditioned areas will be surface mounted on the roof above false ceiling. However vertical drops of conduits will be concealed along walls and finally plastered for better aesthetics. Vertical drops along RCC column shall be exposed. For other areas, conduits shall be surface mounted and shall be hot dip galvanised.

Conduits shall be threaded on both sides and thread length shall be protected by zinc rich paint.

Pull out boxes shall be provided at suitable interval in a conduit run. Boxes shall be suitable for mounting on Walls, columns, structures etc. Pull-out boxes shall have cover with screws and shall be provided with good quality gasket lining. Pull-out boxes used outdoors shall be weather proof type suitable for IP-55 degree of protection and those used indoor shall be suitable for IP-52 degree of protection. Pull-out boxes and its cover shall be hot dip galvanised.

(v) Filling area of wires in conduit shall not exceed 40% of the conduit area.

(vi) Wiring for AC Normal and DC services will run in separate conduits

(vii) Lighting and receptacles will be fed from separate circuits. No two different phase circuits will be run in the same conduit. However, different circuits of same phase may be laid in the same conduit.

7.2 Following Min. sizes of 1100 V grade, PVC insulated, single core, stranded copper conductor wires will be used:

Lighting Panel to Fixtures:	1.5 sq. mm (Cu) wire or cable
Lighting Panel to JBs / Switches:	1.5 sq. mm (Cu) wire or cable
JBs / Switches to Fixtures:	1.5 sq. mm (Cu) wire or cable
Panel to First receptacles:	4 sq. mm (Cu) wire OR 10 sq. mm (Al) cable
First receptacles to looping other receptacles (240V,1 phase receptacles):	4 sq. mm (Cu) wire OR 10 sq. mm (Al) cable
In case of only one receptacles in ckt., Panel to receptacles (240V,1 phase receptacles):	4 sq. mm (Cu) wire OR 10 sq. mm (Al) cable
Panel/ JBs to flood light fixtures:	1.5 sq. mm (Cu) or cable

8.0 EARTHING

Earthing of lighting system will be done by using of following sizes of wire / flat:

Lighting Distribution Board	GS Flat 50x6 mm
Lighting Panels	GS Flat 25x3 mm
Lighting fixtures, receptacles, conduits, junction boxes & switch boxes	14 SWG GI wire
Welding receptacles	GS Flat 50x6 mm
Street light pole / flood light pole / high mast	GS Flat 25x3 mm
Electrode for Pole / High mast earthing	1 nos, 40 mm dia MS rod, 3 mtr long

9.0 SWITCHBOXES

Switchboxes shall be provided as per the requirement and to be decided during detailed engineering.

10.0 STATUTORY & REGULATORY REQUIREMENT

Statutory and regulatory regulation shall be applicable as per Indian Electricity Rule, 1956 with amendment-3 Rule no. 35, 48, 49, 50, 61 & 64 for illumination & low voltage power services.

Annexure - A: Lux levels to be adopted for various area			
Sl No.	Location	Avg Illumination Level (Lux)	Type of Fixture
1	Switchgear rooms, Charger, Rectifier room	200	Industrial type LED Luminaire
2	Control room, computer room, control equipment room	350	LED luminaire equivalent to Mirror optics with anti-glare features or down-lighter.
3	Offices, conference rooms, etc.	300	Decorative mirror optics Type LED luminaire or LED down-lighter
4	Battery rooms	100	Totally enclosed corrosion Proof LED Luminaire
5	Transformer yard	20 (general) 50 (on equipment)	LED Luminaire
6	Diesel generating room /enclosure, Compressor room, pump house etc.	150	LED medium bay/Industrial type LED Luminaire
7	Cable galleries/vault	50	Industrial type LED Luminaire
8	Street lighting- primary roads secondary roads	 20 10	LED street lights
9	Outdoor storage handling and unloading area	20	LED Luminaire
10	Cement stores	150	Industrial dust proof type LED Luminaire
11	Chemical stores/House	150	Corrosion proof LED Luminaire
12	Permanent stores	150	LED high/medium bay /Industrial trough LED Luminaire
13	Workshop. Building	150	LED high/medium bay /Industrial trough LED Luminaire
14	Transfer points, Sheds, tunnels, bunker house, Crusher house, Conveyor Gallery etc.	100	LED Dust tight/Well glass type Luminaire

15	DC Lighting- Control room	-	LED down light fixtures, Decorative recessed type with cylindrical reflector
16	DC Lighting- Other Area	-	LED Industrial Bulkhead
17	Corridors, Walkways	50	LED Luminaire
18	Building Periphery Lighting	10	LED Street Light fixture/LED Luminaire
19	Security Lighting along Boundary	10	LED Street Light fixture/LED Luminaire
20	DM plant, water treatment plant CW Pump house, Raw water PH, Fire Water PH	150	LED high/medium bay /Industrial trough LED Luminaire
21	Toilet	100	LED Luminaire

Annexure - B: Lux levels to be adopted for various area

Sl No.	Location	Normal AC Lighting System	Emergency AC Lighting System	220 V DC Lighting System	Portable DC Fixtures
1	Area Lighting	100%			
2	Street Lighting	100%			
3	Transformer Yard and Storage Yard	100%			
4	Coal Handling Plant	100%		√	
5	Lime Handling Plant	100%		√	
6	Ash Handling Plant	100%		√	

DC Emergency Lighting

Sl No.	Location	Average Lux Level
1	Exit/ Entry of Plant Building	1 fixture
2	Fire Exit sign	1 fixture

Coal to 2000 TPD Ammonium Nitrate, LSTK-1

DESIGN MEMORANDUM FOR 220V DC SYSTEM

BHARAT HEAVY ELECTRICALS LIMITED
INDUSTRIAL SYSTEM GROUP
BANGALORE-12

1.0 FUNCTION

220V DC system shall be an ungrounded system comprising of 2x100% batteries each with individual float cum boost charger, 1x100% sectionalised DCDB. The 220V DC system is designed to cater the control, protection, interlocking, emergency lighting and emergency dc drives for CHP, AHP and LHP requirement.

2.0 DESIGN CRITERIA

Design ambient	: 50°C
Min. Electrolyte Temperature	: 5.0°C
End Cell Voltage	: 1.14V per Cell for Ni-Cd High Discharge Type

2.1 Chargers will be suitable for continuous operation at AC voltage variation of ±10%, frequency variation of +/ -5% and combined voltage and frequency variation of 10% (absolute).

2.2 The batteries will be suitably sized considering emergency load cycle requirement of 60 minutes for CHP/ LHP/ AHP area. An ageing factor of 1.25 is considered. Design margin of 20 % shall be considered. Temperature correction factor corresponding to 5.0°C min. electrolyte temperature is considered for battery sizing.

2.3 The voltage at load terminal will not exceed the limits of minimum 187V and maximum of 242V.

2.4 The 220V DC Power cable between battery & DCDB, charger & DCDB shall be single core cable. Battery isolation box with MCCB shall be provided outside the battery room. Main HRC fuse on battery and charger output shall have alarm contact.

2.5 Each of the charger is suitable to charge the fully discharge Ni-Cd High Discharge Type battery in 7 to 8 hours. This shall be carried out with the respective charger/battery disconnected from DCDB. Ni-Cd battery can be fast charged in 5 hours (0.4C5 A for 2.5 hours followed by 0.2C5 A for 2.5 hours) however fast charging rate shall be as per battery manufacturer's recommendation.

2.6 Suitable electrical interlock shall be provided in the charger to ensure that boost charging can commence only after the relevant load isolating breaker in the DCDB is open. This ensures availability of both redundant feeders to the loads when any charger is isolated from the system for boost charging. However, in case of failure of any charger, the other charger shall feed both sections of DCDB and provide trickle charging to both sets of battery.

3.0 GENERAL DESCRIPTION

3.1 Batteries shall be of high discharge Vented Nickel-Cadmium pocket plate type conforming to IS-10918/ IEC 60623.

3.2 All the terminals and inter-cell connectors will be fully insulated or shrouded.

3.3 Each battery is provided with one number Float-Cum-Boost Charger (FCB). The chargers will be rated based on the following considerations:

Each battery charger will be able to supply the load current while float charging both batteries sets.

3.4 The rectifier assembly shall be full wave bridge type and designed to meet the duty as required by the respective Charger. The rectifier cells shall be provided with their own heat dissipation arrangement with natural air cooling for up to 400A rating chargers. However, the rectifier cells shall be provided with their own heat dissipation arrangement along with forced air cooling for above 400A rating chargers and fan shall be temperature controlled with 100% standby redundancy. The rectifier shall utilise diodes/ thyristors and heat sinks rated to carry 200% of the load current continuously and the temperature of the heat sink shall not be permitted to exceed 85℃ absolute duly considering the maximum charger panel inside temperature. Self-regulating solid-state silicon-controlled, full wave rectifier type designed for single and parallel operation with battery and shall be provided with automatic voltage regulator for close voltage stability even when ac supply voltage and dc load fluctuate. Effective current limiting feature and filters on both input and output to minimise harmonics shall be provided. Ripple content shall be limited to ±1% peak to peak at 0-100% of DC load. The charger output regulation shall be ± 1% from no load to full load with an input power supply voltage & frequency variation on feeding system for +/-10% input supply variation and 0-100% DC load.

Further 4-20mA signals to DDCMIS shall be provided for important parameters like charger O/P voltage, current, battery voltage etc. Charger panels shall also be provided with charger I/P & O/P Voltmeter, Ammeter, battery Voltmeter & Ammeter.

3.5 Suitable annunciation in DDCMIS shall be provided like charger trouble, battery on boost mode etc.

3.6 Technical parameters of charger panels:

1	Mode of Charging	Float cum Boost Charger (Automatic and Manual Mode)
2	Charger Ambient Temp	50 deg C
3	Voltage Rating	220V
4	Trickle Charging	1.4-1.42V per cell (Ni-Cd)
5	Boost Charging Mode	1.53-1.7V per cell (Ni-Cd)
	Automatic Voltage regulator (Trickle Mode)	± 1% at 415 ± 10% and 0-100% Load, Automatic Controlled Feedback-Closed Loop
a	Load Limiter current setting Range(Trickle Mode)	80%-100%
b	% Stabilization of the output DC voltage	1% for ±10% input supply variation and 0-100% DC load
c.	Voltage Range and Stabilizing time for momentary load changes from 20%-100% and Vice versa	+/-6 % and less than 2 secs
d.	Stabilizing time	Less than 15 secs
4	Current setting range in Boost Charging Mode	50-100% of rated output current
5	Voltage limit setting range in Boost Charging Mode	Boost charging limit
6	Rectifier Type	Full wave bridge Type
7	Ripple Content	1% Peak-Peak at 0-100% of DC Load
8	Rectifier Transformer	Dry and Air Cooled (AN) type Class-F Insulation with temp rise limited to Class-B at 50deg C Ambient
9	Charger Enclosure	IP42

3.7 Following protections are provided for batteries and chargers:

- Fuse for short circuit protection of the battery.
- Earth fault protection for DC system
- Current limiting and AC under voltage protection for chargers.
- Under voltage & over voltage for DC system.

3.8 Necessary accessories i.e. cells, inter cell connectors (fully insulated / shrouded) etc. will be supplied alongwith each battery.

4.0 DC DISTRIBUTION BOARD (DCDB)

The DCDB 1x100% shall be fixed type of metal enclosed, indoor floor mounted and free-standing type.

5.0 LAYOUT CONSIDERATIONS

The Battery will be located in battery rooms on steel rack with alkali-resistance for Ni-Cd battery. Chargers / DCDB will be located in separate room. Batteries having cell weight of 50kg or more will be arranged in single tier. No lighting fixtures, conduit run, ventilation duct, pipe hangers will be located directly above the battery bank.

6.0 ACCESSORIES

Following set of accessories shall be provided for each battery bank:

S no	Name of accessory	QTY (in Nos.)
1	Hydrometer	2
2	Set of hydrometer syringes suitable for the vent holes in different cells	2
3	Thermometer for measuring electrolyte temperature	5
4	Wall mounting type holder for hydrometer and thermometer	2
5	Cell testing digital voltmeter (3-0-3V) with testing leads	2
6	Rubber apron	2
7	Pair of rubber hand gloves	2
8	Set of spanners	2
9	`No smoking' notice	2
10	Goggles (industrial)	2
11	Instruction card	10
12	Minimum and maximum temperature indicator for each Battery Room	1
13	Acid / alkali mixing jar	1

6.1 One set of variable metallic resistor and shunt for each battery rating and location, suitable for carrying out the discharge test on the batteries shall also be supplied.
In view of this following discharge resisters will be supplied by BHEL.
1. For CHP/AHP/LHP Area - 1 No.

7.0 220V BATTERY SIZING CALCULATION

Input Data:

Battery type	:	Ni-Cd High Discharge
Design ambient temp.	:	50°C
Provision of voltage drop (From Battery/charger to load)	:	6.8V (Maximum) for Ni-Cd(refer clause 7.2)
Min. electrolyte temp. `t'	:	5.0° C
Ageing Factor	:	1.25
Load details as per duty cycle	:	(Refer load data & duty cycle enclosed)
Total emergency duration	:	60 minutes
Nominal voltage	:	220V
Min. System voltage [Permissible at consumer end]		187V
Max. System voltage [Permissible at consumer end]	:	242V
Nominal float voltage per cell	:	1.42V/cell for Ni-Cd
End Cell voltage	:	1.14V/cell for Ni-Cd

7.1 Calculations for Lead-Acid Battery Plante:

Not applicable as NI-Cd considered.

7.2 Calculations of no. of cell for Ni-Cd Battery High Discharge:

No. of cells = Max dc Voltage/ Nominal float voltage per cell
= 242 / 1.42
= 170.42

No. of cells selected= 170

End voltage of battery = 170 x 1.14 V

= 193.8 V

Permissible voltage drops (from battery to load) = (193.8 – 187) V = 6.8 V (approx.)

Note:

1) ***AH sizing calculation of battery is vendor dependent and hence, final sizing shall be furnished during detailed engineering after finalization of vendor through ordering process. Vendor which will be finalized during detailed engineering, AH capacity of the same vendor will be taken as final. AH capacity calculation will be done on the basis of Load-Duty cycle & design factors given in this document.***

8.0 FCB CHARGER SIZING

8.1 FCB Charger Sizing in case of Lead Acid Plante Battery:

Not applicable as Ni-Cd considered

8.2 FCB Charger Sizing in case of Ni-Cd High Discharge Battery:

Float Mode:

In float mode the charger will be capable of meeting the following float requirements:
a) Trickle charging of the two-battery bank
b) Continuous load current

a) Trickle charging current considered
@ 1.1 mA per AH* = AH capacity of battery X (1.1×10^{-3})
*Trickle charging of battery shall be as per battery OEM recommendation.

b) Continuous load current = 83 A
(Refer load data enclosed)

Float Rating shall be sum of the three aforesaid criteria.

Boost Mode:

In boost mode the charger will be capable of boost charging a fully discharged battery in 7 to 8 hours with the respective battery isolated from DCDB.

Rating for boost mode = 20% of AH capacity of the selected battery

Considering the higher of the required rating float and boost mode, the required Float cum boost charger rating shall be selected.

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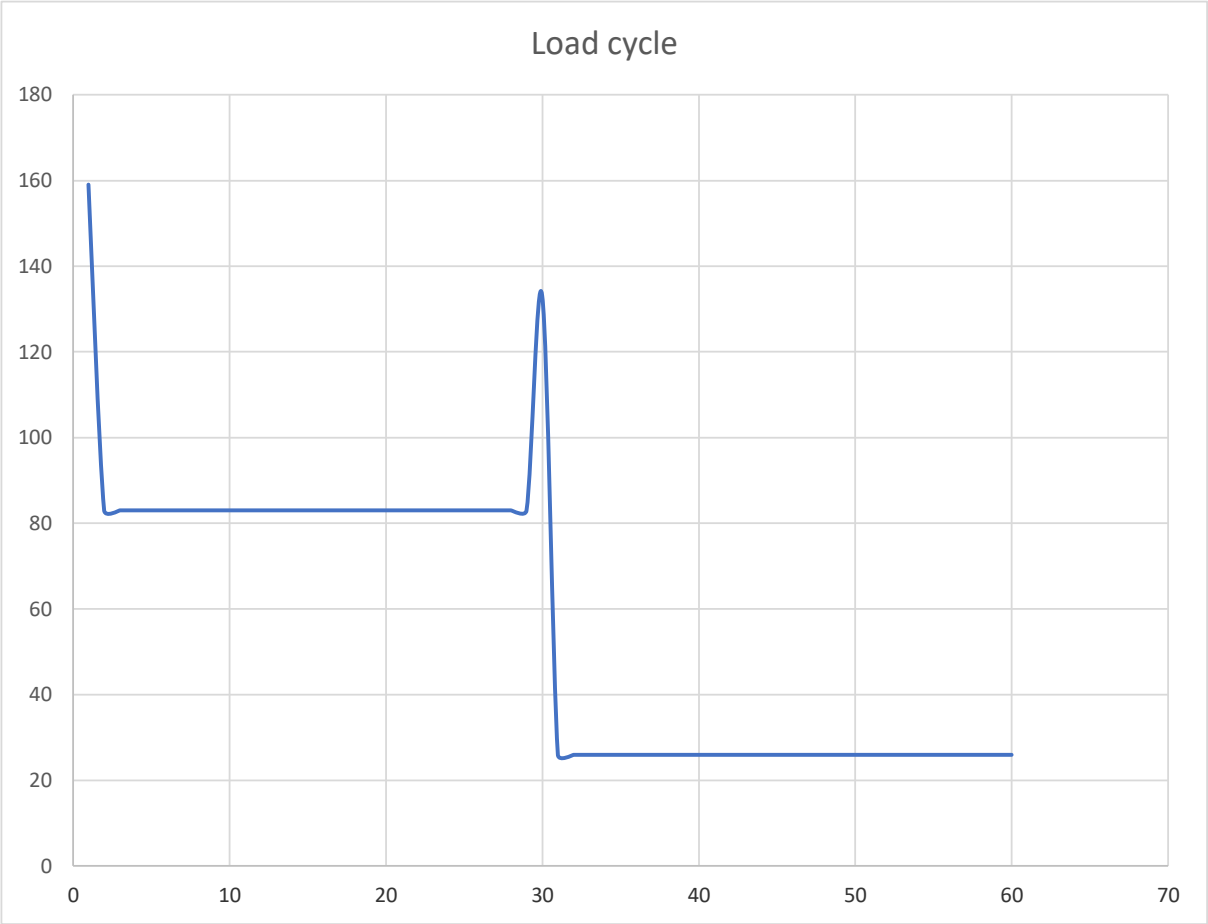
10 *220DC LOAD DATA FOR BATTERY OF COMBINED CHP/AHP/LHP SYSTEM*



FACTORS TO BE CONSIDERED FOR BATTERY SIZING:

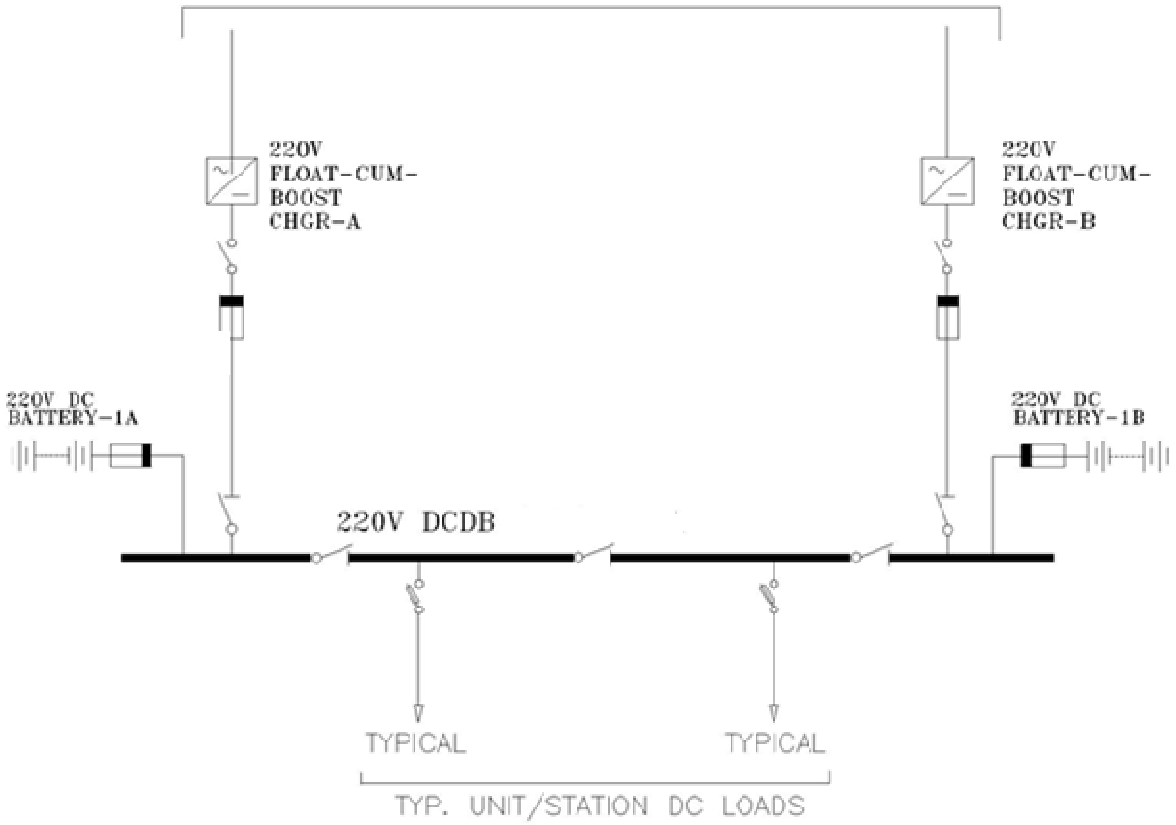
1. AGEING FACTOR : 1.25
2. Design Margin : 1.2
3. MIN.ELECTROLYTIC TEMP. : 5 °C
4. END CELL VOLTAGE : 1.14V (for Ni-Cd) PER CELL
5. TEMPERATURE CORRECTION FACTOR: As per manufacturer's data

Note:

1. **The minimum Battery Bank Rating shall be 90AH for NI-CD High Discharge (KPH) type batteries. Above load is tentative, actual load data shall be submitted as final load list.**

2. **One common 220V DC System along with DCDB shall be located in CHP MCC room and other distributed loads shall be fed from DCFB located at respective MCC rooms of AHP and LHP system.**

11. *ONE LINE DIAGRAM FOR COMMON 220V DC SYSTEM FOR CHP/AHP/LHP SYSTEM*



Coal to 2000 TPD Ammonium Nitrate, LSTK-1

Design Calculations For
LV Cable Sizing & Selection

BHARAT HEAVY ELECTRICALS LIMITED
INDUSTRIAL SYSTEM GROUP
BANGALORE-12

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1	DESIGN CALCULATIONS	13
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1.0 CONTENTS

This document covers the following:

(a) Scope
(b) Type of cables selected
(c) Basis for design calculations for cable sizing
(d) Sample calculations
(f) Cable Data (ANNEXURE-A)

2.0 SCOPE

2.1 The following is included in the document:

(a) Selection and sizing calculations for Power cables for 415V AC, 240V AC and 220V DC system.
(b) Selection criteria for Control cables required for the interconnection of electrical equipment.
(c) Constructional details of LT Power, LT Control & Screened control cables.

2.3 All cables covered in this document are armoured cables.

3.0 CONSTRUCTIONAL DETAILS OF CABLES SELECTED

3.1

(A) **LT POWER & CONTROL CABLES**

S.NO.	PARTICULARS	DETAILS	
		LT POWER CABLES	LT CONTROL CABLES
1	**REFERENCE STANDARD**	IS: 7098 -PART -1	IS -1554 PART -1
2	**SYSTEM**	415 V AC , 240 V AC & BCGCL DC	220V DC & 230/110 V AC
3	**VOLTAGE GRADE**	1.1 KV	1.1 KV
4	**CONDUCTOR**		
4.1	MATERIAL	STRANDED COMPACTED PLAIN ALUMINIUM CONDUCTOR OF H2 GRADE CLASS 2 / STRANDED HIGH CONDUCTIVITY ANNEALED PLAIN COPPER.	STRANDED,NON COMPACTED, HIGH CONDUCTIVITY ANNEALED PLAIN COPPER
4.2	REFERENCE STANDARD	IS 8130	IS 8130
4.3	SHAPE	CIRCULAR/ SHAPED	CIRCULAR
4.4	MINIMUM SIZE	ALUMUNIUM- 10 SQ.MM. COPPER- 2.5 SQ. MM.	1.5 SQ.MM.
4.5	MAXIMUM CONDUCTOR TEMPERATURE WHEN CARRYING CONTINUOSLY CURRENT	90°C	70°C
4.6	MAXIMUM CONDUCTOR TEMPERATURE AT THE TERMINATION OF SHORT CIRCUIT CURRENT	250°C	160°C
5	**NO. OF CORES**	1C,2C,3C,3.5C,4C	AS PER CLAUSE 4.2.1
6	**INSULATION**	EXTRUDED XLPE	EXTRUDED PVC, TYPE-A
6.1	REFERENCE STANDARD	IS: 7098 -PART -1	IS -5831 & IS-1554 PART-I
7	**CORE IDENTIFICATION**	BY COLOR CODING AS PER IS: 7098 -PART -1	i) CONTROL CABLES UPTO 5 CORE- COLOR CODING AS PER IS 1554 (Part-1) (ii) CONTROL CABLES ABOVE 5 CORES- BY NUMBERING AS PER IS 1554 (Part-1). INSULATION TO HAVE BLACK COLOR.
8	**INNER SHEATH**	EXTRUDED HRPVC TYPE -ST2 FOR MULTI CORE CABLES. SINGLE CORE SHALL HAVE NO INNER SHEATH.	EXTRUDED PVC TYPE -ST1 FOR MULTI CORE CABLES.
8.1	REFERENCE STANDARD	IS: 5831 & IS-7098 PART-I	IS: 5831 & IS-1554 PART I
8.2	COLOUR	BLACK	
9	**ARMOUR**	NON-MAGNETIC HARD DRAWN ALUMINIUM ROUND WIRE ARMOUR OF H4 GRADE FOR SINGLE CORE CABLES AND GS ROUND / FORMED WIRE ARMOUR FOR MUTI- CORE CABLES	GS ROUND / FORMED WIRE ARMOUR FOR MUTI- CORE CABLES
9.1	REFERENCE STANDARD	IS:3975 & IS 7098 PART I	IS 3975 & IS-1554 PART I
10	**OUTER SHEATH**	EXTRUDED FRLS HRPVC TYPE ST2	EXTRUDED FRLS PVC TYPE ST1
10.1	REFERENCE STANDARD	IS: 5831 & IS-7098 PART-I	IS: 5831 & IS-1554 PART I
10.2	COLOUR	BLACK	GREY
11	**RODENT AND TERMITE REPULSION TEST**	The test shall be carried out to note the presence of rodent and termite repelling chemical in PVC compound. Normal procedure is that a few chippings of the PVC compound are slowly ignited in a porcelain dish or crucible in a muffle furnace at about 600°C. The resulting ignited ash is boiled with a little ammonium acetate solution (10%). A drop of aqueous sodium sulphide solution is placed on a thick filter paper and it is allowed to soak. The spot is touched with a drop of above extract. A black spot indicates the presence of anti-termite & rodent compound.	
12	**MARKING**	(i) CABLE SIZE (CROSS SECTION AREA AND NO. OF CORES, VOLTAGE GRADE, WORD 'FRLS', REF. IS, TYPE OF CABLE, TYPE OF INSULATION/ SHEATH, MANUFACTURER'S NAME AND/OR TRADE NAME, YEAR OF MANUFACTURE- AT EVERY 5M (BY EMBOSSING), 'BHEL-ISG' and 'CUSTOMER' Name @5m (by embossing), (ii) PROGRESSIVE SEQUENTIAL MARKING OF LENGTH OF CABLE IN METERS- AT EVERY 1M (BY PRINTING)	
13	**CABLE DRUMS**		
13.1	TYPE OF DRUM	WOODEN DRUM	
13.2	STANDARD DRUM LENGTH	500M / 600M / 750M / 1000M (±) 5% (AS SPECIFIED IN BOQ) For each individual cable size, one short length of not less than 250m may be accepted only in the final drum length to complete the supply	

13.3	CONTRUCTION	CABLES SHALL BE SUPPLIED IN WOODEN DRUMS AS PER RELAVENT IS. THE DRUM SHALL BE DESIGNED ON THE BASIS OF WEIGHT, DIAMETER, BENDING RADIUS AND LENGTH OF CABLE. 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. DRUM NUMBER SHALL BE INDICATED ON EACH DRUM.
13.5	PARTICULAR INFORMATION ON DRUM	THE CABLE DRUMS SHALL CARRY THE FOLLOWING DETAILS IN PRINTED FORM: A) BCGCL/ISG B) MANUFACTURER'S NAME OR TRADE MAKE C) TYPE OF CABLE & VOLTAGE GRADE D) YEAR OF MANUFACTURE E) TYPE OF INSULATION E.G. XLPE/HRPVC/IE2 F) NO. OF CORE AND SIZES OF CABLES G) CABLE CODE E.G. FRLS/FS H) SINGLE LENGTH OF CABLE ON DRUM I) DIRECTION OF ROTATION, BY ARROW J) APPROX GROSS MASS

(B) INSTRUMENTATION CABLES (AS PER VDE STANDARD)

S.NO.	PARTICULARS	DETAILS
1.0	**VOLTAGE GRADE**	225 V (Peak)
2.0	**Type of cable**	FRLS SCREENED CONTROL CABLES (F & G TYPE INSTRUMENTATION CABLES)
3.0	**Standards Applicable**	
3.1	VDE 0815, VDE 0816, VDE 0472	General Construction & tests for cables.
3.2	VDE 0207, Part-4, Part-5, Part-6	For insulation thickness.
3.3	SEN-SS-424-1475, IEC-60332 Part-3 Cat-B	Flammability Tests
3.4	ASTMD-2843, ASTMD-2863, IEC-754 Part-1	FRLS Tests
4.0	**CONDUCTOR**	
4.1	Material	Annealed bare copper
4.2	Grade	Electrolytic
4.3	Standard applicable	VDE 0815
4.4	Min number of strands, Dia and cross sectional area	7, 0.3 mm (nom), 0.5 sq.mm
4.5	No. of pairs	2/4/8/12/16/24 / 48
4.6	Max. conductor loop resistance per Km (in ohm) at 20 deg. C	73.4
5.0	**INSULATION**	
5.1	Material	Extruded PVC as per VDE 0207 Part 4, compound Y I3
5.2	Application	Extruded
5.3	Insulation thickness Min / Max	0.25/ 0.35 (for 0.5 sq mm)
5.4	Volume resistivity (Min) in ohm-cm	1x 10^{14} at 20 deg .C & 1x 10^{11} at 70 deg. C
6.0	**PAIRING & TWISTING**	
6.1	Whether cores are twisted	YES
6.2	Min. number of twist per Metre for paired cables.	20 (For 0.5 Sqmm)
6.3	Maximum lay of individual twisted pair	50 mm (For 0.5 Sqmm)
6.4	Core identification	Core & pair identification by suitable colour coding & band marking as well as numbering of cores/ paires as per VDE 0815
6.5	Single Layer of Binder Tape on each pair is provided	YES
6.6	Unit Formation of four pair polyester binder tape for cables more than 4P is provided	YES
7.0	**IDENTIFICATION OF CORES**	Band marking
8.0	**INDIVIDUALLY & OVERALL SCREENED (F TYPE CABLE)**	
8.1	Material	Aluminium-Mylar tape
8.2	Coverage	100%
8.3	Overlap	Minimum 20%
8.4	Min thickness (Micron)	28
8.5	Binder	Polyester tape
9.0	**OVERALL SCREENED (G TYPE CABLE)**	
9.1	Material	Aluminium-Mylar tape
9.2	Coverage	100%
9.3	Overlap	Minimum 20%
9.4	Min thickness (Micron)	55
9.5	Binder	Polyester tape
10.0	**DRAIN WIRE (To be provided separately for individual pair shield and overall shield)**	
10.1	Material	Annealed Tin coated copper conductor as per VDE: 0815
10.2	Min number of strands, Dia and cross sectional area	7, 0.3 mm (nom), 0.5 sq.mm
11.0	**ACCESSORIES (BEDDING, BINDER, TAPE REQ.)**	
10.1	Material	Mylar Tape
12.0	**INNER SHEATH**	
12.1	Material	Extruded PVC (compound YM1) as per VDE 0207 Part-5
12.2	Thickness (Min)	0.3mm
12.3	Whether FRLS	NO
12.4	Fillers	Acceptable

12.5	Material of fillers	Same as inner sheath (With moisture resistant properties & Flame retardant- as applicable)	
12.6	Method of application	Pressure / Vacuum extruded	
13.0	**ARMOUR**		
13.1	Material	Galvanized round steel wire / Formed wire as per IS-3975 & IS-1554 Part-I	
13.2	Minimum coverage	90%	
13.3	Breaking load of joints	95% of normal armour	
13.4	Method of jointing	Welding	
14.0	**OUTER SHEATH**		
14.1	Material	Extruded PVC (compound YM1) with FRLS properties as per VDE 0207 Part-5	
14.2	Thickness	As per VDE 0816 and VDE207 Part-5	
14.3	Minimum & Nominal Thickness at any point	1.8 mm and >1.8 mm respectively, as per IS-1554-I	
14.4	Application	Extruded	
14.5	Colour	Blue for IS ,Black for NIS	
14.6	Whether FRLS	YES	
14.7	Other	Resistant to water, Fungus, Termite & rodent attack.	
14.8	Fillers	Acceptable	
14.9	Material of fillers	Same as inner sheath (With moisture resistant properties & Flame retardant- as applicable)	
15.0	**FRLS/ FLAMMABILITY TESTS**		
15.1	Oxygen Index	29% Minimum as per ASTMD 2863	
15.2	Temperature Index	250℃ Minimum as per ASTMD 2863	
15.3	Acid gas generation	less than 20% by weight (As per IEC-754-1)	
15.4	Smoke density rating	Not more that 60% (As per ASTMD 2843) Defined as average area under curve when the results of smoke density plotted on a curve indicating light absorption v/s time as ASTMD 2843	
15.5	Flammability Test	IEEE-383	
15.6	Swedish Chimney test on complete cable assembly	As SEN-SS-424-1475 Class F3	
16.0	**TOLERANCE ON OVERALL DIAMETER**	±2mm max over the declared value in Technical Data Sheet	
17.0	**VARIATION IN DIA**	Not more than 1.0 mm throughout the length of cable.	
18.0	**CABLE DRUM DETAILS**		
18.1	Material Type & Construction	Non-returnable wooden drum	
18.2	Standard drum length	1000 m: up to & including 12 pairs 500 m: above12 pairs For each individual cable size, one short length of not less than 250m may be accepted only in the final drum length to complete the supply	
18.3	Tolerance on drum length	±5%	
18.4	Painting	Entire surface to be painted	
18.5	Outermost Layer	To be covered with waterproof Cover	
19.0	**RIP CORD**	A non-hygroscopic and non-wicking non metallic cord polyethylene	
20.0	**Markings on Outer Sheath**		
20.1	Progressive sequential length marking to be provided	@ 1M by Printing	
20.2	Progressive marking @ 5M	Manufacturer's name, type of insulation, FRLS, conductor size, no. of pairs, voltage grade, type of cable, year of manufacture, BHEL-ISG by Embossing	
21.0	**TECHNICAL PARAMETERS (C & I)**	As per Table below	
	STANDARD CABLE PARAMETERS FOR INSTRUMENTATION CABLE Cable parameters indicated below are at 20 degC (+/- 3 degC)		
	Parameter	0.5 mm2 (I & OS) type-F	0.5 mm2 (OS) type-G
21.1	Mutual Capacitance (max.)at 0.8 kHz, nF/Km	120	100
21.2	Conductor Loop Resistance (max.), Ohm/Km	73.4 (Plain)	73.4 (Plain)
21.3	Insulation Resistance (min), M Ohm/ Km	100	100
21.4	Cross Talk Figure (min) at 0.8kHz, dB	60	60
21.5	Characteristic impedance(max.) at 1 kHz	320	340
21.6	Attenuation(max.) at 1 kHz db/Km	1.2	1.2
22.0	**TEST VOLTAGE**		
22.1	High voltage test	Core – Core: 2kV RMS for 1 min	Core- shield: 0.5kV RMS for 1 min
23.0	**Continuous operation suitability**	70 deg. C	

3.2 Standards applicable:

a)	IS:7098 Part-1	Specification for Cross Linked Polyethylene Insulated PVC Sheathed Cables (for working voltages up to and including 1100 V).
b)	IS:1554 Part-1	Specification for PVC insulated (Heavy duty) Electric cables (for working voltages up to and including 1100 V).
c)	IS: 3961 Part-6	Recommended current rating for cables (Crosslinked Polyethylene Insulated PVC Sheathed Cable)
d)	IS: 5831	Specification for PVC insulation and sheath of electric cables.

e)	IS: 8130	Specification for conductors for insulated electric cables and flexible cord.
f)	IS:10418	Cable drum
g)	IS: 3975	Low carbon galvanized steel wires, formed wires and tapes for armouring of cables.

4.0 BASIS FOR DESIGN CALCULATIONS FOR CABLE SIZING

4.1 DESIGN CONSIDERATIONS: POWER CABLES

4.1.1 In general, Power Cables are sized to satisfy the following three criteria:

(a) Short circuit current withstand capacity for applicable fault current and duration.

(b) Full load current carrying capacity under installation conditions (i.e. with suitable derating factors to cover site conditions such as ambient and ground temperatures, grouping and soil resistivity and cable laying configuration).

(c) Maximum voltage drop within permissible limits under steady state/transient state as applicable.

NOTE

4.1.2 The normal current ratings for the feeders are considered as under:

(a) 415 V incomers to MCCs

The cable sizes of Incomer to MCCs are selected presently based on maximun continous rating i.e. 90% of of the switchboard / MCC / ACDB ratings.

Power factor for 415 V supply feeders are considered as below :

Cosϕ=	0.8
Sinϕ=	0.6

* Neutral cable size shall be sized corresponding to half of uprated load current.

(b) 415 V Supply feeders:

Cable sizie shall be selected based on Rated current of the equipment

Power factor for 415 V supply feeders are considered as below :

Cosϕ=	0.8
Sinϕ=	0.6

* Neutral cable size shall be sized corresponding to half of uprated load current.

(c) 415 V Motor feeders:

Normal current ratings for motor feeders are taken as the full load current corresponding to the highest rated motor of the group. Efficiency of the motor and the starting current for transient voltage drop consideration,is taken as per IS 12615 TABLE 2 for IE3 motors.

Power factor for 415 V motors under steady state conditions are considered as below :	0.80
Under transient conditions,	
Cosϕ=	0.3
Sinϕ=	0.95

(d) 240 V AC feeders:

Cable sizing is done on the basis of standard ratings / actual load current.

(e) 220 V DC feeders:

Cable sizing is done on the basis of standard ratings / actual load current.

(f) Voltage drop limits considered are as under:

i)	415 V AC Supply Feeders	
-	Steady State (continuous running condition)	5 %
ii)	415 V AC Motor Feeders	
-	Steady State (continuous running condition)	5 %
-	Transient State (during motor starting condition)	10 %
iii)	240 V AC Supply Feeders	10 V
iv)	220 V DC Feeders (Nickel-cadmium)	
-	Battery to DCDB	4.4 V
-	Charger to DCDB	4.4 V
-	DCDB to loads/Motors	11.0 V

4.2 DESIGN CONSIDERATIONS: CONTROL CABLES

4.2.1 Standard control cable sizes are selected. The following considerations are applicable to the selection of these cables:

Control cables are of 1.5 mm2. cross-section, and with up to 24 cores.

4.2.2 Minimum no. of spare cores in control cables shall be as follows:

No. of cores in cable	No. of spare cores (minimum)
2C, 3C	NIL
5C	1
7C- 14C	2
ABOVE 14C	3

4.2.3 Min Cable size for motor space heater shall be 2C-2.5mm^2 or shall be based on actual voltage drop criteria.

4.2.4 Interconnections for Current Transformer terminals shall use two cores of 2.5mm2size per phase

4.3 DESIGN INPUT DATA

The following data is used as the basis input data for sizing & selection of cables.

(a) Design ambient temperature: 50 ℃

(b) Fault current for 415V systems: 50 kA RMS
Fault current for 220V DC systems: 10 kA

(c) Main protection faut clearing time for cables to the feeders protected by breakers 0.12 sec. (min)

(d) **Annexure-A: Cable Data**

- Current ratings (AC/DC)-IS-3961 PART 6

Table-No.	Description	Sht No.
Table-1	Current ratings (a.c) for two single core cable with XLPE insulation and rated voltage 1100V (Clause 3.1)	15 of 46
Table-2	Current ratings (a.c) for three single core cable with XLPE insulation and rated voltage 1100V (Clause 3.1)	16 of 46
Table-3	Current ratings (a.c) for two core cables with XLPE insulation and rated voltage 1100V (Clause 3.1)	16 of 46
Table-4	Current ratings (a.c) for three, four & five core cables with XLPE insulation and rated voltage 1100V (Clause 3.1)	17 of 46
Table-5	Current ratings (d.c) for two single core cables with XLPE insulation and rated voltage 1100V (Clause 3.1)	17 of 46
Table-6	Current ratings (d.c) for two core cables with XLPE insulation and rated voltage 1100V (Clause 3.1)	18 of 46

- Derating factors for installation conditions-IS-3961 PART 6

Table-7	Rating factors for variation in ambient air temperature for cables in free air.	18 of 46
Table-8	Rating factors for variation in ground temperature for directly burried cables.	18 of 46
Table-10	Rating factors for depths of lying for direct burried cable	19 OF 46
Table-14	Rating factors for variation in soil thermal resistivity for three single core cables laid direct in ground.	20 OF 46
Table-16	Rating factors for variation in soil thermal resistivity for multicore cables laid direct in the ground.	21-22 OF 46
Table-19	Group rating factors to be applied for circuits of three single core cables laid direct in the ground, horizontal formation	23 OF 46
Table-22	Group rating factors for multi core cables laid direct in the ground, horizontal formation.	24 OF 46
Table-26	Group rating factors for multi-core cables in air on ladder supports, cleats etc.	25 OF 46
Table-28	Group rating factors to be applied for circuits of three single core cables in air on perforated trays & ladder supports in trefoil formation.	26 OF 46
Table-58 (C)-UCL	Group rating factors for single core cables laid in trefoil formation, trefoil separated by 2 cable dia.(Cable laid in trenches in touching formation).	27 OF 46
Table-UCL	Group rating factors for multi core cableslaid in restricted air circulation conditions (Cable laid in trenches in touching formation).	28 OF 46

Derating factors for installation conditions- CABLE CATALOGUE OF UNIVERSAL CABLES LTD.

Table-49	Rating factors for variation in ground temperature for cables laid directly in the ground.	40 OF 46
Table-51	Rating factors for variation in ambient air temperature.	41 OF 46
Table-52	Rating factors for variation in thermal resistivity of soil for three single core cables laid direct in ground in trefoil touching.	42 OF 46
Table-54	Rating factors for variation in thermal resistivity of soil for twin & multicore cables laid direct in the ground.	43 OF 46
Table-56	Rating factors for variation in depth of laying for cable laid direct in ground.	44 OF 46
Table-58	Group rating factors for single core cables laid in trefoil formation.	45 OF 46
Table-59	Group rating factors for multi core cables	46 OF 46

Resistance & Reactances- CABLE CATALOGUE OF UNIVERSAL CABLES LTD.

Table-62	Approximate AC resistance of conductor (Ohm/ km) at maximum operating conductor temperature PVC, HR PVC and XLPE cables.	29 OF 46
Table-63	Approximate reactance of conductor at 50 Hz (Ohm/ km) 1.1 kV PVC, HR PVC and XLPE cables.	30 OF 46
Table- DC RESISTANCE	TABLE-2- IS 830	31 OF 46

4.3.1 DESIGN INPUTS FOR CABLE SIZING FOR 415 V SYSTEM

(A) MINIMUM SIZE FOR SHORT CIRCUIT CURRENT WITHSTAND CAPACITY-CIRCUIT BREAKER PROTECTED FEEDERS

(i). (a) Outgoing supply feeders from 415V AC boards to MCC (Circuit breaker protected) FOR XLPE CABLES

Minimum cross-sectional area of cable 'A' to withstand	= **Ish.SQRT(t) / k**	
where		
Fault current I_{sh} =	=	50 kA(rms)
Fault clearing time t =	=	0.12 sec(min)
k is a constant (for Al. conductor XLPE insulation)	=	0.0943
Therefore, cross-sectional area (A) =	=	183.6745289 mm^2
So Nearest standard cable conductor size selected for aluminium conductor XLPE insulation=	**=**	**185 mm^2**

(ii). (a) Motor feeders (Circuit breaker protected) FOR XLPE CABLES

Minimum cross-sectional area of cable 'A' to withstand	= **Ish.SQRT(t) / k**	
Fault current I_{sh} =	=	50 kA RMS
Fault clearing time t =	=	0.12 sec(min)
k is a constant (for Al. conductor XLPE insulation)	=	0.0943
Therefore, cross-sectional area (A) =	=	183.675 mm^2
So Nearest standard cable conductor size selected for aluminium conductor XLPE insulation=	**=**	**185 mm^2**

(iii) FUSE/ MCCB PROTECTED FEEDERS

For Fuse/ MCCB protected feeders, minimum cable size of 2.5 sq. mm. (Copper) or 10 sq. mm. (Aluminium) is taken.

(B) CABLE SIZES BASED ON LOAD CURRENT CARRYING CAPACITY : DERATING FACTORS

Cables are rated for laying in the following conditions:

(i) **Cables in air**

Cables are laid in cable trays in ventilated cable vaults and outdoor overhead pipe -cum cable trestles.
Derating factors for cables in air are listed below:

(1) Temperature derating factor

For 50℃ ambient temperature & maximum conductor temperature of 90℃,derating factor (K_1) for XLPE cables (refer Table-7, Sht 18 of 46)= 0.89

(2) Group derating factor (K_8) FOR XLPE CABLES

No. of cores	Arrangement of cables	K8	Table ref.	Sht No.
Single core	3 Trays & 3 no. of trefoils per tray, separated by 2 cable dia	0.9	Table-28	26 OF 46
Multi core	3 Trays & 9 no. of cables per tray in air, touching each other	0.7	Table-26	25 OF 46

(3) Overall derating factor (K)

$K = K_1 \times K_8$ (XLPE)

For XLPE, single core LT cables (K_{Lasx}) = 0.80

For XLPE, multi core LT cables (K_{Lamx}) = 0.62

(ii) **Cables laid directly in ground**

Such cables as may be required to be buried directly in ground to meet statutory requirements (e.g. for fire fighting system equipment etc.). Derating factors for cables laid in ground are listed below:

(1) Temperature derating factor

For 40℃ ground temperature & maximum conductor temperature of 90℃,derating factor (K_3) for XLPE cables (refer Table-8, Sht 18 of 46) = 0.91

For 40℃ ground temperature & maximum conductor temperature of 70℃,derating factor (K_{3P}) for PVC cables (refer Table-49, Sht 40 of 46) = 0.87

(2) Group derating factor (K_4) FOR XLPE CABLES

No. of cores	Arrangement of cables	K4	Table ref.	Sht No.
Single core	3 no. of trefoils in horizontal formation (touching)	0.67	Table-19	23 of 46
Multi core	3 no. cables in horizontal formation (touching)	0.68	Table-22	24 of 46

(3) Derating factor for variation in thermal resistivity of soil (150 deg. C/cm/W) (K11)= 1

(FOR XLPE CABLES-refer Tables-14 & 16, sht 20-22 of 46) & (FOR PVC CABLES-refer Tables-52 & 54, sht 42-43 of 46)

(4) Derating factor for depth of laying (K12)= 1
(depth of laying considered=0.75m.)
(FOR XLPE CABLES refer Table-10, sht 19 of 46) & (FOR PVC CABLES refer Table-56, sht 44 of 46)

(5) Overall derating factor K
= K3 x K4 x K11 x K12 (XLPE)
For single core XLPE, LT cables (K_{Lgsx}) = 0.61
For multi core XLPE, LT cables (K_{Lgmx}) = 0.62

(iii) **Cables in covered trench with restricted air circulation.**

Restricted air circulation conditions (cables laid in cable trays in cable trenches e.g. in auxiliary plant areas). Derating factors for cables in covered trench with restricted air circulation are listed below:

(1) Temperature derating factor
For 50℃ ambient temperature & maximum conductor temperature of 90℃,derating factor (K_1) for XLPE cables (refer Table-7, sht 18 of 46) = 0.89

(2) Group derating factor (K_4) FOR XLPE

No. of cores	Arrangement of cables	K4	Table ref.	Sht No.
Single core	3 Trays & 3 no. of trefoils per tray, separated by 2 cable dia	0.81	Table-58 (C)-UCL	27 OF 46
Multi core	3 Trays & 9 cables/tray, cables touching	0.6	TABLE-UCL	28 OF 46

(3) Overall derating factor
=K1x K4 (XLPE)
For single core XLPE, LT cables (K_{Ltsx}) = 0.72
For multi core XLPE, LT cables (K_{Ltmx}) = 0.53

(C) CABLE SIZES BASED ON VOLTAGE DROP CRITERIA

Cable size based on voltage drop limits:

The voltage drop for a given cable length under steady state conditions is given by the formula:

Voltage drop in %= $\frac{\sqrt{3} * I * l * (R * Cos\phi + X * Sin\phi)}{V * 1000} * 100$

Where:
I= Full Load current in Amperes for steady state conditions
Starting current for transient conditions (for motor feeders)
l= Feeder length in metres
R= AC Resistance of cable in Ohm/km
X= Reactance of cable in Ohm/km at 50 Hz.

Under starting conditions for LT motors, the voltage drop is also checked with locked rotor current including IS tolerance times the full load current as starting current as per IS 12615 and power factor taken as 0.3.

4.3.2 CABLE SIZING FOR 240 V SUPPLY FEEDER

(A) MINIMUM SIZE FOR SHORT CIRCUIT CURRENT WITHSTAND CAPACITY

(i) FUSE/ MCCB PROTECTED FEEDERS

For Fuse/ MCCB protected feeders, minimum cable size of 2.5 sq. mm. (Copper) or 10 sq. mm. (Aluminium) is taken.

(B) CABLE SIZES BASED ON LOAD CURRENT CARRYING CAPACITY : DERATING FACTORS

Derating factors for 240 V supply feeders are taken same as for 415 V system listed at 4.3.1 (b) above.

(C) CABLE SIZES BASED ON VOLTAGE DROP CRITERIA

The voltage drop for a given cable length under steady state conditions is given by the formula:

Voltage drop in %= $\frac{2 * I * l * R * Cos\phi + X * Sin\phi}{1000}$

Where:

I=	Full Load current in Amperes for steady state conditions
	Starting current for transient conditions (for motor feeders)
l=	Feeder length in metres
R=	AC Resistance of cable in Ohm/km
X=	Reactance of cable in Ohm/km at 50 Hz.

4.3.3 CABLE SIZING FOR 220V DC SYSTEM

(A) MINIMUM SIZE FOR SHORT CIRCUIT CURRENT WITHSTAND CAPACITY

(i) FUSE/ MCCB PROTECTED FEEDERS

For Fuse/ MCCB protected feeders, minimum cable size of 2.5 sq. mm. (Copper) or 10 sq. mm. (Aluminium) is taken.

(B) CABLE SIZES BASED ON LOAD CURRENT CARRYING CAPACITY : DERATING FACTORS

Derating factors for 220 V DC system are taken same as for 415 V system listed at 4.3.1 (b) above.

(C) CABLE SIZES BASED ON VOLTAGE DROP CRITERIA

The voltage drop for a given cable length is given by the formula:

Voltage drop= $\frac{2 * I * l * R * t_{cor}}{1000}$

Where:

I=	Full Load current in Amperes for steady state conditions
l=	Feeder length in metres
R=	DC Resistance of cable at 20 deg C in Ohm/km
tcor=	Temperature Correction factor

4.3.4 CALCULATION OF DC RESISTANCE AT 90°C FROM DC RESISTANCE AT 20°C

R90=R20(1+α(90-20))

Where

α(Cu)=0.00393

α(Al)=0.00403

Sample Calculation of R90 for 50sq. mm.(Al)

R20 for 50 sq. mm.(Al)=0.641 Ω

(Refer ANNEXURE A # Table: DC Resistance)

R90 = R20(1+α(90-20))

= 0.641(1+0.00403*70)

= 0.8218 Ω

5.0 SAMPLE CALCULATIONS

5.1 415 V SUPPLY FEEDERS (LAID IN AIR)

5.1.1 Supply Feeder of standard rating 630 Amp.

(a) Fault Current Criterion

Minimum size = 185 sq. mm.

(b) Load Current Criterion

Corresponding to rating (0.9*630)=	567 A
Overall Derating Factor for XLPE-1-core LT cables laid in air (K_{Lasx})=	0.80
Uprated load current=567/0.8	708.75 A
From Annex.-A,Table-2 (Sht 35 of 67), current rating of 3.5C-240 sq. mm. (Al) Cable in air=	392 A

Hence Cable size for load current 793A is 2-3.5C-240 sq. mm./ph

The neutral cable is sized on the basis of half the uprated load current i.e. 354.4A. Cable size selected for neutral cable is 3.5C-240 sq. mm. (Al).

(c) Voltage Drop Criterion

(i) Steady State Conditions

The voltage drop for a given cable length under steady state conditions is given by the formula: $\frac{\sqrt{3} * I * l * (R * Cos\phi + X * Sin\phi)}{V * 1000} * 100$

where:

Load current (I) in A.=	567 A
Resistance (R) of 240 mm2 conductor at 90 deg. C =	0.161 Ohms/km.
(Refer Table-62, Sht 29 of 46)	
Reactance (X) of 240 mm2 at 90 deg. C with XLPE insulation=	0.0737 Ohms/km.
(Refer Table-63, Sht 30 of 46)	
Cosϕ=	0.8
Sinϕ=	0.6
Feeder length=	50 m.

Voltage drop in % for 2-3.5C-2400 sq. mm. = 1.02 %

Since this voltage drop is less than the permissible limit of 5%, cable size of 2-3.5C-2400 sq. mm./ph is adequate.
or feeder lengths of 100m, 150m & 200m cable sizes selected & their corresponding steady state voltage drop are listed in Table-A.

5.2 415 V AC MOTOR FEEDERS [Cables Laid in Air]

5.2.1 Motors rated from 0.01 kW to 1.1 kW

(a) Fault Current Criterion

Minimum size = 2.5 sq. mm.

(b) Load Current Criterion

Corresponding to rating =	1.1 kW
Full load Current=1.1*1000 /(SQRT(3) * 415*0.8*0.841)=	2.27 A
Overall Derating Factor for XLPE 3-core LT cables laid in air (K_{Lamx})=	0.62
Uprated load current=2.27/0.62=	3.67 A
From Annex.-B, Table-4 (sht 36 of 67), current rating of 3C-2.5 sq. mm. (Cu) Cable in air=	30 A

Hence Cable size for load current of 3.73 A is 3C-2.5 sq. mm.

(c) Voltage Drop Criterion

For motor feeders, the voltage drop is calculated for both steady state (running) conditions, as well as transient state (starting) conditions. The voltage drop is calculated for feeder lengths of 50m, 100m, 150m and 200m. The actual cable size for any load can be chosen after determining it's cabling distance from the feeding switchboard.

(i) Steady State Conditions

The voltage drop for a given cable length under steady state conditions is given by the formula:

$$\frac{\sqrt{3} * I * l * (R * Cos\phi + X * Sin\phi)}{V * 1000} * 100$$

where:

Load current (I) in A.=	2.27 A
Resistance (R) of 2.5 mm2 Cu conductor at 90 deg. C = (Refer Table-62, sht 48 of 67)	9.5 Ohms/km.
Reactance (X) of 2.5 mm2 at 90 deg. C with PVC insulation= (Refer Table-63, sht 49 of 67)	0.0985 Ohms/km.
Cosϕ=	0.8
Sinϕ=	0.6
Feeder length=	50 m.
Voltage drop in % for 3C-2.5 sq. mm. =	0.36 %

Since this voltage drop is less than the permissible limit of 5%, selected cable size is 1 no. 3C-2.5 sq. mm for feeder lengths of 50m.

(ii) Transient State Conditions

The voltage drop for a given cable length under transient state conditions is given by the formula:

$$\frac{\sqrt{3} * I_{st} * l * (R * Cos\phi_t + X * Sin\phi_t)}{V * 1000} X100$$

where:

Starting current (I_{st}) in A.=7.8*I	17.74 A
Resistance (R) of 2.5 mm2 Cu conductor at 90 deg. C = (Refer Table-62, sht 48 of 67)	9.5 Ohms/km.
Reactance (X) of 2.5 mm2 at 90 deg. C with PVC insulation= (Refer Table-63, sht 49 of 67)	0.0985 Ohms/km.
Cosϕ=	0.3
Sinϕ=	0.95
Feeder length=	50 m.
Voltage drop in % for 3C-2.5 sq. mm. for starting current of 17.74 A.=	1.09 %

Since this voltage drop is less than the permissible limit of 10.0%, selected cable size of "1 no. 3C-2.5 sq. mm (Cu)" is adequate for feeder lengths of 50m.

5.2.2 Motors rated from 18.51 kW to 22 kW

(a) Fault Current Criterion

Minimum size = 2.5 sq. mm.

(b) Load Current Criterion

Corresponding to rating =	22 kW
Full load Current=22*1000 /(SQRT(3) * 415*0.8*0.930)=	41.14 A
Overall Derating Factor for XLPE 3-core LT cables laid in air (KLamx)=	0.62
Uprated load current=41.14/0.62=	66.35 A

From Annex.-B, Table-4 (sht 36 of 67), current rating of 3C-16 sq. mm. (Al) Cable in air= 69 A
Hence Cable size for load current= 3C-16 sq. mm.

(c) Voltage Drop Criterion

(i) Steady State Conditions

The voltage drop for a given cable length under steady state conditions is given by the formula:

$$\frac{\sqrt{3} * I * l * (R * Cos\phi + X * Sin\phi)}{V * 1000} * 100$$

where:

Load current (I) in A.=	41.14 A
Resistance (R) of 16 mm2 conductor at 90 deg. C = (Refer Table-62, sht 48 of 67)	2.44 Ohms/km.
Reactance (X) of 16 mm2 at 90 deg. C with XLPE insulation= (Refer Table-63, sht 49 of 67)	0.0808 Ohms/km.
Cosϕ=	0.80
Sinϕ=	0.6
Feeder length=	50 m.
Voltage drop in % for 3C-16 sq. mm. for load current of 41.14A.=	1.72 %

Since this voltage drop is less than the permissible limit of 5%, cable size of 1 no. 3C-16 sq. mm. is adequate for feeder lengths of 50m.

(ii) Transient State Conditions

The voltage drop for a given cable length under transient state conditions is given by the formula:

$$\frac{\sqrt{3} * I_{st} * l * (R * Cos\phi_t + X * Sin\phi_t)}{V * 1000} X100$$

where:

Starting current (I_{st}) in A.=9*I	370.24 A
Resistance (R) of 16 mm2 conductor at 90 deg. C = (Refer Table-62, sht 48 of 67)	2.44 Ohms/km.
Reactance (X) of 16 mm2 at 90 deg. C with XLPE insulation= (Refer Table-63, sht 49 of 67)	0.0808 Ohms/km.
Cosϕ=	0.3
Sinϕ=	0.95
Feeder length=	50 m.
Voltage drop in % for 3C-16 sq. mm. for starting current of 370.24 A.=	6.25 %

Since this voltage drop is less than the permissible limit of 10 %, cable size of one no. 3C-16 sq. mm. is adequate for feeder lengths of 50m.

5.3 240 V AC SUPPLY FEEDERS, LAID IN AIR

5.3.1 Supply Feeder of rating 50 Amp

(a) Fault Current Criteria

Minimum size = 2.5 sq.mm.(Cu)/ 10 sq.mm.(Al)

(b) Load Current Criteria

Rating of feeder	50 A
Overall Derating Factor for XLPE Multi-core LT cables laid in air (K_{Lamx})=	0.62
Uprated load current=50/0.62	80.65 A
From Annex.-B, Table-3 (sht 35 of 67), current rating of 2C-25 sq. mm. (Al) Cable in air=	109 A

Hence cable size for load current of 50 A = 2C-25 sq. mm. (Al)

(c) Voltage Drop Criteria

(i) Steady State Conditions

The voltage drop for a given cable length (in volts) under steady state conditions is given by the formula:

$$\frac{2 * I * l * R * Cos\phi + X * Sin\phi}{1000}$$

where:

Load current (I) in A.=	50 A
Resistance (R) of 25 mm² (Al) conductor at 90 deg. C with XLPE insulation= (Refer Table-62, sht 48 of 67)	1.53 Ohms/km.
Resistance (R) of 25 mm² (Al) conductor at 90 deg. C with XLPE insulation= (Refer Table-63, sht 49 of 67)	0.0805 Ohms/km.
Cosϕ=	0.8
Sinϕ=	0.6
Voltage =	240 V
Feeder length=	50 m
Voltage drop in volts for 2C-25 sq. mm. for load current of 50A=	6.36 V

Since this voltage drop is less than the permissible limit of 10V, cable size of 2C-25 sq. mm. is adequate.
On the basis of above three criterion, cable size of 2C-25 sq. mm. is selected.

5.4 220 V DC SUPPLY FEEDERS (IN AIR)

5.4.1 Supply Feeder for 32 A rating **(for DC battery)**

(a) Fault Current Criterion

Minimum size = 2.5 sq. mm.

(b) Load Current Criterion

Corresponding to actual loading=	32 A
Overall Derating Factor for XLPE 1-core LT cables laid in air (K_{Lasx})=	0.80
Uprated load current=32/0.80	40 A
From Annex.-A, Table-6, current rating of 2C-50 sq. mm. (Al) Cable in air =	162 A

Hence Cable size for load current of 32A is 2C-50 sq. mm.

(c) Voltage Drop Criterion

(i) Steady State Conditions

The voltage drop for a given cable length (in volts) under steady state conditions is given by the formula:

$$\frac{2 * I * l * R * t_{cor}}{1000}$$

where:

Load current (I) in A.=	32 A
Resistance (R) of 50 mm² (Al) conductor at 90 deg. C with XLPE insulation= (Refer Table-DC Resistance)	0.82183 Ohms/km.
Feeder length=	50 m.
Voltage drop in volts for 2C-50 sq. mm. for load current of 32A=	2.63 V

Since this voltage drop is less than the permissible limit of 4.4 volts, cable size of 2C-50 sq. mm (Al)/Pole is adequate for feeder length of 50 m.

On the basis of above three criterion, cable size of 2C-50 sq. mm (Al) is selected.

6.0 Cable sizes finalised for the project are indicated at Annexure-C.

7.0 CONCLUSION

Cables selection is summarized as follows:

a) The minimum conductor size for LT power cables is 2.5 sq. mm with copper conductor & 10 sq. mm with aluminium conductor.

b) All LT power cables shall be XLPE insulated .

c) All LT Power cables upto and including 300 sq. mm. shall be multi core type.

d) All LT power cables of 400 sq. mm & 630 sq. mm shall be single core type

e) Cable sizing is done considering the factors for laying conditions for the longest route of the cable e.g. if majority of the cable route is in trench, then the cable sizing for the feeder is done considering factor for "cables laid in trench" for the entire feeder length.

f) For LT Cable, same cable sizes shall be used for same type & rating of motor i.e. if there are three pumps for one application, all three pump motor shall be provided with same cable size. However for CHP/AHP application, This clause will make cable sizes over designed; viz for CHP/AHP applications where cable lengths are on higher end. Further this may also require PJB's on the motor/panel ends to meet the no. of runs requirement. To avoid this practical issues, cable size arrived as per voltage drop calculation, shall be used for each rating of the motor.

ANNEXURE - A
CABLE DATA

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Overall Cable Diameter	*Inside Duct Diameter*	*Outside Duct Diameter*
mm	mm	mm
(1)	(2)	(3)
Up to and including 65	100	130
Above 65 and up to and including 90	125	160
Above 90 and up to and including 115	150	190

8 CABLES IN AIR

Single core cables are assumed to be spaced at least 0.5 times the cable diameter from any vertical surface and installed on brackets or ladder racks. Multi-core cables installed in air spaced at least 0.3 times the cable diameter from any vertical surface.

9 RATING FACTORS

The current ratings given in the respective tables apply to continuous loading of cables at a rated frequency of 50 Hz under the specific conditions of installation mentioned in **2.1** and **3.1**. For the various rating factors which may have to be used under different conditions, reference shall be made to appropriate Tables from 7 to 29.

When a number of circuits are installed in close proximity the current rating should be reduced by the appropriate factor from Tables 18 to 29.

These factors should also be applied to groups of parallel cables forming the same circuit. In such cases, attention should also be given to the arrangement of the cables to ensure that the load current is shared equally between the parallel cables.

Table 1 Current Ratings (a.c.) for Two Single-Core Cables with XLPE Insulation and Rated Voltage 1 100 V

(*Clause* 3.1)

Sl No.	Nominal Area of Conductor	Buried Direct in the Ground		In Single-Way Ducts		In Air	
		Copper	Aluminium	Copper	Aluminium	Copper	Aluminium
	mm²	A	A	A	A	A	A
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	1.5	32	26	27	22	28	22
ii)	2.5	42	32	36	28	37	28
iii)	4	54	43	46	36	48	38
iv)	6	67	55	57	47	61	50
v)	10	90	69	76	58	83	64
vi)	16	115	89	97	75	108	84
vii)	25	148	115	124	96	144	112
viii)	35	177	137	148	115	176	137
ix)	50	208	161	174	135	212	165
x)	70	255	198	213	165	269	209
xi)	95	312	243	256	199	340	264
xii)	120	355	276	291	226	396	308
xiii)	150	396	308	324	252	450	350
xiv)	185	447	349	365	285	519	406
xv)	240	515	404	420	329	613	480
xvi)	300	576	454	469	369	700	551
xvii)	400	651	518	528	421	813	647
xviii)	500	727	588	589	476	930	751
xix)	630	806	663	651	536	1056	868
xx)	800	877	740	707	596	1179	992
xxi)	1000	935	812	751	652	1288	1117

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Table 2 Current Ratings (a.c.) for Three Single-Core Cables with XLPE Insulation and Rated Voltage 1 100 V

(*Clause* 3.1)

Sl No.	Nominal Area of Conductor	Buried Direct in the Ground		In Single-Way Ducts		In Air	
		Copper	Aluminium	Copper	Aluminium	Copper	Aluminium
	mm²	A	A	A	A	A	A
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	1.5	28	23	26	21	24	19
ii)	2.5	36	28	33	26	31	24
iii)	4	47	37	43	34	41	33
iv)	6	58	47	53	43	52	43
v)	10	77	59	70	54	71	55
vi)	16	98	76	89	69	94	72
vii)	25	126	98	114	89	126	98
viii)	35	150	116	136	106	154	119
ix)	50	177	137	160	124	187	145
x)	70	216	168	195	151	238	185
xi)	95	260	202	233	181	303	235
xii)	120	295	230	264	206	354	276
xiii)	150	329	256	294	229	403	314
xiv)	185	371	290	330	258	468	366
xv)	240	427	335	379	298	553	434
xvi)	300	477	376	422	333	634	500
xvii)	400	537	429	473	378	737	589
xviii)	500	598	485	525	426	844	685
xix)	630	661	546	578	477	961	793
xx)	800	721	608	626	528	1077	907
xxi)	1000	772	665	668	575	1188	1022

Table 3 Current Ratings (a.c.) for Two-Core Cables with XLPE Insulation and Rated Voltage 1 100 V

(*Clause* 3.1)

Sl No.	Nominal Area of Conductor	Buried Direct in the Ground		In Single-Way Ducts		In Air	
		Copper	Aluminium	Copper	Aluminium	Copper	Aluminium
	mm²	A	A	A	A	A	A
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	1.5	31	26	27	22	27	22
ii)	2.5	41	32	35	27	36	28
iii)	4	54	42	45	36	48	38
iv)	6	67	55	56	46	61	50
v)	10	89	68	75	57	83	64
vi)	16	115	89	96	74	108	83
vii)	25	147	114	122	95	140	109
viii)	35	176	136	146	113	172	133
ix)	50	208	161	173	134	208	162
x)	70	253	197	211	164	262	204
xi)	95	302	235	252	196	322	251
xii)	120	340	266	284	222	368	287
xiii)	150	379	296	317	248	419	328
xiv)	185	425	335	357	281	482	379
xv)	240	486	385	409	324	566	448
xvi)	300	541	432	456	364	644	513
xvii)	400	602	487	508	412	734	593
xviii)	500	665	548	562	463	831	683
xix)	630	728	612	616	518	936	784

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Table 4 Current Ratings (a.c.) for Three, Four and Five-Core Cables with XLPE Insulation and Rated Voltage 1 100 V

(*Clause* 3.1)

Sl No.	Nominal Area of Conductor	Buried Direct in the Ground		In Single-Way Ducts		In Air	
		Copper	Aluminium	Copper	Aluminium	Copper	Aluminium
	mm²	A	A	A	A	A	A
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	1.5	26	22	22	18	23	19
ii)	2.5	34	27	29	23	30	24
iii)	4	45	35	38	30	41	32
iv)	6	56	46	47	38	52	42
v)	10	74	57	62	48	70	54
vi)	16	95	74	79	61	89	69
vii)	25	122	95	102	79	119	93
viii)	35	146	114	122	94	147	114
ix)	50	173	134	144	112	179	138
x)	70	212	164	177	137	226	175
xi)	95	254	197	212	164	279	216
xii)	120	287	223	240	187	320	249
xiii)	150	321	249	269	209	365	284
xiv)	185	362	282	304	238	422	329
xv)	240	418	327	352	276	500	392
xvi)	300	469	369	396	312	574	452
xvii)	400	528	420	447	356	662	526
xviii)	500	593	478	511	412	760	612
xix)	630	661	542	571	468	870	712

Table 5 Current Ratings (d.c.) for Two Single-Core Cables with XLPE Insulation and Rated Voltage 1 100 V

(*Clause* 3.1)

Sl No.	Nominal Area of Conductor	Buried Direct in the Ground		In Single-Way Ducts		In Air	
		Copper	Aluminium	Copper	Aluminium	Copper	Aluminium
	mm²	A	A	A	A	A	A
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	1.5	32	26	27	22	28	22
ii)	2.5	42	32	36	28	37	28
iii)	4	54	43	46	36	48	38
iv)	6	67	55	57	47	61	50
v)	10	90	69	76	58	83	64
vi)	16	115	89	97	75	108	84
vii)	25	148	115	124	96	144	112
viii)	35	177	137	148	115	176	137
ix)	50	208	161	174	135	212	165
x)	70	255	198	213	165	269	209
xi)	95	314	243	258	200	342	265
xii)	120	358	278	293	227	399	310
xiii)	150	401	310	328	254	455	352
xiv)	185	455	352	371	288	528	409
xv)	240	528	409	431	334	628	487
xvi)	300	598	463	487	377	726	561
xvii)	400	687	533	558	433	857	664
xviii)	500	790	613	640	497	1 008	782
xix)	630	911	705	736	570	1 189	921
xx)	800	1 046	809	843	652	1 398	1 082
xxi)	1 000	1 190	923	956	741	1 629	1 264

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Table 6 Current Ratings (d.c.) for Two-Core Cables with XLPE Insulation and Rated Voltage 1 100 V

(*Clause* 3.1)

Sl No.	Nominal Area of Conductor	Buried Direct in the Ground		In Single-Way Ducts		In Air	
		Copper	Aluminium	Copper	Aluminium	Copper	Aluminium
	mm²	A	A	A	A	A	A
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	1.5	31	26	27	22	27	22
ii)	2.5	41	32	35	27	36	28
iii)	4	54	42	45	36	48	38
iv)	6	67	55	56	46	61	50
v)	10	89	68	75	57	83	64
vi)	16	115	89	96	74	108	84
vii)	25	147	114	122	95	141	109
viii)	35	176	137	146	113	172	133
ix)	50	209	162	174	134	209	162
x)	70	256	198	213	165	265	205
xi)	95	306	237	255	198	326	253
xii)	120	347	269	290	225	375	290
xiii)	150	389	301	326	252	430	332
xiv)	185	441	342	370	287	498	386
xv)	240	513	397	432	334	595	461
xvi)	300	581	449	490	379	689	533
xvii)	400	666	516	563	436	807	626
xviii)	500	764	593	647	502	948	735
xix)	630	883	684	749	580	1 123	870

Table 7 Rating Factors for Variation in Ambient Air Temperature for Cables in Free Air

(*Clauses* 3.1 *and* 9.1)

Maximum Conductor Temperature	Ambient Air Temperature °C							
°C	25	30	35	40	45	50	55	60
90	1.14	1.10	1.05	1.00	0.95	0.89	0.84	0.77

Table 8 Rating Factors for Variation in Ground Temperature for Direct Buried Cables

(*Clauses* 3.1 *and* 9.1)

Maximum Conductor Temperature	Ground Temperature °C							
°C	15	20	25	30	35	40	45	50
90	1.12	1.08	1.04	1.00	0.96	0.91	0.87	0.82

Table 9 Rating Factors for Variation in Ground Temperature for Cables in Ducts

(*Clauses* 3.1 *and* 9.1)

Maximum Conductor Temperature	Ground Temperature °C							
°C	15	20	25	30	35	40	45	50
90	1.12	1.08	1.04	1.00	0.96	0.91	0.87	0.82

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Table 10 Rating Factors for Depths of Lying for Direct Buried Cables

(*Clauses* 3.1 *and* 9.1)

Sl No.	Depth of Laying mm	Up to 25 mm²		Above 25 mm² and Up to 300 mm²		Above 300 mm²	
		Single-Core	Multi-Core	Single-Core	Multi-Core	Single-Core	Multi-Core
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	750	1.00	1.00	1.00	1.00	1.00	1.00
ii)	900	0.98	0.98	0.98	0.98	0.98	0.98
iii)	1 050	0.97	0.98	0.96	0.97	0.96	0.96
iv)	1 200	0.96	0.97	0.95	0.95	0.94	0.95
v)	1 500	0.94	0.95	0.93	0.93	0.92	0.93
vi)	1 800	0.93	0.93	0.91	0.92	0.90	0.91
vii)	2 000	0.92	0.93	0.90	0.91	0.89	0.90
viii)	2 500	0.90	0.92	0.89	0.89	0.87	0.88
ix)	3 000	0.90	0.90	0.87	0.88	0.86	0.87

Table 11 Rating Factors for Depths of Laying for Cables in Ducts

(*Clauses* 3.1 *and* 9.1)

Sl No.	Depth of Laying mm	Up to 25 mm²		Above 25 mm² and Up to 300 mm²		Above 300 mm²	
		Single-Core	Multi-Core	Single-Core	Multi-Core	Single-Core	Multi-Core
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	750	1.00	1.00	1.00	1.00	1.00	1.00
ii)	900	0.98	0.98	0.98	0.99	0.98	0.98
iii)	1 050	0.97	0.98	0.96	0.97	0.96	0.97
iv)	1 200	0.96	0.97	0.95	0.97	0.94	0.96
v)	1 500	0.94	0.96	0.93	0.95	0.92	0.94
vi)	1 800	0.93	0.95	0.91	0.94	0.90	0.93
vii)	2 000	0.92	0.94	0.90	0.93	0.89	0.92
viii)	2 500	0.90	0.93	0.88	0.92	0.87	0.91
ix)	3 000	0.89	0.92	0.87	0.91	0.86	0.90

Table 12 Rating Factors for Variations in Soil Thermal Resistivity for Two Single-Core Cables Laid Direct in Ground

(*Clauses* 3.1 *and* 9.1)

Sl No.	Nominal Area of Conductor mm²	Values of Soil Thermal Resistivity K.m/W					
		1.0	1.2	1.5	2.0	2.5	3.0
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	1.5	1.16	1.09	1.00	0.91	0.81	0.75
ii)	2.5	1.16	1.09	1.00	0.89	0.81	0.75
iii)	4	1.17	1.09	1.00	0.89	0.81	0.75
iv)	6	1.17	1.09	1.00	0.89	0.81	0.75
v)	10	1.17	1.09	1.00	0.89	0.80	0.74
vi)	16	1.17	1.09	1.00	0.89	0.80	0.74
vii)	25	1.18	1.09	1.00	0.89	0.80	0.74
viii)	35	1.18	1.10	1.00	0.88	0.80	0.73
ix)	50	1.19	1.10	1.00	0.88	0.80	0.73
x)	70	1.19	1.10	1.00	0.88	0.80	0.73
xi)	95	1.19	1.10	1.00	0.88	0.79	0.73
xii)	120	1.19	1.10	1.00	0.88	0.79	0.73
xiii)	150	1.19	1.10	1.00	0.88	0.79	0.73
xiv)	185	1.19	1.10	1.00	0.88	0.79	0.72
xv)	240	1.20	1.10	1.00	0.88	0.79	0.72
xvi)	300	1.20	1.10	1.00	0.88	0.79	0.72

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Table 12 — (*Concluded*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
xvii)	400	1.20	1.10	1.00	0.88	0.79	0.72
xviii)	500	1.20	1.11	1.00	0.87	0.79	0.72
xix)	630	1.20	1.11	1.00	0.87	0.79	0.72
xx)	800	1.20	1.11	1.00	0.87	0.79	0.72
xxi)	1 000	1.20	1.11	1.00	0.87	0.79	0.72

Table 13 Rating Factors for Variations in Soil Thermal Resistivity for Two Single-Core Cables Laid in Buried Duct

(*Clauses* 3.1 *and* 9.1)

Sl No.	**Nominal Area of Conductor** mm²	**Values of Soil Thermal Resistivity** K.m/W					
		1.0	1.2	1.5	2.0	2.5	3.0
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	1.5	1.16	1.09	1.00	0.91	0.81	0.75
ii)	2.5	1.16	1.09	1.00	0.89	0.81	0.75
iii)	4	1.17	1.09	1.00	0.89	0.81	0.75
iv)	6	1.17	1.09	1.00	0.89	0.81	0.75
v)	10	1.17	1.09	1.00	0.89	0.80	0.74
vi)	16	1.17	1.09	1.00	0.89	0.80	0.74
vii)	25	1.18	1.09	1.00	0.89	0.80	0.74
viii)	35	1.18	1.10	1.00	0.88	0.80	0.73
ix)	50	1.19	1.10	1.00	0.88	0.80	0.73
x)	70	1.19	1.10	1.00	0.88	0.80	0.73
xi)	95	1.19	1.10	1.00	0.88	0.79	0.73
xii)	120	1.19	1.10	1.00	0.88	0.79	0.73
xiii)	150	1.19	1.10	1.00	0.88	0.79	0.73
xiv)	185	1.19	1.10	1.00	0.88	0.79	0.72
xv)	240	1.20	1.10	1.00	0.88	0.79	0.72
xvi)	300	1.20	1.10	1.00	0.88	0.79	0.72
xvii)	400	1.20	1.10	1.00	0.88	0.79	0.72
xviii)	500	1.20	1.11	1.00	0.87	0.79	0.72
xix)	630	1.20	1.11	1.00	0.87	0.79	0.72
xx)	800	1.20	1.11	1.00	0.87	0.79	0.72
xxi)	1 000	1.20	1.11	1.00	0.87	0.79	0.72

Table 14 Rating Factors for Variations in Soil Thermal Resistivity for Three Single-Core Cables Laid Direct in Ground

(*Clauses* 3.1 *and* 9.1)

Sl No.	**Nominal Area of Conductor** mm²	**Values of Soil Thermal Resistivity** K.m/W					
		1.0	1.2	1.5	2.0	2.5	3.0
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	1.5	1.14	1.07	1.00	0.89	0.80	0.75
ii)	2.5	1.17	1.08	1.00	0.89	0.80	0.75
iii)	4	1.17	1.09	1.00	0.88	0.79	0.73
iv)	6	1.17	1.09	1.00	0.88	0.79	0.73
v)	10	1.18	1.09	1.00	0.88	0.79	0.73
vi)	16	1.18	1.10	1.00	0.88	0.79	0.72
vii)	25	1.19	1.10	1.00	0.88	0.79	0.72
viii)	35	1.19	1.10	1.00	0.88	0.79	0.72
ix)	50	1.19	1.10	1.00	0.88	0.79	0.72
x)	70	1.20	1.11	1.00	0.88	0.79	0.72

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Table 14 — (*Concluded*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
xi)	95	1.20	1.11	1.00	0.87	0.79	0.72
xii)	120	1.20	1.11	1.00	0.87	0.79	0.72
xiii)	150	1.20	1.11	1.00	0.87	0.79	0.72
xiv)	185	1.20	1.11	1.00	0.87	0.78	0.72
xv)	240	1.20	1.11	1.00	0.87	0.78	0.72
xvi)	300	1.20	1.11	1.00	0.87	0.78	0.72
xvii)	400	1.20	1.11	1.00	0.87	0.78	0.72
xviii)	500	1.21	1.11	1.00	0.87	0.78	0.72
xix)	630	1.21	1.11	1.00	0.87	0.78	0.72
xx)	800	1.21	1.11	1.00	0.87	0.78	0.72
xxi)	1 000	1.21	1.11	1.00	0.87	0.78	0.72

Table 15 Rating Factors for Variations in Soil Thermal Resistivity for Three Single-Core Cables Laid in Buried Duct

(*Clauses* 3.1 *and* 9.1)

Sl No.	Nominal Area of Conductor mm²	Values of Soil Thermal Resistivity K.m/W					
		1.0	1.2	1.5	2.0	2.5	3.0
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	1.5	1.08	1.04	1.00	0.92	0.88	0.84
ii)	2.5	1.08	1.05	1.00	0.93	0.88	0.84
iii)	4	1.08	1.05	1.00	0.93	0.87	0.83
iv)	6	1.09	1.06	1.00	0.93	0.87	0.83
v)	10	1.10	1.06	1.00	0.93	0.87	0.82
vi)	16	1.10	1.06	1.00	0.93	0.87	0.82
vii)	25	1.10	1.06	1.00	0.93	0.87	0.82
viii)	35	1.10	1.06	1.00	0.93	0.86	0.81
ix)	50	1.11	1.06	1.00	0.92	0.86	0.81
x)	70	1.11	1.06	1.00	0.92	0.86	0.80
xi)	95	1.12	1.06	1.00	0.92	0.85	0.80
xii)	120	1.12	1.06	1.00	0.91	0.85	0.79
xiii)	150	1.12	1.07	1.00	0.91	0.85	0.79
xiv)	185	1.12	1.07	1.00	0.91	0.84	0.79
xv)	240	1.12	1.07	1.00	0.91	0.84	0.78
xvi)	300	1.13	1.07	1.00	0.91	0.84	0.78
xvii)	400	1.13	1.07	1.00	0.91	0.84	0.78
xviii)	500	1.13	1.07	1.00	0.90	0.83	0.78
xix)	630	1.13	1.07	1.00	0.90	0.83	0.77
xx)	800	1.14	1.08	1.00	0.90	0.83	0.77
xxi)	1 000	1.14	1.08	1.00	0.90	0.82	0.77

Table 16 Rating Factors for Variations in Soil Thermal Resistivity for Multi-Core Cables Laid Direct in Ground

(*Clauses* 3.1 *and* 9.1)

Sl No.	Nominal Area of Conductor mm²	Values of Soil Thermal Resistivity K.m/W					
		1.0	1.2	1.5	2.0	2.5	3.0
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	1.5	1.14	1.08	1.00	0.90	0.83	0.77
ii)	2.5	1.15	1.08	1.00	0.90	0.82	0.76
iii)	4	1.15	1.08	1.00	0.89	0.82	0.76

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Table 16 — (*Concluded*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
iv)	6	1.16	1.09	1.00	0.89	0.81	0.75
v)	10	1.16	1.09	1.00	0.89	0.81	0.75
vi)	16	1.17	1.09	1.00	0.89	0.80	0.74
vii)	25	1.17	1.09	1.00	0.89	0.80	0.74
viii)	35	1.18	1.10	1.00	0.88	0.80	0.74
ix)	50	1.18	1.10	1.00	0.88	0.80	0.74
x)	70	1.18	1.10	1.00	0.88	0.80	0.74
xi)	95	1.18	1.10	1.00	0.88	0.80	0.73
xii)	120	1.18	1.10	1.00	0.88	0.80	0.73
xiii)	150	1.18	1.10	1.00	0.88	0.80	0.73
xiv)	185	1.18	1.10	1.00	0.88	0.80	0.73
xv)	240	1.19	1.10	1.00	0.88	0.80	0.73
xvi)	300	1.19	1.10	1.00	0.88	0.80	0.73
xvii)	400	1.19	1.10	1.00	0.88	0.80	0.73
xviii)	500	1.19	1.10	1.00	0.88	0.80	0.73
xix)	630	1.19	1.10	1.00	0.88	0.80	0.73

Table 17 Rating Factors for Variations in Soil Thermal Resistivity for Multi-Core Cables Laid in Buried Duct

(*Clauses* 3.1 *and* 9.1)

Sl No.	Nominal Area of Conductor mm²	Values of Soil Thermal Resistivity K.m/W					
		1.0	1.2	1.5	2.0	2.5	3.0
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	1.5	1.05	1.03	1.00	0.96	0.92	0.88
ii)	2.5	1.05	1.03	1.00	0.95	0.91	0.88
iii)	4	1.06	1.03	1.00	0.95	0.91	0.87
iv)	6	1.06	1.03	1.00	0.95	0.91	0.87
v)	10	1.06	1.04	1.00	0.95	0.90	0.86
vi)	16	1.06	1.04	1.00	0.95	0.90	0.86
vii)	25	1.07	1.04	1.00	0.95	0.90	0.86
viii)	35	1.07	1.04	1.00	0.94	0.90	0.85
ix)	50	1.07	1.04	1.00	0.94	0.89	0.85
x)	70	1.07	1.04	1.00	0.94	0.89	0.84
xi)	95	1.08	1.04	1.00	0.94	0.88	0.84
xii)	120	1.08	1.05	1.00	0.94	0.88	0.84
xiii)	150	1.08	1.05	1.00	0.93	0.88	0.83
xiv)	185	1.08	1.05	1.00	0.93	0.88	0.83
xv)	240	1.09	1.05	1.00	0.93	0.87	0.83
xvi)	300	1.09	1.05	1.00	0.93	0.87	0.82
xvii)	400	1.09	1.05	1.00	0.93	0.87	0.82
xviii)	500	1.09	1.05	1.00	0.93	0.87	0.82
xix)	630	1.10	1.06	1.00	0.92	0.86	0.81

Table 18 Group Rating Factors for Circuits of Two Single-Core Cables Laid Direct in the Ground, Horizontal Formation

(*Clauses* 3.1, 9.1 *and* 9.2)

Sl No.	Number of Circuits	Spacing Between Group Centre mm				
		Touching	150	300	450	600
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	2	0.80	0.85	0.90	0.92	0.95

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Table 18 — (*Concluded*)

(1)	(2)	(3)	(4)	(5)	(6)	(7)
ii)	3	0.70	0.78	0.85	0.88	0.91
iii)	4	0.64	0.73	0.81	0.86	0.89
iv)	5	0.59	0.70	0.79	0.84	0.88
v)	6	0.55	0.67	0.77	0.83	0.87
vi)	7	0.53	0.65	0.76	0.82	0.86
vii)	8	0.51	0.64	0.75	0.82	0.86
viii)	9	0.49	0.63	0.74	0.81	0.85
ix)	10	0.48	0.63	0.74	0.81	0.85
x)	11	0.47	0.62	0.73	0.80	0.84
xi)	12	0.46	0.61	0.73	0.80	0.84

Table 19 Group Rating Factors for Circuits of Three Single-Core Cables Laid Direct in the Ground, Horizontal Formation

(*Clauses* 3.1, 9.1 *and* 9.2)

Sl No.	Number of Circuits	Spacing Between Group Centre mm				
		Touching	150	300	450	600
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	2	0.77	0.81	0.86	0.88	0.89
ii)	3	0.67	0.71	0.78	0.81	0.83
iii)	4	0.61	0.64	0.72	0.76	0.80
iv)	5	0.57	0.60	0.69	0.74	0.77
v)	6	0.53	0.57	0.66	0.72	0.75
vi)	7	0.51	0.55	0.64	0.70	0.74
vii)	8	0.49	0.53	0.63	0.69	0.73
viii)	9	0.47	0.52	0.62	0.68	0.73
ix)	10	0.45	0.51	0.61	0.67	0.72
x)	11	0.44	0.50	0.60	0.66	0.72
xi)	12	0.43	0.49	0.59	0.65	0.71

Table 20 Group Rating Factors for Circuits of Three Single-Core Cables in Single-Way Ducts

(*Clauses* 3.1, 9.1 *and* 9.2)

Sl No.	Number of Circuits	Spacing Between Group Centre mm				
		Touching	150	300	450	600
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	2	0.78	0.83	0.87	0.90	0.91
ii)	3	0.66	0.73	0.78	0.82	0.85
iii)	4	0.59	0.67	0.74	0.78	0.82
iv)	5	0.55	0.63	0.70	0.76	0.80
v)	6	0.51	0.61	0.68	0.74	0.78
vi)	7	0.48	0.58	0.66	0.73	0.77
vii)	8	0.46	0.57	0.65	0.72	0.76
viii)	9	0.44	0.55	0.64	0.71	0.76
ix)	10	0.43	0.54	0.63	0.70	—
x)	11	0.42	0.53	0.62	0.69	—
xi)	12	0.40	0.51	0.61	0.69	—

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Table 21 Group Rating Factors for Multi-Core Cables Laid Direct in the Ground, in Tier Formation

(*Clauses* 3.1, 9.1 *and* 9.2)

Sl No.	Number of Cables	Number of Tiers	Spacing Between Group Centre mm				
			Touching	150	300	450	600
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	2	1	0.80	0.84	0.87	0.90	0.91
ii)	3	1	0.68	0.74	0.79	0.83	0.86
iii)	4	2	0.60	0.66	0.73	0.77	0.79
iv)	5	2	0.55	0.61	0.68	0.71	0.73
v)	6	2	0.51	0.57	0.63	0.67	0.69
vi)	7	3	0.48	0.54	0.59	0.63	0.64
vii)	8	3	0.46	0.51	0.56	0.60	0.61
viii)	9	3	0.44	0.48	0.53	0.57	0.58
ix)	10	4	0.42	0.47	0.52	0.55	0.56
x)	11	4	0.41	0.46	0.50	0.54	0.55
xi)	12	4	0.40	0.45	0.49	0.53	0.54

Table 22 Group Rating Factors for Multi-Core Cables Laid Direct in the Ground, in Horizontal Formation

(*Clauses* 3.1, 9.1 *and* 9.2)

Sl No.	Number of Circuits	Spacing Between Duct Group Centre mm				
		Touching	150	300	450	600
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	2	0.80	0.84	0.87	0.90	0.91
ii)	3	0.68	0.74	0.79	0.83	0.86
iii)	4	0.62	0.69	0.75	0.80	0.83
iv)	5	0.58	0.65	0.72	0.77	0.80
v)	6	0.55	0.62	0.69	0.75	0.78
vi)	7	0.52	0.59	0.67	0.73	0.77
vii)	8	0.50	0.57	0.66	0.72	0.75
viii)	9	0.48	0.55	0.65	0.71	0.75
ix)	10	0.46	0.54	0.64	0.70	0.74
x)	11	0.45	0.53	0.63	0.70	0.74
xi)	12	0.44	0.52	0.62	0.69	0.73

Table 23 Group Rating Factors for Three-Core Cables in Single Way Ducts in Horizontal Formation

(*Clauses* 3.1, 9.1 *and* 9.2)

Sl No.	Number of Cables	Spacing Between Cable Centres mm				
		Touching	150	300	450	600
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	2	0.85	0.87	0.90	0.92	0.94
ii)	3	0.75	0.79	0.83	0.86	0.88
iii)	4	0.69	0.74	0.79	0.83	0.86
iv)	5	0.65	0.70	0.76	0.80	0.84
v)	6	0.62	0.67	0.73	0.79	0.83
vi)	7	0.59	0.65	0.72	0.78	0.82
vii)	8	0.57	0.63	0.70	0.77	0.81
viii)	9	0.55	0.62	0.69	0.76	0.80
ix)	10	0.54	0.61	0.68	0.75	—
x)	11	0.52	0.60	0.68	0.75	—
xi)	12	0.51	0.59	0.67	0.74	—

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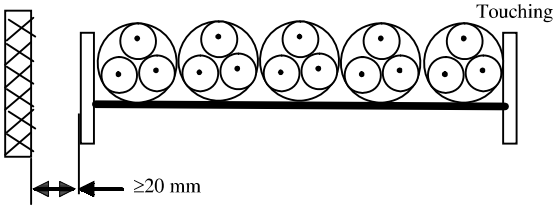
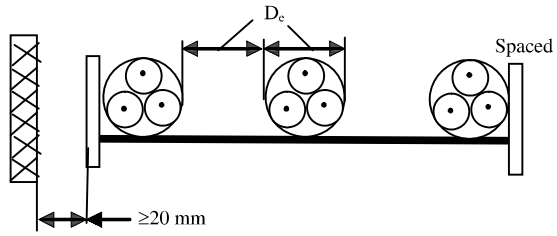
Table 26 Group Rating Factors for Multi-Core Cables in Air on Ladder Supports, Cleats, etc

(*Clauses* 3.1, 9.1 *and* 9.2)

	Number of Trays	Number of Cables					
		1	2	3	4	6	9
Touching 	1	1.00	0.87	0.82	0.80	0.79	0.78
	2	1.00	0.86	0.80	0.78	0.76	0.73
	3	1.00	0.85	0.79	0.76	0.73	0.70
Spaced 	1	1.00	1.00	1.00	1.00	1.00	—
	2	1.00	0.99	0.98	0.97	0.96	—
	3	1.00	0.98	0.97	0.96	0.93	—

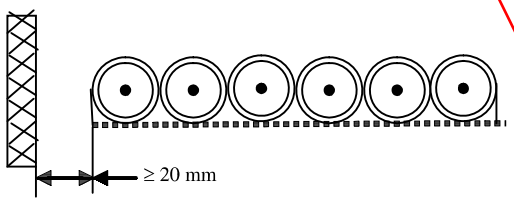
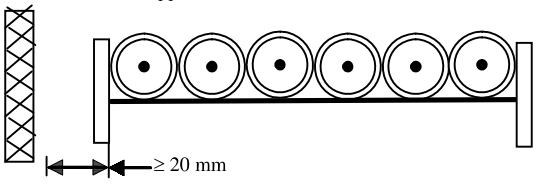
NOTES

1 Factors apply to single layer groups of cables as shown above. Factors for cables installed in more than one layer touching each other will be significantly lower and must be determined by an appropriate method.

2 Factors are given for vertical spacing between trays of 300 mm and at least 20 mm between trays and wall. For closer spacing, the factors should be reduced.

Table 27 Group Rating Factors to be Applied for Circuits of Three Single-core Cables in Air Flat Touching

(*Clauses* 3.1, 9.1 *and* 9.2)

	Number of Trays	Number of Three-Phase Circuits		
		1	2	3
Cables on perforated trays 	1	0.98	0.91	0.87
	2	0.96	0.87	0.81
	3	0.95	0.85	0.78
Cables on ladder supports, cleats, etc 	1	1.00	0.97	0.96
	2	0.98	0.93	0.89
	3	0.97	0.90	0.86

NOTES

1 Factors are given for single layers of cables as shown above. Factors for cables installed in more than one layer touching each other will be significantly lower and must be determined by an appropriate method.

2 Factors are given for vertical spacing between trays of 300 mm and at least 20 mm between trays and wall. For closer spacing, the factors should be reduced.

3 For circuits having more than one cable in parallel per phase, each three phase set of conductors should be considered as a circuit for the purpose of this table.

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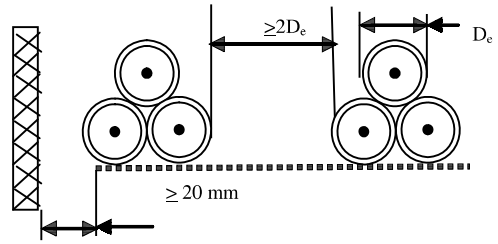
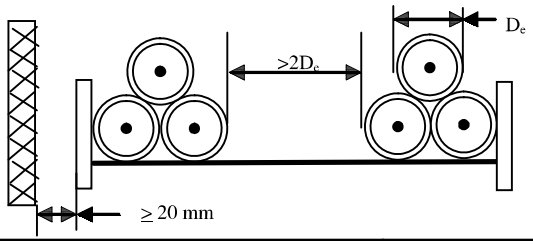
Table 28 Group Rating Factors to be Applied for Circuits of Three Single Core Cables in Air on Perforated Trays and Ladder Supports in Trefoil Formation

(*Clauses* 3.1, 9.1 *and* 9.2)

	Number of Trays	Number of Three-Phase Circuits		
		1	2	3
Cables on perforated trays 	1	1.00	0.98	0.96
	2	0.97	0.93	0.89
	3	0.96	0.92	0.86
Cables on ladder supports, cleats, etc 	1	1.00	1.00	1.00
	2	0.97	0.95	0.93
	3	0.96	0.94	0.90

NOTES

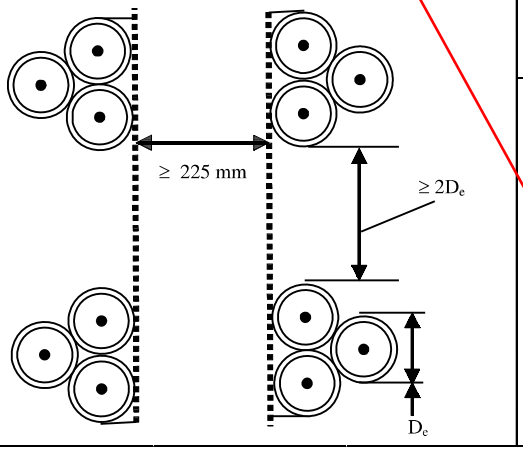
1 Factors are given for single layers of trefoil groups as shown above. Factors for trefoil groups installed in more than one layer touching each other will be significantly lower and must be determined by an appropriate method.

2 Factors are given for vertical spacing between trays of 300 mm and at least 20 mm between trays and wall. For closer spacing, the factors should be reduced.

3 For circuits having more than one cable in parallel per phase, each three phase set of conductors should be considered as a circuit for the purpose of this table.

Table 29 Group Rating Factors to be Applied for Circuits of Three Single Core Cables in Air on Vertical Perforated Trays in Trefoil Formation

(*Clauses* 3.1, 9.1 *and* 9.2)

	Number of Trays	Number of Three-Phase Circuits		
		1	2	3
	1	1.00	0.91	0.89
	2	1.00	0.90	0.86

NOTES

1 Factors are given for single layers of trefoil groups as shown above. Factors for trefoil groups installed in more than one layer touching each other will be significantly lower and must be determined by an appropriate method.

2 Factors are given for horizontal spacing between vertical trays of 225 mm with trays mounted back to back. For closer spacing the factors should be reduced.

3 For circuits having more than one cable in parallel per phase, each three phase set of conductors should be considered as a circuit for the purpose of this table.

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TABLE 58

GROUP RATING FACTORS
FOR SINGLE CORE CABLES LAID IN TREFOIL FORMATION

A) Cables laid in ground in horizontal formation.

No. of Trefoils in group	Spacing between Trefoils			
	Touching	15 cm.	30 cm.	45 cm.
2	0.78	0.81	0.85	0.88
3	0.68	0.71	0.77	0.81
4	0.61	0.65	0.72	0.76
5	0.56	0.61	0.68	0.73

B) Cables laid in Trefoil Ducts in horizontal formation.

No. of Trefoils in group	Spacing between Trefoils		
	Touching	45 cm.	60 cm.
2	0.87	0.90	0.91
3	0.79	0.83	0.86
4	0.74	0.79	0.82
5	0.71	0.76	0.80

C) Cables laid on Racks/Trays in covered trench with removable covers where air circulation is restricted, Trefoils are seperated by two cable dia horizontally and the trays are in tiers with 30 cm. gap between them.

No. of racks/trays in tiers	No. of trefoils in Horizontal formation		
	1	2	3
1	0.95	0.90	0.88
2	0.90	0.85	0.83
3	0.88	0.83	0.81
6	0.86	0.81	0.79

D) Cables laid as in 'C' but in open air.

1	1.0	0.98	0.96
2	1.0	0.95	0.93
3	1.0	0.94	0.92
6	1.0	0.93	0.90

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TABLE-UCL

DERATING FACTORS FOR MULTICORE CABLES LAID IN RESTRICTED AIR CIRCULATION CONDITIONS (CABLES LAID IN TRENCHES IN TOUCHING FORMATION)

NUMBER OF CABLE TRAYS IN TIER	NUMBER OF CABLES				
	1	2	3	6	9
1	0.95	0.77	0.73	0.69	0.67
2	0.90	0.72	0.68	0.64	0 62
3	0.88	0.69	0.65	0.62	0.60
6	0.86	0.66	0.63	0 60	0.58

TABLE 62

APPROXIMATE A.C. RESISTANCE OF CONDUCTOR (OHM/KM)
AT MAX. OPERATING CONDUCTOR TEMPERATURE PVC, HR PVC & XLPE CABLES

Nominal area of conductor (sq. mm)	PVC CABLES (70 °C)		HR PVC CABLES (85 °C)		XLPE CABLES (90 °C)	
	Aluminium	Copper	Aluminium	Copper	Aluminium	Copper
1.5	21.72	14.52	22.81	15.25	23.2	15.5
2.5	14.52	8.89	15.25	9.34	15.5	9.5
4	8.89	5.53	9.34	5.81	9.5	5.9
6	5.53	3.70	5.81	3.88	5.9	3.94
10	3.70	2.20	3.88	2.31	3.94	2.34
16	2.29	1.38	2.41	1.45	2.44	1.47
25	1.44	0.873	1.51	0.916	1.53	0.931
35	1.04	0.629	1.09	0.661	1.11	0.671
50	0.770	0.465	0.808	0.488	0.818	0.496
70	0.532	0.322	0.559	0.338	0.565	0.344
95	0.384	0.233	0.404	0.244	0.409	0.248
120	0.304	0.185	0.328	0.194	0.323	0.197
150	0.248	0.150	0.261	0.158	0.264	0.160
185	0.198	0.121	0.208	0.127	0.210	0.129
240	0.152	0.094	0.159	0.098	0.161	0.099
300	0.122	0.075	0.126	0.079	0.129	0.080
400	0.096	0.061	0.101	0.063	0.102	0.064
500	0.076	0.049	0.079	0.051	0.082	0.052
630	0.061	0.040	0.063	0.042	0.065	0.043

TABLE 63

APPROXIMATE REACTANCE AT 50 HZ (OHMS/KM) 1.1 KV PVC, HR PVC AND XLPE CABLES

Nominal Area of conductor (sq. mm)	PVC and HR PVC Cables			XLPE Cables		
	Single Core		Multicore	Single Core		Multicore
	Unarmoured	Armoured *		Unarmoured	Armoured *	
1.5	0.157	--	0.110	0.155	--	0.107
2.5	0.145	--	0.106	0.142	--	0.0985
4	0.136	--	0.102	0.132	--	0.0927
6	0.128	--	0.0962	0.123	--	0.0884
10	0.118	0.137	0.0908	0.114	0.134	0.0837
16	0.110	0.128	0.0859	0.108	0.125	0.0808
25	0.107	0.122	0.0849	0.103	0.120	0.0805
35	0.105	0.116	0.0823	0.0986	0.114	0.0783
50	0.0973	0.110	0.0765	0.0937	0.108	0.0750
70	0.0924	0.107	0.0769	0.0900	0.102	0.0740
95	0.0900	0.103	0.0766	0.0865	0.100	0.0724
120	0.0880	0.0989	0.0741	0.0841	0.0968	0.0712
150	0.0862	0.0960	0.0743	0.0839	0.0941	0.0716
185	0.0857	0.0950	0.0742	0.0836	0.0932	0.0718
240	0.0837	0.0929	0.0737	0.0813	0.0900	0.0710
300	0.0828	0.0922	0.0733	0.0[illegible]	0.0881	0.0705
400	0.0810	0.0893	0.0729	0.0797	0.0873	0.0704
500	0.0807	0.0890	0.0732	0.0779	0.0859	0.0702
630	0.0803	0.0876	0.0731	0.0765	0.0843	0.0698
800	0.0782	0.0862	--	0.0756	0.0826	--
1000	0.0772	0.0849	--	0.0[illegible]	0.0829	--

* Round wire armoured

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Table 2 Stranded Conductors for Single Core and Multicore Cables (Class 2)

(*Clauses* 6.2.3, 6.3.3 *and* 7.3.1)

Sl No.	Nominal Cross-Sectional Area	Minimum Number of Wires in the Conductor				Maximum Resistance of Conductor at 20°C		
		Circular Conductor (Non-Compacted)		Circular Compacted or Shaped Conductor		Copper Conductor		Aluminium Conductor
						Plain Wires	Tinned Wires	
	mm²	Cu	Al	Cu	Al	Ω/km	Ω/km	Ω/km
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
i)	1	3	—	—	—	18.1	18.2	—
ii)	1.5	3	3	—	—	12.1	12.2	18.1
iii)	2.5	3	3	—	—	7.41	7.56	12.1
iv)	4	7	3	—	—	4.61	4.70	7.41
v)	6	7	3	—	—	3.08	3.11	4.61
vi)	10	7	7	6	—	1.83	1.84	3.08
vii)	16	7	7	6	6	1.15	1.16	1.91
viii)	25	7	7	6	6	0.727	0.734	1.20
ix)	35	7	7	6	6	0.524	0.529	0.868
x)	50	19	19	6	6	0.387	0.391	0.641
xi)	70	19	19	12	12	0.268	0.270	0.443
xii)	95	19	19	15	15	0.193	0.195	0.320
xiii)	120	37	37	18	15	0.153	0.154	0.253
xiv)	150	37	37	18	15	0.124	0.126	0.206
xv)	185	37	37	30	30	0.099 1	0.100	0.164
xvi)	240	61	37	34	30	0.075 4	0.076 2	0.125
xvii)	300	61	61	34	30	0.060 1	0.060 7	0.100
xviii)	400	61	61	53	53	0.047 0	0.047 5	0.077 8
xix)	500	61	61	53	53	0.036 6	0.036 9	0.060 5
xx)	630	91	91	53	53	0.028 3	0.028 6	0.046 9
xxi)	800[1)]	91	91	53	53	0.022 1	0.022 4	0.036 7
xxii)	1 000[1)]	91	91	53	53	0.017 6	0.017 7	0.029 1
xxiii)	1 200[2)]	—	[3)]	—	—	0.015 1	0.015 1	0.024 7
xxiv)	1 400[2)]	—	[3)]	—	—	0.012 9	0.012 9	0.021 2
xxv)	1 600[2)]	—	[3)]	—	—	0.011 3	0.011 3	0.018 6
xxvi)	1 800[2)]	—	[3)]	—	—	0.010 1	0.010 1	0.016 5
xxvii)	2 000[2)]	—	[3)]	—	—	0.009 0	0.009 0	0.014 9
xxviii)	2 500[2)]	—	[3)]	—	—	0.007 2	0.007 2	0.012 7

[1)] These are segmental conductors.

[2)] Can be either stranded or segmental.

[3)] The minimum number of wires for these sizes is not specified. These sizes may be constructed from 4, 5 or 6 equal segments (Milliken).

NOTE — In case 800 and 1 000 square mm if constructed as per segment construction then the minimum number of wires is not specified. However the number of segments can be 4, 5 or 6.

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TABLE 21

CURRENT RATINGS FOR TWO SINGLE-CORE 650/1100 VOLTS UNARMOURED OR NON-MAGNETIC ARMOURED PVC CABLES ACCORDING TO IS:1554 (Part 1)

NOMINAL AREA OF CONDUCTOR	LAID DIRECT IN THE GROUND		IN DUCTS		IN AIR	
	Copper	Aluminium	Copper	Aluminium	Copper	Aluminium
mm²	A	A	A	A	A	A
1.5	25	21	23	19	24	18
2.5	35	28	31	25	32	25
4	46	36	42	33	43	32
6	57	44	54	42	54	41
10	75	59	72	56	72	56
16	94	75	92	71	92	72
25	125	97	120	93	125	99
35	150	120	140	110	155	120
50	180	145	165	130	190	150
70	220	170	200	155	235	185
95	265	205	230	180	275	215
120	300	230	255	200	310	240
150	340	265	280	220	345	270
185	380	300	305	240	390	305
240	420	335	340	270	445	350
300	465	370	370	295	500	395
400	500	410	405	335	570	455
500	540	435	430	355	610	490
630	590	485	465	395	680	560
800	645	535	505	430	780	640
1000	705	580	555	470	900	740

TABLE 22

CURRENT RATINGS FOR THREE SINGLE-CORE 650/1100 VOLTS UNARMOURED ON NON-MAGNETIC ARMOURED PVC CABLES ACCORDING TO IS:1554 (Part 1)

NOMINAL AREA OF CONDUCTOR	LAID DIRECT IN THE GROUND		IN DUCTS		IN AIR	
	Copper	Aluminium	Copper	Alunimium	Copper	Aluminium
mm²	A	A	A	A	A	A
1.5	22	17	21	17	20	15
2.5	30	24	29	24	27	21
4	39	31	38	30	35	27
6	49	39	46	37	44	35
10	65	51	64	51	60	47
16	85	66	83	66	82	64
25	110	86	110	84	110	84
35	130	100	125	100	130	105
50	155	120	150	115	165	130
70	190	140	175	135	205	155
95	220	175	200	155	245	190
120	250	195	220	170	280	220
150	280	220	245	190	320	250
185	305	240	260	210	370	290
240	345	270	285	225	425	335
300	375	295	310	245	475	380
400	400	325	335	275	550	435
500	425	345	355	295	590	480
630	470	390	375	320	660	550
800	530	440	410	350	770	640
1000	590	490	450	385	865	720

TABLE 23
CURRENT RATINGS FOR TWIN 650/1100 VOLTS ARMOURED OR UNARMOURED PVC CABLES ACCORDING TO IS:1554 (Part 1)

NOMINAL AREA OF CONDUCTOR	LAID DIRECT IN THE GROUND		IN DUCTS		IN AIR	
	Copper	Aluminium	Copper	Aluminium	Copper	Aluminium
mm²	A	A	A	A	A	A
1.5	23	18	20	16	20	16
2.5	32	25	27	21	27	21
4	41	32	35	27	35	27
6	50	40	44	34	45	35
10	70	55	58	45	60	47
16	90	70	75	58	78	59
25	115	90	97	76	105	78
35	140	110	120	92	125	99
50	165	135	145	115	155	125
70	205	160	180	140	195	150
95	240	190	215	170	230	185
120	275	210	235	190	265	210
150	310	240	270	210	305	240
185	350	275	300	240	350	275
240	405	320	345	275	410	325
300	450	355	385	305	465	365
400	490	385	425	345	530	420
500	520	415	460	365	575	455
630	565	460	510	405	655	520

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TABLE '4

CURRENT RATINGS FOR THREE, THREE AND HALF AND FOUR CORE 650/1100 VOLTS ARMOURED OR UNARMOURED PVC CABLES ACCORDING TO IS:1554 (Part 1)

NOMINAL AREA OF CONDUCTOR	LAID DIRECT IN THE GROUND		IN DUCTS		IN AIR	
	Copper	Aluminium	Copper	Aluminium	Copper	Aluminium
mm²	A	A	A	A	A	A
1.5	21	16	17	14	17	13
2.5	27	21	24	18	24	18
4	36	28	30	23	30	23
6	45	35	36	30	39	30
10	60	46	50	39	52	40
16	77	60	64	50	66	51
25	99	76	81	63	90	70
35	120	92	96	77	110	86
50	145	110	125	95	135	105
70	175	135	150	115	165	130
95	210	165	175	140	200	155
120	240	185	195	155	230	180
150	270	210	225	175	265	205
185	300	235	255	200	305	240
240	345	275	295	235	355	280
300	385	305	330	260	400	315
400	425	335	360	290	455	375
500	470	370	405	320	540	425
630	515	405	445	350	610	480

TABLE 29

CURRENT RATINGS FOR TWO SINGLE-CORE 650/1100 VOLTS UNARMOURED OR NON-MAGNETIC ARMOURED 1.1 KV XLPE CABLES ACCORDING TO IS:7098 (Part 1)

NOMINAL AREA OF CONDUCTOR	LAID DIRECT IN THE GROUND		IN DUCTS		IN AIR	
	Copper	Aluminium	Copper	Aluminium	Copper	Aluminium
mm²	A	A	A	A	A	A
1.5	31	24	[illegible]	22	25	19
2.5	41	32	[illegible]	29	33	26
4	54	42	[illegible]	38	44	34
6	68	52	[illegible]	47	55	43
10	89	69	[illegible]	62	80	60
16	116	90	[illegible]	81	104	82
25	148	116	[illegible]	104	139	108
35	181	139	[illegible]	125	172	136
50	213	162	[illegible]	146	213	163
70	259	199	[illegible]	179	271	208
95	310	241	[illegible]	217	335	258
120	352	273	[illegible]	246	389	303
150	393	305	[illegible]	275	447	348
185	444	347	[illegible]	312	524	407
240	518	407	[illegible]	366	623	488
300	583	458	[illegible]	412	722	569
400	657	518	[illegible]	466	850	669
500	731	592	[illegible]	533	976	766
630	823	666	[illegible]	599	1130	922
800	[illegible]	750	[illegible]	675	1284	1067
1000	931	831	[illegible]	750	1457	1229

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TABLE 30

CURRENT RATINGS FOR THREE SINGLE-CORE 650/1100 VOLTS UNARMOURED OR NON-MAGNETIC ARMOURED 1.1 KV XLPE CABLES ACCORDING TO IS:7098 (Part 1)

NOMINAL AREA OF CONDUCTOR	LAID DIRECT IN THE GROUND		IN DUCTS		IN AIR	
	Copper	Aluminium	Copper	Aluminium	Copper	Aluminium
mm²	A	A	A	A	A	A
1.5	27	21	24	19	22	17
2.5	36	28	32	25	29	23
4	46	36	41	32	40	31
6	57	44	51	40	51	39
10	76	59	68	53	71	53
16	97	75	87	68	95	73
25	124	96	112	86	126	98
35	148	114	133	103	152	121
50	174	135	157	122	189	150
70	213	166	192	149	240	187
95	256	198	230	178	297	230
120	289	225	260	203	346	268
150	326	253	293	228	390	309
185	366	286	329	257	460	360
240	425	332	383	299	552	433
300	479	376	431	338	640	501
400	544	431	490	388	753	596
500	611	490	550	441	865	693
630	684	557	616	501	1001	814
800	762	632	686	569	1176	968
1000	838	701	745	631	1299	1102

TABLE 31

CURRENT RATINGS FOR TWIN 650/1100 VOLTS ARMOURED OR UNARMOURED 1.1 KV XLPE CABLES TO IS:7098 (Part 1)

NOMINAL AREA OF CONDUCTOR	LAID DIRECT IN THE GROUND		IN DUCTS		IN AIR	
	Copper	Aluminium	Copper	Aluminium	Copper	Aluminium
mm²	A	A	A	A	A	A
1.5	33	26	30	23	29	23
2.5	43	34	39	31	39	30
4	56	43	50	39	51	39
6	71	55	64	50	64	50
10	92	71	83	64	88	67
16	116	91	104	82	113	88
25	152	120	137	106	153	117
35	180	143	162	129	186	145
50	218	167	196	150	226	176
70	264	204	239	184	284	221
95	314	245	283	221	348	271
120	357	278	321	250	402	316
150	403	315	363	284	461	362
185	453	356	408	320	533	420
240	518	407	466	366	633	497
300	583	463	525	417	732	578
400	658	528	592	475	841	678
500	730	594	667	535	957	768
630	814	676	733	608	1103	913

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TABLE 32

CURRENT RATINGS FOR THREE, THREE AND HALF AND FOUR CORE 650/1100 VOLTS ARMOURED OR UNARMOURED 1.1 KV XLPE CABLES ACCORDING TO IS:7098 (Part 1)

NOMINAL AREA OF CONDUCTOR	LAID DIRECT IN THE GROUND		IN DUCTS		IN AIR	
	Copper	Aluminium	Copper	Aluminium	Copper	Aluminium
mm²	A	A	A	A	A	A
1.5	25	20	23	18	22	18
2.5	34	27	31	24	30	23
4	44	34	40	31	40	31
6	55	43	50	39	51	40
10	73	57	66	51	70	53
16	97	73	87	66	90	70
25	122	94	110	85	123	96
35	146	113	131	102	151	117
50	172	133	155	120	183	142
70	211	164	190	148	231	179
95	253	196	228	176	285	221
120	287	223	259	201	330	257
150	321	249	[illegible]	224	375	292
185	361	282	[illegible]	254	430	337
240	416	326	[illegible]	293	508	399
300	464	367	418	330	575	455
400	521	410	465	376	661	530
500	582	470	[illegible]	423	753	612
630	644	529	[illegible]	476	851	707

TABLE 49

RATING FACTORS FOR VARIATION IN GROUND TEMPERATURE FOR CABLES LAID DIRECT IN THE GROUND

Max. conductor temperature (°C)	Ground temperature in °C						
	15	20	25	30	35	40	45
65	1.2	1.13	1.07	1.0	0.93	0.85	0.76
70	1.17	1.12	1.06	1.0	0.94	0.87	0.79
80	1.14	1.10	1.05	1.0	0.95	0.89	0.84
85	1.13	1.09	1.04	1.0	0.95	0.90	0.85
90	1.12	1.08	1.03	1.0	0.96	0.91	0.87

TABLE 51

RATING FACTORS FOR VARIATION IN AMBIENT AIR TEMPERATURE

Maximum Conductor temperature (°C)	Ambient Air temperature (°C)																				
	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	110	120	130	140
60	1.32	1.22	1.10	1.0	0.86	0.69	--	--	--	--	--	--	--	--	--	--	--	--	--	--
65	1.30	1.21	1.10	1.0	0.88	0.77	0.63	--	--	--	--	--	--	--	--	--	--	--	--	--
70	1.25	1.16	1.09	1.0	0.9	0.81	0.70	0.57	--	--	--	--	--	--	--	--	--	--	--	--
80	1.19	1.12	1.06	1.0	0.92	0.86	0.79	0.70	0.61	0.50	--	--	--	--	--	--	--	--	--	--
85	1.15	1.10	1.05	1.0	0.94	0.88	0.81	0.74	0.66	0.57	0.47	--	--	--	--	--	--	--	--	--
90	1.14	1.10	1.04	1.0	0.95	0.90	--	--	--	--	--	--	--	--	--	--	--	--	--	--
105	--	--	1.0	1.0	1.0	1.0	0.95	0.90	0.85	0.80	0.74	0.67	0.60	0.52	0.43	--	--	--	--	--
150	--	--	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.94	0.82	0.71	0.56	0.39

TABLE 52

RATING FACTORS
FOR VARIATION IN THERMAL RESISTIVITY OF SOIL FOR THREE SINGLE CORE CABLES LAID DIRECT IN GROUND IN TREFOIL TOUCHING

Nom. area of conductor (sq. mm)	Thermal resistivity of Soil in °C cm/watt.					
	100	120	150	200	250	300
1.5	1.18	1.09	1.0	0.9	0.82	0.76
2.5	1.18	1.09	1.0	0.9	0.82	0.76
4	1.18	1.09	1.0	0.9	0.82	0.76
6	1.18	1.09	1.0	0.9	0.82	0.76
10	1.18	1.09	1.0	0.89	0.81	0.75
16	1.19	1.09	1.0	0.89	0.81	0.74
25	1.19	1.09	1.0	0.89	0.80	0.74
35	1.20	1.09	1.0	0.88	0.80	0.74
50	1.20	1.09	1.0	0.88	0.80	0.74
70	1.21	1.10	1.0	0.88	0.80	0.74
95	1.22	1.10	1.0	0.88	0.80	0.74
120	1.22	1.10	1.0	0.88	0.79	0.74
150	1.22	1.10	1.0	0.88	0.79	0.73
185	1.22	1.10	1.0	0.88	0.79	0.73
240	1.22	1.10	1.0	0.88	0.79	0.73
300	1.22	1.10	1.0	0.88	0.79	0.72
400	1.24	1.11	1.0	0.88	0.79	0.72
500	1.24	1.11	1.0	0.88	0.79	0.72
630	1.24	1.11	1.0	0.88	0.79	0.72
800	1.24	1.11	1.0	0.88	0.79	0.72
1000	1.24	1.11	1.0	0.88	0.79	0.72

TABLE 54

RATING FACTORS FOR VARIATION IN THERMAL RESISTIVITY OF SOIL FOR TWIN AND MULTICORE CABLES LAID DIRECT IN THE GROUND

Nom. area of conductor (sq. mm)	Thermal resistivity of Soil in °C cm/watt					
	100	120	150	200	250	300
1.5	1.10	1.05	1.0	0.92	0.86	0.81
2.5	1.10	1.05	1.0	0.92	0.86	0.81
4	1.10	1.05	1.0	0.92	0.86	0.81
6	1.10	1.05	1.0	0.92	0.86	0.81
10	1.10	1.06	1.0	0.92	0.85	0.80
16	1.12	1.06	1.0	0.91	0.84	0.79
25	1.14	1.08	1.0	0.91	0.84	0.78
35	1.15	1.08	1.0	0.91	0.84	0.77
50	1.15	1.08	1.0	0.91	0.84	0.77
70	1.15	1.08	1.0	0.90	0.83	0.76
95	1.15	1.08	1.0	0.90	0.83	0.76
120	1.17	1.09	1.0	0.90	0.82	0.76
150	1.17	1.09	1.0	0.90	0.82	0.76
185	1.18	1.09	1.0	0.89	0.81	0.75
240	1.18	1.09	1.0	0.89	0.81	0.75
300	1.18	1.09	1.0	0.89	0.81	0.75
400	1.19	1.10	1.0	0.89	0.81	0.75
500	1.21	1.10	1.0	0.89	0.81	0.75
630	1.22	1.10	1.0	0.89	0.81	0.74

TABLE 55

RATING FACTORS FOR VARIATION IN THERMAL RESISTIVITY OF SOIL FOR TWIN AND MULTICORE CABLES LAID IN SINGLE WAY DUCTS

Nom. area of conductor (sq. mm)	Thermal resistivity of Soil in °C cm/watt.					
	100	120	150	200	250	300
1.5	1.05	1.03	1.0	0.96	0.91	0.88
2.5	1.05	1.03	1.0	0.96	0.91	0.88
4	1.05	1.03	1.0	0.96	0.91	0.88
6	1.05	1.03	1.0	0.96	0.91	0.88
10	1.05	1.03	1.0	0.95	0.90	0.87
16	1.06	1.03	1.0	0.95	0.90	0.86
25	1.07	1.04	1.0	0.95	0.90	0.85
35	1.08	1.04	1.0	0.94	0.89	0.84
50	1.08	1.04	1.0	0.94	0.89	0.84
70	1.08	1.04	1.0	0.94	0.88	0.83
95	1.08	1.04	1.0	0.94	0.87	0.83
120	1.09	1.05	1.0	0.94	0.87	0.82
150	1.09	1.05	1.0	0.93	0.86	0.82
185	1.10	1.05	1.0	0.93	0.86	0.81
240	1.10	1.05	1.0	0.92	0.86	0.81
300	1.10	1.05	1.0	0.92	0.86	0.81
400	1.11	1.06	1.0	0.92	0.86	0.81
500	1.12	1.06	1.0	0.92	0.86	0.81
630	1.12	1.06	1.0	0.92	0.85	0.80

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TABLE 56

RATING FACTORS
FOR VARIATION IN DEPTH OF LAYING FOR CABLE LAID DIRECT IN GROUND

Depth of laying (cm)	1.1 KV Cables			3.3, 6.6 & 11 KV Cables	22, & 33 KV Cables
	Upto 25 sq. mm	Above 25 sq. mm upto 300 sq. mm	Above 300 sq. mm	(All sizes)	(All sizes)
75	1.0	1.0	1.0	--	--
90	0.99	0.98	0.97	1.0	--
105	0.98	0.97	0.96	0.99	1.0
120	0.97	0.96	0.95	0.98	0.99
150	0.96	0.94	0.92	0.96	0.97
180 or more	0.95	0.93	0.91	0.95	0.96

TABLE 57

RATING FACTORS
FOR VARIATION IN DEPTH OF LAYING FOR TWIN AND *MULTICORE CABLES LAID IN SINGLE WAY DUCTS*

Depth of laying (cm)	1.1 KV Cables	3.3, 6.6 KV & 11 KV Cables	22 & 33 KV Cables
75	1.0	--	--
90	0.99	1.0	--
105	0.98	0.99	1.0
120	0.97	0.98	0.99
150	0.96	0.97	0.98
180	0.95	0.96	0.97
270	0.92	0.93	0.94
360	0.91	0.92	0.92
450	0.90	0.91	0.91
540 or more	0.89	0.90	0.90

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TABLE 58

GROUP RATING FACTORS
FOR SINGLE CORE CABLES LAID IN TREFOIL FORMATION

A) Cables laid in ground in horizontal formation.

No. of Trefoils in group	Spacing between Trefoils			
	Touching	15 cm.	30 cm.	45 cm.
2	0.78	0.81	0.85	0.88
3	0.68	0.71	0.77	0.81
4	0.61	0.65	0.72	0.76
5	0.56	0.61	0.68	0.73

B) Cables laid in Trefoil Ducts in horizontal formation.

No. of Trefoils in group	Spacing between Trefoils		
	Touching	45 cm.	60 cm.
2	0.87	0.90	0.91
3	0.79	0.83	0.86
4	0.74	0.79	0.82
5	0.71	0.76	0.80

C) Cables laid on Racks/Trays in covered trench with removable covers where air circulation is restricted, Trefoils are seperated by two cable dia horizontally and the trays are in tiers with 30 cm. gap between them.

No. of racks/trays in tiers	No. of trefoils in Horizontal formation		
	1	2	3
1	0.95	0.90	0.88
2	0.90	0.85	0.83
3	0.88	0.83	0.81
6	0.86	0.81	0.79

D) Cables laid as in 'C' but in open air.

1	1.0	0.98	0.96
2	1.0	0.95	0.93
3	1.0	0.94	0.92
6	1.0	0.93	0.90

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TABLE 59
GROUP RATING FACTORS
FOR MULTICORE CABLES

A) Cables laid inside concrete trench with removable covers, on cable trays where air circulation is restricted. The cables spaced by one cable diameter and trays in tiers by 300 mm. The clearance of the cable from the wall is 25 mm.

No. of cable trays in tier	No. of cables				
	1	2	3	6	9
1	0.95	0.90	0.88	0.85	0.84
2	0.90	0.85	0.83	0.81	0.80
3	0.88	0.83	0.81	0.79	0.78
6	0.86	0.81	0.79	0.77	0.76

B) Cables laid on cable trays exposed to air, the cables spaced by one cable diameter and trays in tiers by 300 mm. The clearance between the wall and the cable is 25 mm

No. of cable trays in tier	No. of cables				
	1	2	3	6	9
1	1	0.98	0.96	0.93	0.92
2	1	0.95	0.93	0.90	0.89
3	1	0.94	0.92	0.89	0.88
6	1	0.93	0.90	0.87	0.86

C) Cables laid on cable trays exposed to air, the cables touching and trays in tiers by 300 mm. The clearance between the wall and the cable 25 mm.

No. of trays	No. of cables per tray				
	1	2	3	6	9
1	1.0	0.84	0.80	0.75	0.73
2	1.0	0.80	0.76	0.71	0.69
3	1.0	0.78	0.74	0.70	0.68
6	1.0	0.76	0.72	0.68	0.66

D) Cables laid direct in ground in horizontal formation

No. of cables in group	Spacing of cables			
	Touching	15 cm.	30 cm.	45 cm.
2	0.79	0.82	0.87	0.90
3	0.69	0.75	0.79	0.83
4	0.62	0.69	0.74	0.79
5	0.58	0.65	0.72	0.76
6	0.54	0.61	0.69	0.75

E) Cables laid in single way ducts/pipes in horizontal formation.

No. of cables in group	Spacing of cables			
	Touching	30 cm.	45 cm.	60 cm.
2	0.88	0.90	0.92	0.94
3	0.82	0.84	0.87	0.89
4	0.77	0.80	0.84	0.87
5	0.74	0.78	0.82	0.85
6	0.71	0.76	0.81	0.84

Coal to 2000 TPD Ammonium Nitrate, LSTK-1

Design Calculations For MV Cable Sizing & Selection

BHARAT HEAVY ELECTRICALS LIMITED
INDUSTRIAL SYSTEM GROUP
BANGALORE-12

INDEX

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1.0 **CONTENTS**

This document includes the following:

(a) Scope

(b) Type of cables selected

(c) Basis for design calculations

(d) Sample calculations

(e) Selection tables for cable sizes

(f) Cable data

(g) Selected cable summary

2.0 **SCOPE**

2.1 The scope of this document covers the selection and/or sizing calculations of 11kV & 3.3 kV grade power cables required for the interconnection of electrical equipment of CHP, AHP and LHP package.

2.2 Reference Documents

Cable Sizing shown in this document are done at 40 KA for 11kV & 40 kA for 3.3kV.

3.0 **TYPES OF CABLES SELECTED**

S.NO.	ITEM	PARTICULARS
1	**REFERENCE STANDARD**	IS-7098 PART-II IN GENERAL
2	**SYSTEM VOLTAGE**	11 KV & 3.3 KV
3	**VOLTAGE GRADE OF CABLES**	11/11KV (UE)
		3.3/3.3 KV (UE)
4	**CONDUCTOR**	
(a)	REFERENCE STANDARD	IS-8130
(b)	MATERIAL	STRANDED ALUMINIUM H2 GRADE CLASS 2
(c)	SHAPE	COMPACTED CIRCULAR
(d)	SIZES (NO. OF CORES -CROSS-SECTIONAL AREA)	
	(i) 11 KV SYSTEM	(UE): 3C-300 (ARMOURED)
	(ii) 3.3KV SYSTEM	(UE) 3C-240 (ARMOURED), (UE) 3C-150 (ARMOURED), (UE) 3C-95 (ARMOURED) 1C-150(ARMOURED) FOR NGR
5	**CONDUCTOR SCREENING**	EXTRUDED SEMI-CONDUCTING COMPOUND
6	**INSULATION**	
(a)	REFERENCE STANDARD	IS-7098 PART-II
(b)	MATERIAL	EXTRUDED XLPE
7	**INSULATION SCREENING**	
(i)	NON METALLIC	
(a)	REFERENCE STANDARD	IS-7098 PART -II
(b)	MATERIAL	EXTRUDED SEMI-CONDUCTING COMPOUND
(ii)	METALLIC	COPPER TAPE SIZED FOR CARRYING EARTH FAULT CURRENT OF 600A FOR 2 SEC except for Single Core Armoured Cables where armour shall constitute the metallinc part of the screening
8	**INNER SHEATH**	
(a)	REFERENCE STANDARD	IS-5831 & IS-7098 PART II
(b)	MATERIAL	EXTRUDED PVC TYPE ST2
(C)	COLOR	BLACK
(D)	APPLICATION	Only for multicore cables
9	**ARMOUR**	

(a)	SINGLE CORE CABLES	
(i)	REFERENCE STANDARD	IS- 3975 & IS- 7098 PART II
(ii)	MATERIAL	NON-MAGNETIC HARD DRAWN ALUMINIUM GRADE H4
(iii)	SHAPE	ROUND WIRE
(b)	MULTI- CORE CABLES	
(i)	REFERENCE STANDARD	IS- 3975 & IS- 7098 PART II
(ii)	MATERIAL	GALVANISED STEEL
(iii)	SHAPE	ROUND WIRE/ STRIP
10	**OUTER SHEATH**	
(i)	REFERENCE STANDARD	IS 5831 & IS 7098 PART II
(ii)	MATERIAL	EXTRUDED FRLS PVC TYPE ST2
(iii)	COLOR	Black
11	Type of curing	DRY CURING/GAS CURING/STEAM CURING

4.0 BASIS FOR DESIGN CALCULATIONS

4.1 DESIGN CONSIDERATIONS

4.1.1 In general, MV Power Cables are sized to satisfy the following three criteria:

(a) Short circuit current withstand capacity for applicable fault current and duration.

(b) Full load current carrying capacity under installation conditions (i.e. with suitable derating factors to cover site conditions such as ambient and ground temperatures, grouping and soil resistivity and cable laying configuration).

(c) Maximum voltage drop limits under steady state / transient state as applicable.

4.1.2 The normal current ratings for the feeders are considered as under:

(a) 11 kV and 3.3KV Transformer feeders:

Current ratings corresponding to max. current tap of the transformer.

(b) 3.3kV Motor feeders:

Current ratings corresponding to the full load current of motor :

Power factor and efficiency for 3.3 kV motors are considered as below :

Cosf for all 3.3 KV Motors=	0.85
PF during starting	0.2
Efficiency for 3.3 kV motors=	0.95

4.2 BASIC INPUT DATA

The following data is used as the basic input data for sizing & selection of cables.

(a)	Design ambient temperature:	50 ℃
(b)	Fault current for 11 kV system:	40 kA RMS
	Fault current for 3.3 KV system:	40 kA RMS
(c)	Main protection fault clearing time for cables protected by Breaker :-	
(i)	TRANSFORMER FEEDERS (11 kV/433 V, 3.3KV/433V & 11 kV/3.45 kV)	0.12 sec. (min.)
(ii)	11 kV /3.3kV MOTOR FEEDERS IF VCB PROVIDED	0.12 sec. (min.)
(ii)	11 kV /3.3kV MOTOR FEEDERS IF VC WIYH HT FUSE PROVIDED	0.01 sec. (min.)

(d) Annexure-B: Cable Technical Data

Current ratings (AC)-IS-3961 PART-7 : 2017

- Table-2	**Current ratings (a.c.) for two single core cables with XLPE insulation, Aluminium conductor and Rated voltage 1.9/ 3.3kV to 3.8/6.6 kV (Clause 3)**
Table-4	**Current ratings (a.c.) for two single core cables with XLPE insulation, Aluminium conductor and Rated voltage 6.6/ 6.6kV to 11/11 kV (Clause 3)**
Table-6	**Current ratings (a.c.) for two single core cables with XLPE insulation, Aluminium conductor and Rated voltage 12.7/ 22kV and 19/33 kV (Clause 3)**
Table-8	**Current ratings three-core cables with XLPE insulation, Aluminium conductor and Rated voltage 1.9/ 3.3 kV to 3.8/6.6 kV (Clause 3)**
Table-10	**Current ratings three-core cables with XLPE insulation, Aluminium conductor and Rated voltage 6.6/ 6.6kV to 11/11 kV (Clause 3)**

Table-12 **Current ratings three-core cables with XLPE insulation, Aluminium conductor and Rated voltage 12.7/ 22 kV to 19/33 kV (Clause 3)**

Derating factors for installation conditions-IS-3961 PART-7 : 2017

- **Table-13** **Rating factors for variation in ambient air temperature for cables in free air.**

Table-14 **Rating factors for variation in Ground temperature for direct burried cables.**

Table-16 **Rating factors for Depths of Laying for direct burried cables.**

Table-18 **Rating factors for variation in Soil Thermal Resistivity for single core 3.3kV, 6.6kV and 11kV cables laid direct in ground**

Table-22 **Rating factors for variation in Soil Thermal Resistivity for three core 3.3kV, 6.6kV and 11kV cables laid direct in ground**

Table-28 **Group rating factors for three core cables in horizontal formationlaid direct in the ground**

Table-34 **Group rating factors to be applied for circuits of three single core cables in air on perforated trays and ladder supports in trefoil formation.**

Table-32 **Group rating factors for three-core cables in air on ladder supports, cleats, etc.**

Resistances & Reactances-CABLE CATALOGUE OF UNIVERSAL CABLES LIMITED

- Table-62 Approximate AC resistance of conductor (Ohm/ km) at maximum operating conductor temperature PVC, HR PVC and XLPE cables.

Table-64 Approximate reactance at 50 Hz (Ohms/km), single core HV XLPE cables

Table-65 Approximate reactance at 50 Hz (Ohms/km), three core HV XLPE cables

4.3 DESIGN BASIS OF CABLE SIZING

(a) MINIMUM SIZE FOR SHORT CIRCUIT CURRENT WITHSTAND CAPACITY

(i)a 11 KV and 3.3KV Transformer/Motor feeders with VCB

Fault current Ish	=	40	kA RMS
Fault clearing time t	=	0.12	sec. (min.)
Minimum cross-sectional area to withstand short circuit, A	=	Ish x SQRT(t) / k	
where k is a constant (for aluminium conductor XLPE insulation)	=	0.094	
Therefore, A	=	147.41	mm^2
Nearest conductor size =		150	mm^2
Minimum Cable conductor size selected =		150	mm^2

(ii) 3.3 KV Motor feeders with VC and HT Fuse

Fault current Ish =	40	kA RMS
Fault clearing time t =	0.01	sec. (min.)
Minimum cross-sectional area to withstand short circuit, A=	Ish x SQRT(t) / k	
where k is a constant (for aluminium conductor XLPE insulation) =	0.094	
Therefore, A=	42.55	mm^2
Nearest conductor size =	50	mm^2
Minimum Cable conductor size selected =	50	mm^2

(b) CABLE SIZES BASED ON LOAD CURRENT CARRYING CAPACITY : DERATING FACTORS

(i) CABLES LAID IN AIR :

Cables are laid in cable trays in ventilated cable vaults/Trenches and outdoor overhead pipe -cum-cable trestles for most part. Very short local runs of individual cables near equipmment may be routed through local trenches/ slits to suit termination requirements. Hence the following derating factors are considered:-

(1) Temperature derating factor (K1)

For 50 deg. C ambient temperature, derating factor (K1)= 0.89

(refer Table-13)

(2) Group derating factor (K2)

No. of cores	Arrangement of cables	K2	Table ref.
Single core	3 Trays & 3 no. of trefoils per tray, separated by 2 cable dia	**0.9**	**Table 34**
Multi core	3 Trays & 6 cables/tray, cables touching	**0.73**	**Table 32**

(3) Overall derating factor = K1 x K2

For single core HTcables (Khas) = 0.80

Khas = Overall derating factor for HT single core cable laid in air

For multi core HT cables (Kham) = 0.65

Kham = Overall derating factor for HTmulti core cable laid in air

CABLES LAID DIRECTLY IN GROUND

ii) Derating factors for cables laid directly in ground are listed below:

Temperature derating factor (K3)

i) For 40 deg. C ground temperature, derating factor = 0.91

(refer Table-14)

Group derating factor (K4)

ii) No. of cores Arrangement of cables = K4

Multi core 4 no. cable in horizontal formation = 0.62

Derating factor for variation in thermal resistivity of soil (150 deg. C cm/ W) (K5) = 1

iii) (Refer Table-18 & 22)

Derating factor for depth of laying 1

iv) (depth of laying considered=0.9m.)

(Refer Table-16)

Overall derating factor = K3 x K4 x K5 x K6

For multi core HT cables (K_{Hgm}) = 0.56

(c) **CABLE SIZES BASED ON VOLTAGE DROP CRITERIA**

Cable size based on voltage drop limits:

For motor feeders, the voltage drop is calculated for both steadystate (running) conditions as well as transient (starting) conditions.

Permissible voltage drop in cable under Steady State considered as 3% and under transient state considered as 10%

(i) Steady state conditions

The voltage drop for a given cable length under steady state conditions is given by the formula:

Voltage drop in %=

$$(\sqrt{3}*I*l*(R*Cos\varphi+X*Sin\varphi))/(V*n)*100$$

Where:

I= Full Load current in Amperes for steady state conditions

COS Φ = Power Factor at running (for motor feeders).

l= Feeder length in KM

R= AC Resistance of conductor in Ohm/km

X= Reactance of conductor in Ohm/km at 50 Hz.

n= Number of runs of cable

(ii) Transient state conditions

The voltage drop for a given cable length under transient state conditions is given by the formula:

Voltage drop in %=

$$(\sqrt{3}*Ist*l*(R*Cos\varphi st+X*Sin\varphi st))/(V*n)*100$$

Where:

I_{st} = Starting current for transient conditions (for motor feeders).

COS Φ_{st} = Power Factor at starting (for motor feeders).

n= Number of runs of cable

Starting load power factor = 0.2

5.0 SAMPLE CALCULATIONS

5.1 11 kV FEEDERS

5.1.1 FEEDER FROM 11KV Board TO 20000KVA Transformer(Max Rating envisaged for CHP/LHP/AHP)

(a) Fault Current Criterion

Minimum size =	150	sq. mm.

(b) Load Current Criterion

Rating of the Transformer =	20000	kVA
Full load Current=20000 /(SQRT(3) * 11)=	1049.73	A
Overall Derating Factor for 3-core HT cables laid in air (K_{ham})=	0.65	
Uprated load current=1049.73/0.65=	1614.97	A
From Annex.-B, Table-10, current rating of 3C-300 sq. mm. Cable in air=	441	A

Hence Cable size for load current=4RX3C-300sq. mm.

Final cable size selected is 4RX3C-300 sq mm. No of Runs will change as per Final MVA

5.1.2 FEEDER FROM 3.3KV AHP/CHP/LHP Board TO 2500KVA Transformer

(a) Fault Current Criterion

Minimum size =	150	sq. mm.

(b) Load Current Criterion

Rating of the Transformer =	2500	kVA
Full load Current=2500 /(SQRT(3) * 3.3)=	437.39	A
Overall Derating Factor for 3-core HT cables laid in air (K_{ham})=	0.65	
Uprated load current=437.39/0.65=	672.91	A
From Annex.-B, Table-8, current rating of 3C-240 sq. mm. Cable in air=	385	A

Hence Cable size for load current=2RX3C-240sq. mm.

Final cable size selected is 2RX3C-240 sq mm.

5.2 FEEDER FROM 3.3 KV BOARD TO MOTOR WITH VCB

(a) Fault Current Criterion

Minimum size =	150	sq. mm.

(b) Load Current Criterion

Rating of motor =	600	KW
Full load Current=600 /(SQRT(3) * 3.3*0.95*0.85)=	130.00	A
Overall Derating Factor for 3-core HT cables laid in air Khas=	0.65	
Uprated load current=130/0.65=	200.00	A
From Annex.-B, Table-8, current rating of 3C-150 sq. mm. cable in air=	286	A

Final cable size selected is 3C-150 sq mm if VCB type is used.

(c) **Voltage drop Criterion***

For motor feeders, the voltage drop is calculated for both steady state (running) conditions as well as transient state (starting) conditions.

(i) Steady state conditions

Full load current=	130.00	A
Resistance (R) of 3C-150 sq.mm Al. conductor at 90ºC with XLPE insulation = 0.264 (Refer Table 62)		ohms/km
Reactance (X) of 3C-150 sq.mm Al. conductor at 90ºC with XLPE insulation = 0.0769 (Refer Table 65)		ohms/km
CosΦ =	0.85	
SinΦ =	0.526782688	
Feeder length l =	0.8	km
Voltage drop in % for 3C-150 sq. mm (AL.) Cable =	0.434	%

(ii) Transient state conditions

Starting current= 7.2*I	936	A
Resistance (R) of 3C-150 sq.mm Al. conductor at 90ºC with XLPE insulation = 0.264 (Refer Table 62)		ohms/km
Reactance (X) of 3C-150 sq.mm Al. conductor at 90ºC with XLPE insulation = 0.0769 (Refer Table 65)		ohms/km
CosΦ =	0.2	
SinΦ =	0.979795897	
Feeder length l =	0.8	km
Voltage drop in % for 3C-150 sq. mm (AL.) Cable =	5.03627469	%

Thus, final cable size selected is 3C-150 sq mm is sufficient as per voltage drop criteria also.

5.3 FEEDER FROM 3.3 KV BOARD TO MOTOR WITH VC AND HT FUSE

(a) Fault Current Criterion

Minimum size =	50	sq. mm.

(b) Load Current Criterion

Rating of motor =	600	KW
Full load Current=600 /(SQRT(3) * 3.3*0.95*0.85)=	130.00	A
Overall Derating Factor for 3-core HT cables laid in air Khas=	0.65	
Uprated load current=130/0.65=	200.00	A
From Annex.-B, Table-8, current rating of 3C-95 sq. mm. cable in air=	221	A

Final cable size selected is 3C-95 sq mm if Vacuum Contactor type is used.

(c) **Voltage drop Criterion***

For motor feeders, the voltage drop is calculated for both steady state (running) conditions as well as transient state (starting) conditions.

(i) Steady state conditions

Full load current=		130.00	A
Resistance (R) of 3C-95 sq.mm Al. conductor at 90ºC with XLPE insulation (Refer Table 62)	= 0.409		ohms/km
Reactance (X) of 3C-95 sq.mm Al. conductor at 90ºC with XLPE insulation (Refer Table 65)	= 0.0813		ohms/km
CosΦ =		0.85	
SinΦ =		0.526782688	
Feeder length l =		0.8	km
Voltage drop in % for 3C-95 sq. mm (AL.) Cable =		0.639	%

(ii) Transient state conditions

Starting current= 7.2*I		936	A
Resistance (R) of 3C-95 sq.mm Al. conductor at 90ºC with XLPE insulation (Refer Table 62)	= 0.409		ohms/km
Reactance (X) of 3C-95 sq.mm Al. conductor at 90ºC with XLPE insulation (Refer Table 65)	= 0.0813		ohms/km
CosΦ =		0.2	
SinΦ =		0.979795897	
Feeder length l =		0.8	km
Voltage drop in % for 3C-95 sq. mm (AL.) Cable =		6.345433469	%

Thus, final cable size selected is 3C-95 sq mm is sufficient as per voltage drop criteria also.

SR. NO.	Feeder	Rating (MW/ MVA)	Unit	Voltage, (KV)	Efficiency	Running PF	Starting PF	Full Load Current in Amps	Ambient &Grouping rating factor	Laid in air / ground	Required current rating of Cable (A)	Short Circuit rating in KA	Short Circiut with stand duration in sec	Min size for Sh.Ckt. w/stand capacity (mm2)	Selected Cable details(sq.mm)	Cable rating in Amps	No. of runs required	Selected No.of 3C Cable / 1C Cables per Ph.	Cable resistance in Ohms\km	Cable reactance in Ohms\km	Route Length in meter	%Voltage drop during Running	%Voltage drop during Starting	Remarks
1	CONV/CRUSHER MOTOR WITH VCB	0.6	MW	3.3	0.95	0.85	0.2	130.00	0.65	Air	200.00	40	0.12	150	3C X 150 SQ. MM XLPE-AL (A)FRLS	286	0.699	1	0.264	0.0769	800	0.434	5.036	
1	CONV/CRUSHER MOTOR WITH VC & HT FUSE	0.6	MW	3.3	0.95	0.85	0.2	130.00	0.65	Air	200.00	40	0.12	50	3C X 95 SQ. MM XLPE-AL (A)FRLS	221	0.905	1	0.409	0.0813	800	0.639	6.345	

ANNEXURE - A
CABLE DATA

Table 4 Current Ratings (a.c.) for Two Single-Core Cables with XLPE Insulation, Aluminum Conductor and Rated Voltage 6.6/6.6 kV to 11/11 kV

(*Clause* 3)

Sl No.	Nominal Area of Conductor	Buried Direct in the Ground		In Single-Way Ducts		In Air	
		Trefoil	Flat Touching	Trefoil Ducts	Flat Touching Ducts	Trefoil	Flat Touching
	mm²	A	A	A	A	A	A
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	25	99	101	88	86	116	119
ii)	35	118	120	104	102	140	143
iii)	50	138	141	122	120	167	171
iv)	70	168	172	149	146	209	213
v)	95	200	204	177	172	254	258
vi)	120	227	230	200	194	294	298
vii)	150	252	255	223	215	331	335
viii)	185	284	284	250	238	383	384
ix)	240	326	323	286	270	450	446
x)	300	365	357	319	297	512	503
xi)	400	412	397	359	329	594	575
xii)	500	461	436	401	360	680	647
xiii)	630	514	476	445	390	778	725
xiv)	800	553	496	476	404	863	781
xv)	1 000	595	523	509	423	954	846

Table 6 Current Ratings (a.c.) for Two Single-Core Cables with XLPE Insulation, Aluminum Conductor and Rated Voltage 12.7/22 kV and 19/33 kV

(Clause 3)

Sl No.	Nominal Area of Conductor	Buried Direct in the Ground		In Single-Way Ducts		In Air	
		Trefoil	Flat Touching	Trefoil Ducts	Flat Touching Ducts	Trefoil	Flat Touching
	mm²	A	A	A	A	A	A
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	35	116	119	102	101	144	146
ii)	50	137	139	120	117	174	177
iii)	70	167	169	146	142	217	220
iv)	95	198	200	172	167	262	264
v)	120	224	225	195	188	302	303
vi)	150	249	249	217	207	339	340
vii)	185	280	279	243	231	389	387
viii)	240	321	316	278	261	455	449
ix)	300	355	343	307	282	515	501
x)	400	400	380	345	312	594	571
xi)	500	447	417	384	340	678	641
xii)	630	496	453	424	367	770	715
xiii)	800	543	486	475	402	866	789
xiv)	1 000	572	508	498	417	944	851

Table 8 Current Ratings for three-core cables with XLPE insulation, Aluminium Conductor and Rated Voltage 1.9/3.3 kV to 3.8/6.6 kV

(*Clause* 3)

Sl No.	Nominal Area of Conductor	Buried Direct in Ground	In a Buried Duct	In Air
	mm²	A	A	A
(1)	(2)	(3)	(4)	(5)
i)	25	94	81	102
ii)	35	112	96	123
iii)	50	131	113	146
iv)	70	160	138	182
v)	95	191	165	221
vi)	120	216	187	254
vii)	150	241	208	286
viii)	185	273	236	330
ix)	240	315	277	385
x)	300	354	312	440
xi)	400	403	355	512
xii)	500	457	403	590

Table 10 Current Ratings for Three-Core Cables with XLPE Insulation, Aluminium Conductor and Rated Voltage 6.6/6.6 kV to 11/11 kV

(Clause 3)

Sl No.	Nominal Area of Conductor	Buried Direct in Ground	In a Buried Duct	In Air
	mm^2	A	A	A
(1)	(2)	(3)	(4)	(5)
i)	25	94	81	103
ii)	35	112	97	124
iii)	50	131	114	148
iv)	70	161	139	184
v)	95	190	165	222
vi)	120	216	188	256
vii)	150	242	209	288
viii)	185	273	240	330
ix)	240	315	278	387
x)	300	354	312	441
xi)	400	404	356	512
xii)	500	457	403	590

Table 12 Current Ratings for Three-Core Cables with XLPE Insulation, Aluminium Conductor and Rated Voltage 12.7/22 kV to 19/33 kV

(Clause 3)

Sl No.	Nominal Area of Conductor	Buried Direct in Ground	In a Buried Duct	In Air
	mm²	A	A	A
(1)	(2)	(3)	(4)	(5)
i)	35	111	97	127
ii)	50	130	116	152
iii)	70	159	142	189
iv)	95	189	169	227
v)	120	215	192	262
vi)	150	239	214	294
vii)	185	270	245	336
viii)	240	312	282	393
ix)	300	351	317	448
x)	400	400	361	519
xi)	500	454	408	598

Table 13 Rating Factors for Variation in Ambient Air Temperature for Cables in Free Air

(*Clauses* 3 *and* 9.1)

Maximum Conductor Temperature °C	Ambient Air Temperature °C							
	25	30	35	40	45	50	55	60
90	1.14	1.10	1.05	1.00	0.95	0.89	0.84	0.77

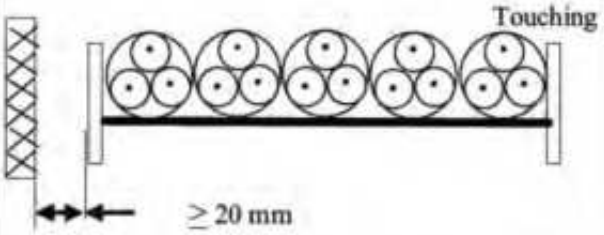
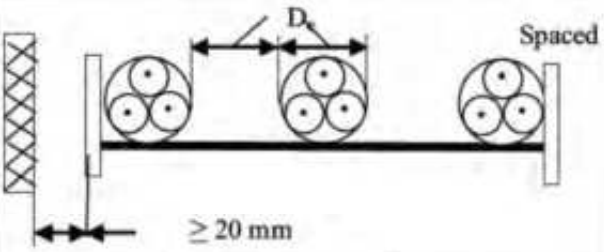
Table 14 Rating Factors for Variation in Ground Temperature for Direct Buried Cables

(*Clauses* 3 *and* 9.1)

Maximum Conductor Temperature °C	Ground Temperature °C							
	15	20	25	30	35	40	45	50
90	1.12	1.08	1.04	1.00	0.96	0.91	0.87	0.82

Table 32 Group Rating Factors for Three-Core Cables in Air on Ladder Supports, Cleats, etc

(Clause 3, 9.1 and 9.2)

	Number of Trays	Number of Cables					
		1	2	3	4	6	9
	1	1.00	0.87	0.82	0.80	0.79	0.78
	2	1.00	0.86	0.80	0.78	0.76	0.73
	3	1.00	0.85	0.79	0.76	0.73	0.70
	1	1.00	1.00	1.00	1.00	1.00	—
	2	1.00	0.99	0.98	0.97	0.96	—
	3	1.00	0.98	0.97	0.96	0.93	—

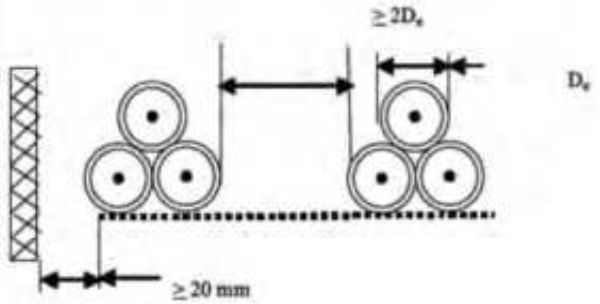
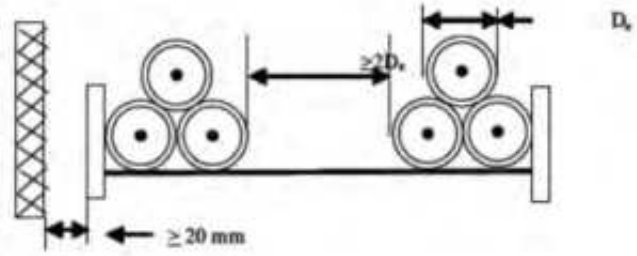
NOTES

1 Factors apply to single layer groups of cables as shown above. Factors for cables installed in more than one layer touching each other shall be significantly lower and must be determined by an appropriate method.

2 Factors are given for vertical spacing between trays of 300 mm and at least 20 mm between trays and wall. For closer spacing, the factors should be reduced.

Table 34 Group Rating Factors to be Applied for Circuits of Three Single Core Cables in Air on Perforated Trays and Ladder Supports in Trefoil Formation

(*Clauses* 3.1, 9.1 *and* 9.2)

	Number of Trays	Number of Three-Phase Circuits		
		1	2	3
Cables on perforated trays 	1	1.00	0.98	0.96
	2	0.97	0.93	0.89
	3	0.96	0.92	0.86
Cables on ladder supports, cleats, etc 	1	1.00	1.00	1.00
	2	0.97	0.95	0.93
	3	0.96	0.94	0.90

NOTES

1 Factors are given for single layers of trefoil groups as shown above. Factors for trefoil groups installed in more than one layer touching each other shall be significantly lower and must be determined by an appropriate method.

2 Factors are given for vertical spacing between trays of 300 mm and at least 20 mm between trays and wall. For closer spacing, the factors should be reduced.

3 For circuits having more than one cable in parallel per phase, each three phase set of conductors should be considered as a circuit for the purpose of this table.

TABLE 62

APPROXIMATE A.C. RESISTANCE OF CONDUCTOR (OHM/KM) AT MAX. OPERATING CONDUCTOR TEMPERATURE PVC, HR PVC & XLPE CABLES

Nominal area of conductor (sq. mm)	PVC CABLES (70 °C)		HR PVC CABLES (85 °C)		XLPE CABLES (90 °C)	
	Aluminium	Copper	Aluminium	Copper	Aluminium	Copper
1.5	21.72	14.52	22.81	15.25	23.2	15.5
2.5	14.52	8.89	15.25	9.34	15.5	9.5
4	8.89	5.53	9.34	5.81	9.5	5.9
6	5.53	3.70	5.81	3.88	5.9	3.94
10	3.70	2.20	3.88	2.31	3.94	2.34
16	2.29	1.38	2.41	1.45	2.44	1.47
25	1.44	0.873	1.51	0.916	1.53	0.931
35	1.04	0.629	1.09	0.661	1.11	0.671
50	0.770	0.465	0.808	0.488	0.818	0.496
70	0.532	0.322	0.559	0.338	0.565	0.344
95	0.384	0.233	0.404	0.244	0.409	0.248
120	0.304	0.185	0.328	0.194	0.323	0.197
150	0.248	0.150	0.261	0.158	0.264	0.160
185	0.198	0.121	0.206	0.127	0.210	0.129
240	0.152	0.094	0.159	0.098	0.161	0.099
300	0.122	0.075	0.128	0.079	0.129	0.080
400	0.096	0.061	0.101	0.063	0.102	0.064
500	0.076	0.049	0.079	0.051	0.082	0.052
630	0.061	0.040	0.063	0.042	0.065	0.043

TABLE 64

APPROXIMATE REACTANCE AT 50 HZ (OHMS/KM) SINGLE CORE HV XLPE CABLES

Nominal Area of Conductor (sq. mm)	3.3 KV (E) & (UE)		6.6 KV (E)		11 KV (E)		11 KV (UE)		22 KV (E)		33 KV (E)	
	Un-armoured	* Armoured	Un-armoured	* Armoured	Un-armoured	* Armoured	Un-armoured	* Armoured	Un-armoured	* Armoured	Un-armoured	* Armoured
25	0.116	0.125	0.130	0.138	0.136	0.143	0.148	0.153	–	–	–	–
35	0.110	0.119	0.125	0.131	0.130	0.136	0.140	0.145	0.143	0.146	–	–
50	0.103	0.112	0.119	0.123	0.124	0.127	0.134	0.137	0.136	0.139	0.140	0.153
70	0.0980	0.107	0.110	0.116	0.115	0.120	0.124	0.129	0.126	0.131	0.133	0.145
95	0.0945	0.102	0.105	0.110	0.109	0.114	0.117	0.122	0.120	0.126	0.127	0.137
120	0.0912	0.0981	0.102	0.106	0.105	0.110	0.115	0.119	0.117	0.121	0.122	0.132
150	0.089	0.0953	0.099	0.103	0.102	0.107	0.111	0.115	0.113	0.117	0.117	0.128
185	0.0865	0.0925	0.095	0.100	0.099	0.105	0.107	0.112	0.108	0.113	0.116	0.124
240	0.0835	0.0897	0.092	0.0976	0.095	0.101	0.102	0.107	0.104	0.109	0.111	0.121
300	0.0816	0.0874	0.091	0.0961	0.093	0.0982	0.099	0.105	0.102	0.106	0.106	0.117
400	0.080	0.0862	0.089	0.0940	0.090	0.0949	0.097	0.101	0.098	0.102	0.103	0.112
500	0.0787	0.0843	0.087	0.0921	0.088	0.0917	0.093	0.0974	0.0952	0.100	0.0994	0.109
630	0.0774	0.0830	0.085	0.0890	0.085	0.0892	0.091	0.0956	0.092	0.0967	0.0960	0.106
800	0.0764	0.0815	0.082	0.0891	0.083	0.0893	0.088	0.0937	0.0889	0.0948	0.0925	0.101
1000	0.0761	0.0818	0.081	0.0874	0.081	0.0874	0.086	0.0913	0.0871	0.0926	0.0907	0.100

* Round wire armoured (without inner sheath construction)

TABLE 65

APPROXIMATE REACTANCE AT 50 HZ (OHMS/KM) THREE CORE HV XLPE CABLES

Nominal Area of Conductor (sq. mm)	3.3 KV (E) & (UE)	6.6 KV (E)	11 KV (E)	11 KV (UE)	22 KV (E)	33 KV (E)
25	0.0981	0.118	0.125	0.139	–	–
35	0.0940	0.113	0.118	0.132	0.135	–
50	0.0878	0.105	0.111	0.123	0.127	0.140
70	0.0842	0.100	0.105	0.116	0.119	0.132
95	0.0813	0.095	0.101	0.111	0.113	0.125
120	0.0785	0.092	0.0964	0.106	0.109	0.120
150	0.0769	0.090	0.0952	0.103	0.105	0.117
185	0.0755	0.087	0.0913	0.100	0.102	0.113
240	0.0737	0.084	0.0879	0.096	0.0980	0.108
300	0.0725	0.083	0.0866	0.094	0.0960	0.105
400	0.0712	0.081	0.0839	0.091	0.0925	0.101
500	0.0688	0.079	–	–	–	–
630	0.0678	0.077	–	–	–	–

Table 16 Rating Factors for Depths of Laying for Direct Buried Cables

(Clauses 3 and 9.1)

Sl No.	Depth of Laying mm	3.3 kV, 6.6 kV and 11 kV Cables			22 kV and 33 kV Cables		
		Single-Core Nominal Conductor Size, mm²		Three-core	Single Core Nominal Conductor Size, mm²		Three-Core
		≤185	>185		≤185	>185	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	900	1.00	1.00	1.00	—	—	—
ii)	1 050	0.99	0.98	0.98	1.00	1.00	1.00
iii)	1 200	0.97	0.96	0.97	0.99	0.98	0.99
iv)	1 500	0.95	0.94	0.95	0.97	0.96	0.97
v)	1 800	0.93	0.92	0.94	0.95	0.94	0.95
vi)	2 000	0.92	0.91	0.93	0.94	0.93	0.94
vii)	2 500	0.91	0.89	0.91	0.92	0.91	0.92
viii)	3 000	0.89	0.87	0.90	0.90	0.89	0.91

Table 18 Rating Factors for Variations in Soil Thermal Resistivity for Single-Core 3.3 kV, 6.6 kV and 11 kV Cables Laid Direct in Ground

(Clauses 3 and 9.1)

Sl No.	Nominal Area of Conductor	Values of Soil Thermal Resistivity K.m/W					
	mm²	1.0	1.2	1.5	2.0	2.5	3.0
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	25	1.17	1.09	1.00	0.89	0.80	0.74
ii)	35	1.18	1.10	1.00	0.89	0.80	0.74
iii)	50	1.18	1.10	1.00	0.88	0.80	0.74
iv)	70	1.19	1.10	1.00	0.88	0.80	0.73
v)	95	1.19	1.10	1.00	0.88	0.79	0.73
vi)	120	1.19	1.10	1.00	0.88	0.79	0.73
vii)	150	1.19	1.10	1.00	0.88	0.79	0.73
viii)	185	1.19	1.11	1.00	0.88	0.79	0.73
ix)	240	1.19	1.11	1.00	0.88	0.79	0.73
x)	300	1.20	1.11	1.00	0.88	0.79	0.72
xi)	400	1.20	1.11	1.00	0.87	0.79	0.72
xii)	500	1.20	1.11	1.00	0.87	0.79	0.72
xiii)	630	1.20	1.11	1.00	0.87	0.79	0.72
xiv)	800	1.20	1.11	1.00	0.87	0.78	0.72
xv)	1 000	1.21	1.11	1.00	0.87	0.78	0.72

Table 22 Rating Factors for Variations in Soil Thermal Resistivity for Three-Core 3.3 kV, 6.6 kV and 11 kV Cables Laid Direct in Ground

(Clauses 3 and 9.1)

Sl No.	Nominal Area of Conductor	Values of Soil Thermal Resistivity K.m/W					
	mm²	1.0	1.2	1.5	2.0	2.5	3.0
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	25	1.15	1.08	1.00	0.90	0.82	0.76
ii)	35	1.15	1.08	1.00	0.90	0.82	0.76
iii)	50	1.15	1.08	1.00	0.90	0.82	0.76
iv)	70	1.15	1.08	1.00	0.89	0.82	0.76
v)	95	1.15	1.09	1.00	0.89	0.82	0.76
vi)	120	1.15	1.09	1.00	0.89	0.82	0.76
vii)	150	1.15	1.09	1.00	0.89	0.81	0.75
viii)	185	1.16	1.09	1.00	0.89	0.81	0.75
ix)	240	1.16	1.09	1.00	0.89	0.81	0.75
x)	300	1.16	1.09	1.00	0.89	0.81	0.75
xi)	400	1.16	1.09	1.00	0.89	0.81	0.75
xii)	500	1.16	1.09	1.00	0.89	0.81	0.75

9

R02

Table 28 Group Rating Factors for Three-Core Cables in Horizontal Formation Laid Direct in the Ground

(*Clauses* 3, 9.1 *and* 9.2)

Sl No.	Number of Cables	Spacing Between Group Centre mm				
		Touching	200	400	600	800
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	2	0.80	0.86	0.90	0.92	0.94
ii)	3	0.69	0.77	0.82	0.86	0.89
iii)	4	0.62	0.72	0.79	0.83	0.87
iv)	5	0.57	0.68	0.76	0.81	0.85
v)	6	0.54	0.65	0.74	0.80	0.84
vi)	7	0.51	0.63	0.72	0.78	0.83
vii)	8	0.49	0.61	0.71	0.78	—
viii)	9	0.47	0.60	0.70	0.77	—
ix)	10	0.46	0.59	0.69	—	—
x)	11	0.45	0.57	0.69	—	—
xi)	12	0.43	0.56	0.68	—	—

Coal to 2000 TPD Ammonium Nitrate, LSTK-1

DRIVE CONTROL PHILOSOPHY

BHARAT HEAVY ELECTRICALS LIMITED
INDUSTRIAL SYSTEM GROUP
BANGALORE-12

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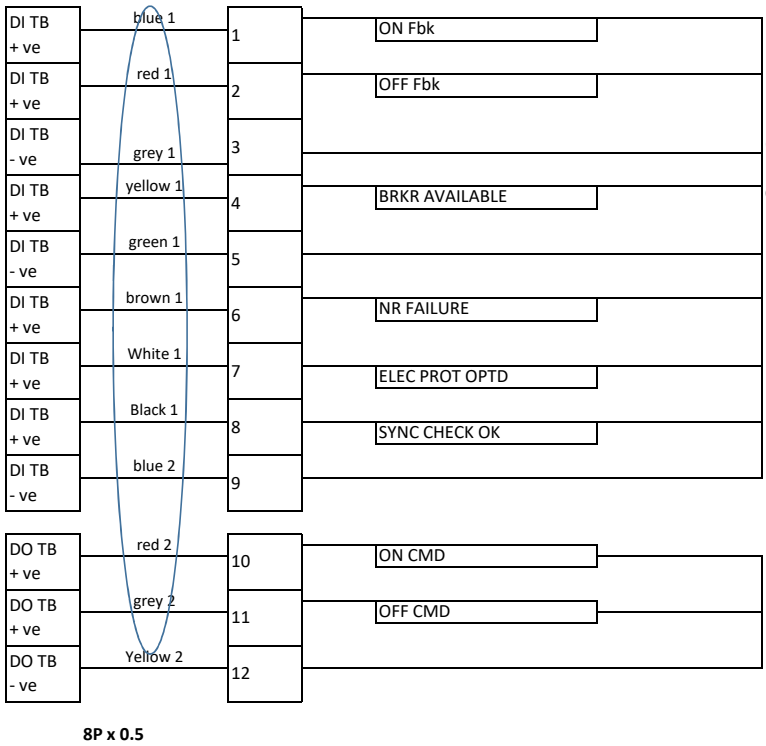
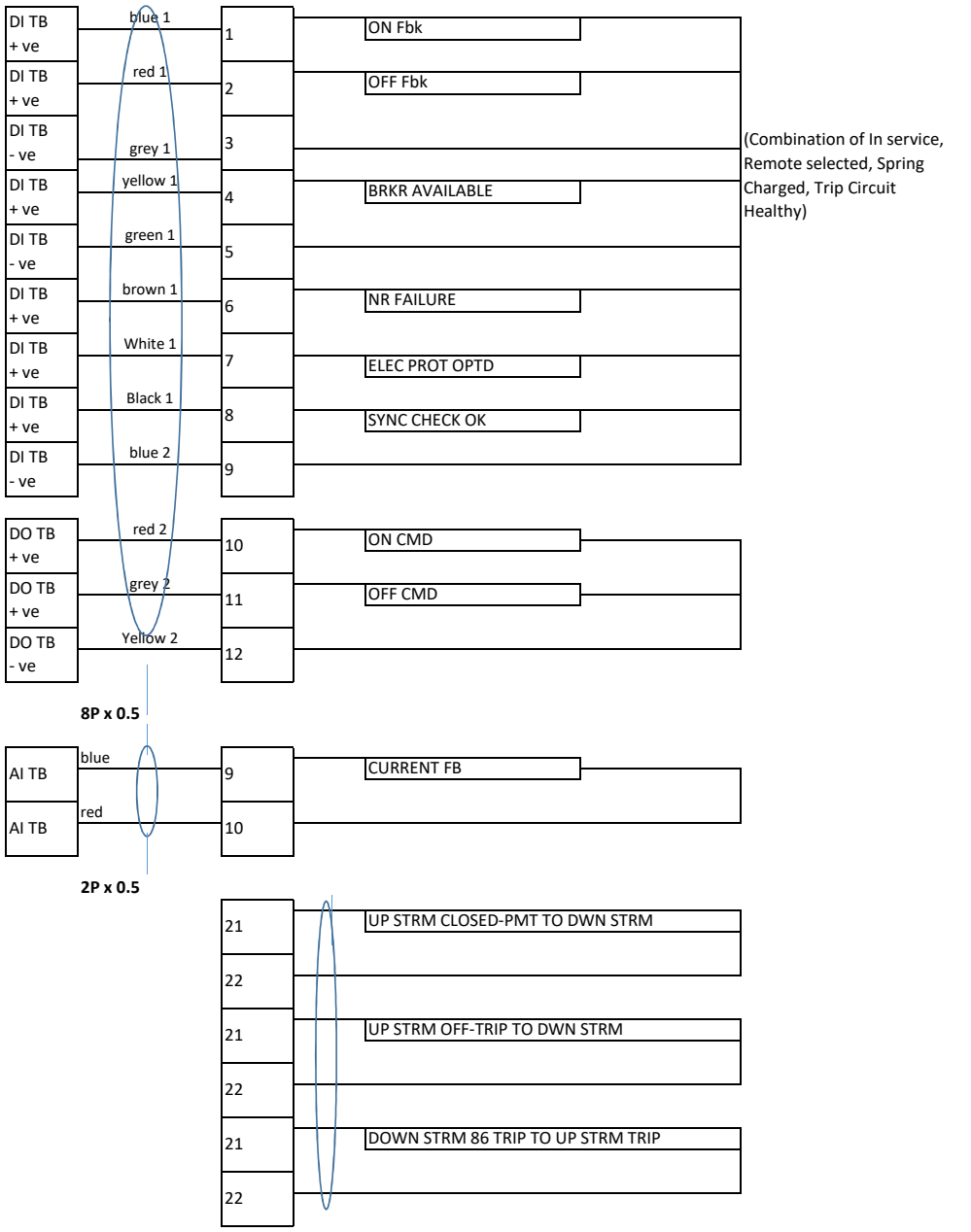
LT INC/BC


DI TB + ve
DI TB + ve
DI TB - ve
DI TB + ve
DI TB - ve
DI TB + ve
DI TB + ve
DI TB + ve
DI TB - ve
blue 1
red 1
grey 1
yellow 1
green 1
brown 1
White 1
Black 1
blue 2
1
2
3
4
5
6
7
8
9
ON Fbk
OFF Fbk
BRKR AVAILABLE
NR FAILURE
ELEC PROT OPTD
SYNC CHECK OK
(Combination of In service, Remote selected, Spring Charged, Trip Circuit Healthy)
DO TB + ve
DO TB + ve
DO TB - ve
red 2
grey 2
Yellow 2
10
11
12
ON CMD
OFF CMD
8P x 0.5
AI TB
AI TB
blue
red
9
10
CURRENT FB
2P x 0.5
21
22
21
22
21
22
UP STRM CLOSED-PMT TO DWN STRM
UP STRM OFF-TRIP TO DWN STRM
DOWN STRM 86 TRIP TO UP STRM TRIP
10C x 1.5 / 2.5 based on distance / voltage drop

HT INC/BC


DI TB + ve
DI TB + ve
DI TB - ve
DI TB + ve
DI TB - ve
DI TB + ve
DI TB + ve
DI TB + ve
DI TB - ve
blue 1
red 1
grey 1
yellow 1
green 1
brown 1
White 1
Black 1
blue 2
1
2
3
4
5
6
7
8
9
ON Fbk
OFF Fbk
BRKR AVAILABLE
NR FAILURE
ELEC PROT OPTD
SYNC CHECK OK
(Combination of In service, Remote selected, Spring Charged, Trip Circuit Healthy)
DO TB + ve
DO TB + ve
DO TB - ve
red 2
grey 2
Yellow 2
10
11
12
ON CMD
OFF CMD
8P x 0.5
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AI TB
blue
red
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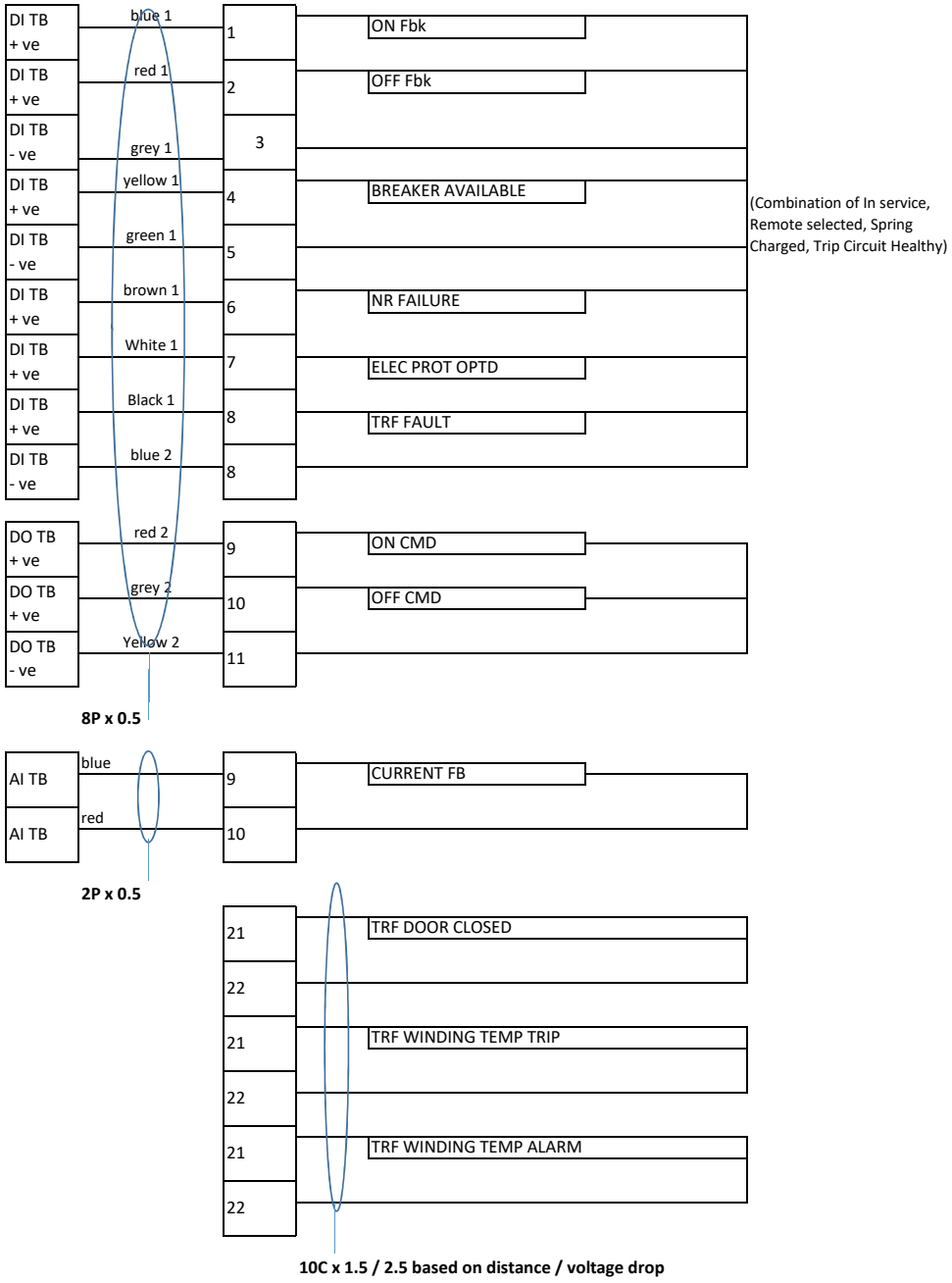
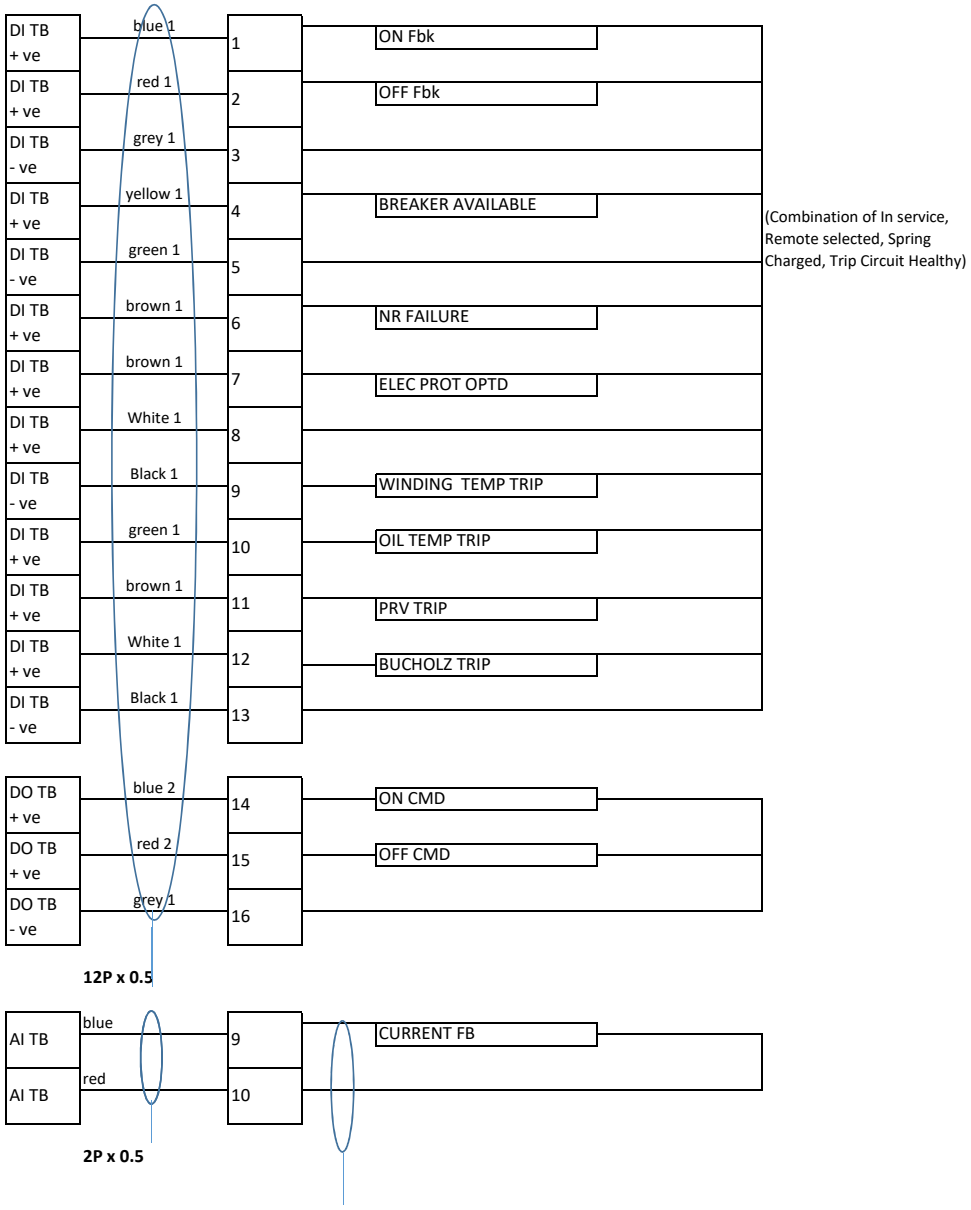
CURRENT FB
2P x 0.5
21
22
21
22
21
22
UP STRM CLOSED-PMT TO DWN STRM
UP STRM OFF-TRIP TO DWN STRM
DOWN STRM 86 TRIP TO UP STRM TRIP
10C x 1.5 / 2.5 based on distance / voltage drop

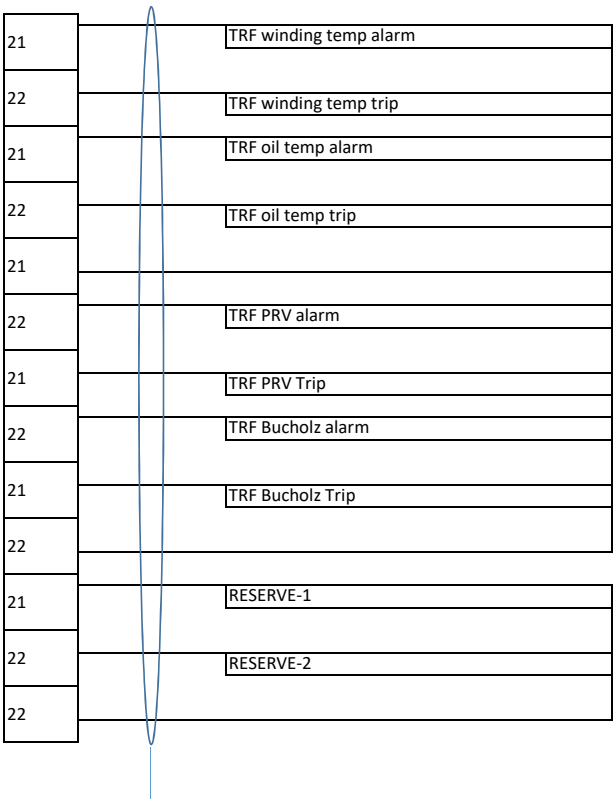
DRY TYPE TRF FDR



HT TRF FDR (OIL TYPE)

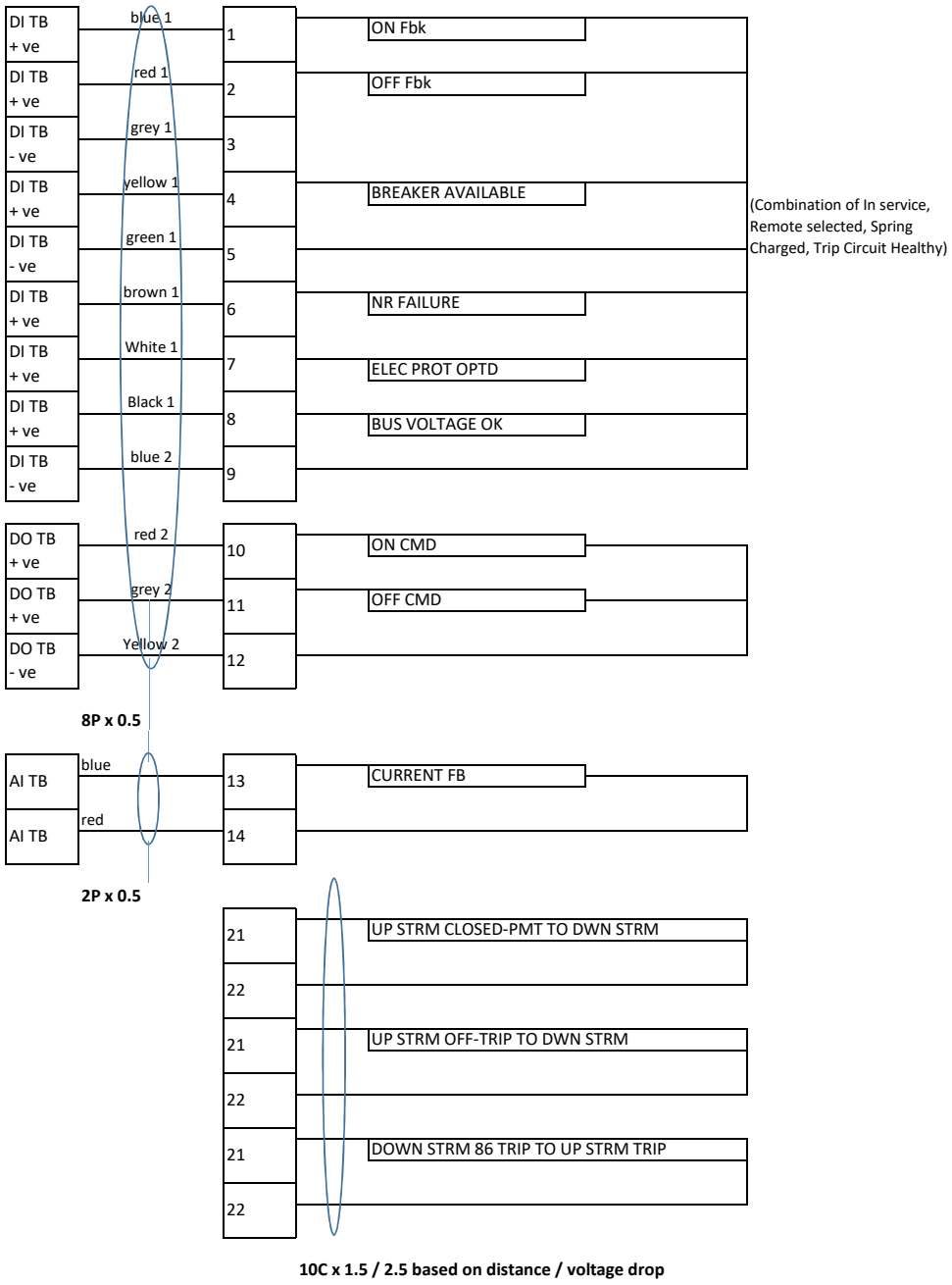


HT TRF FDR (OIL TYPE)

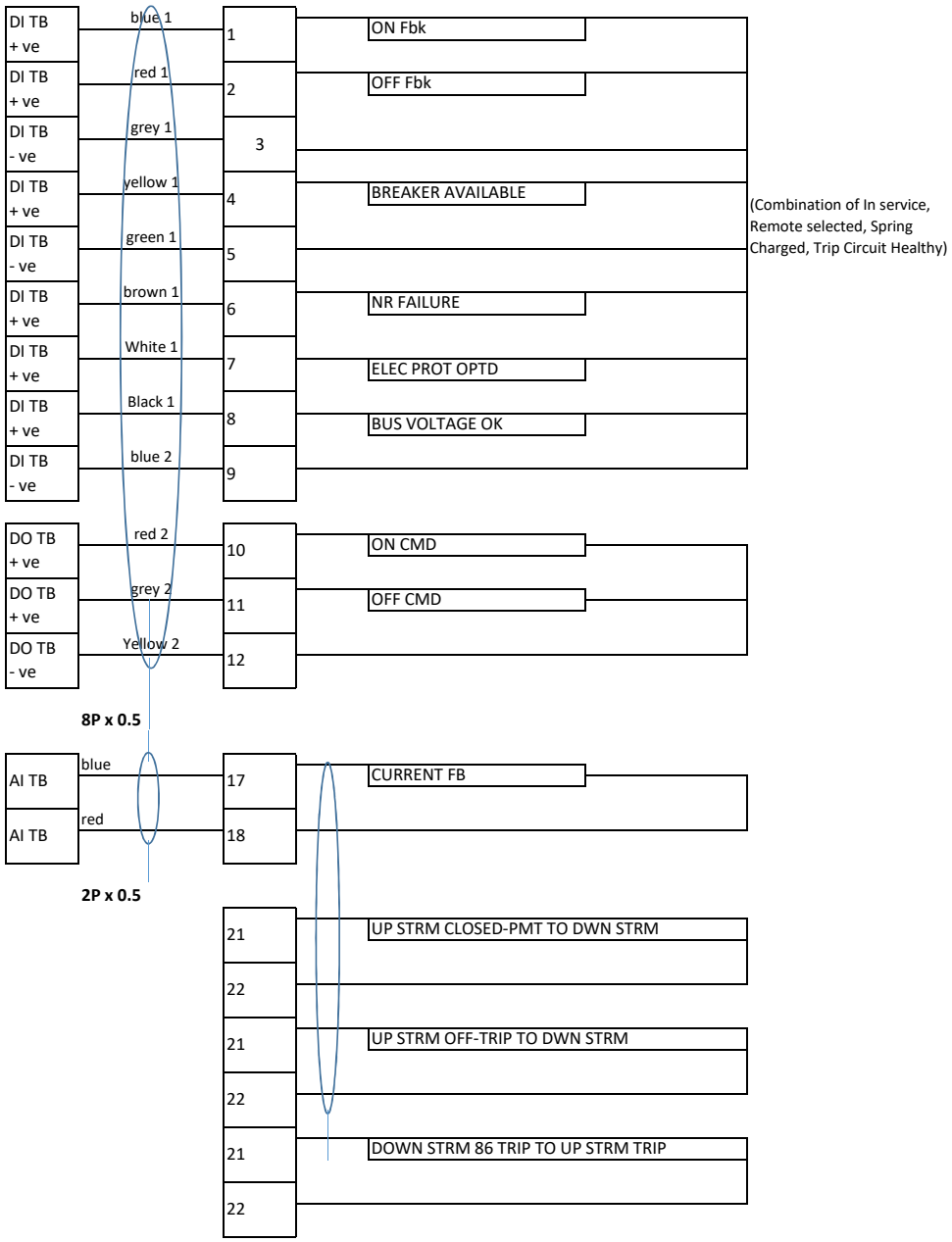


16C x 1.5 / 2.5 based on distance / voltage drop

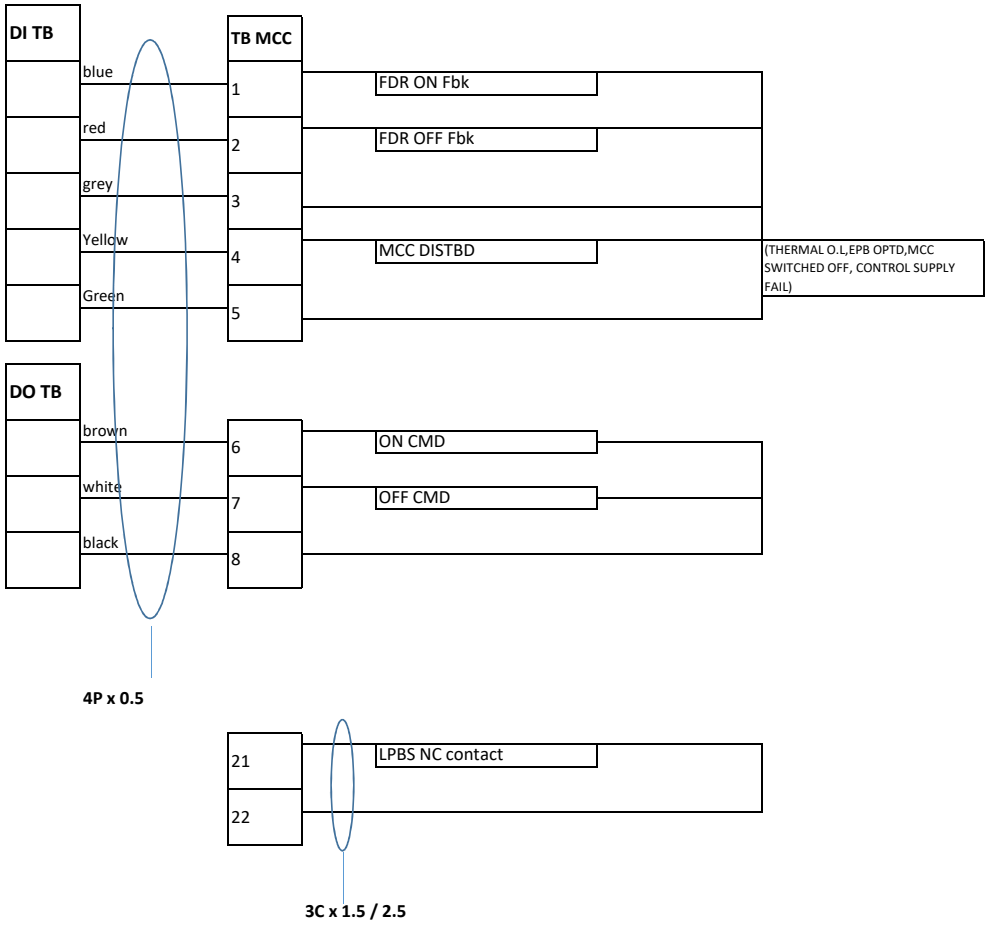
HT OUTG TIE FEEDER



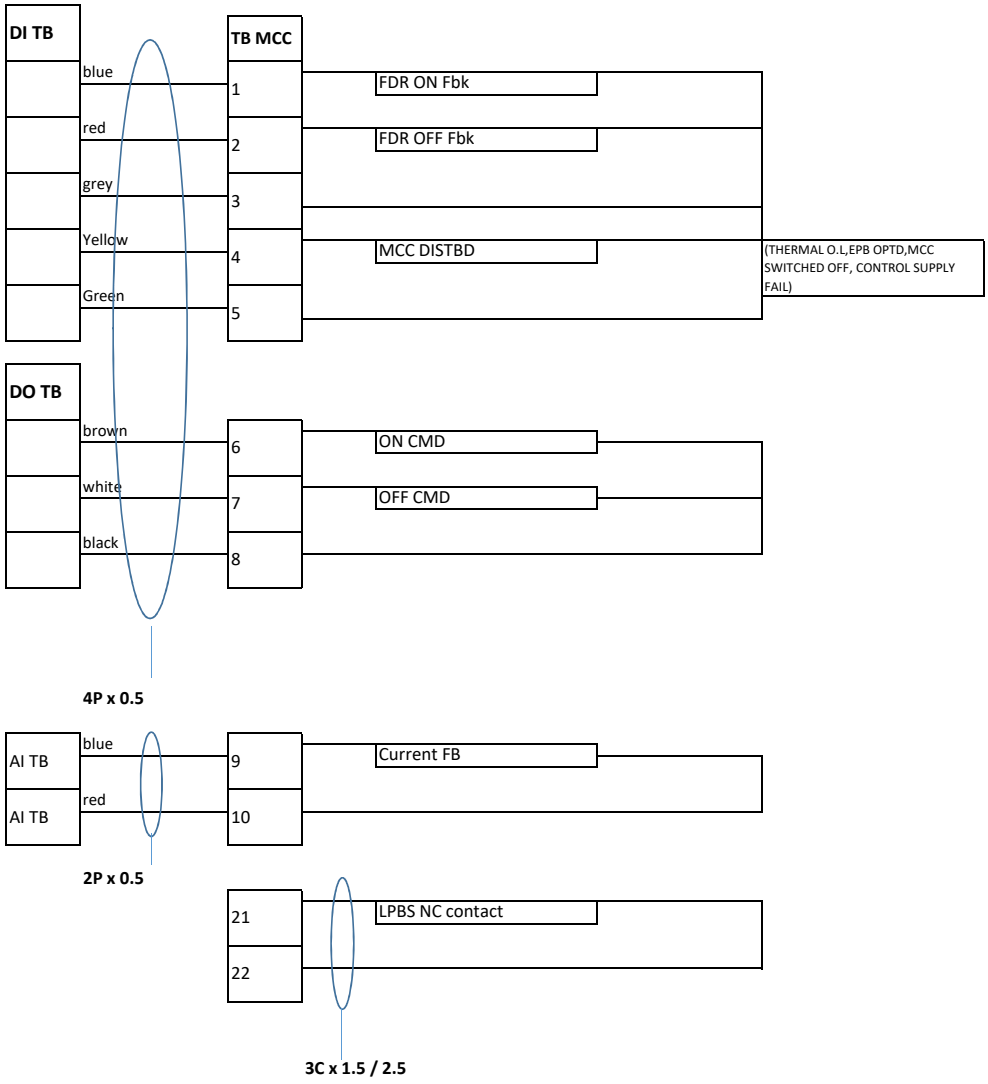
LT OUTG TIE FEEDER



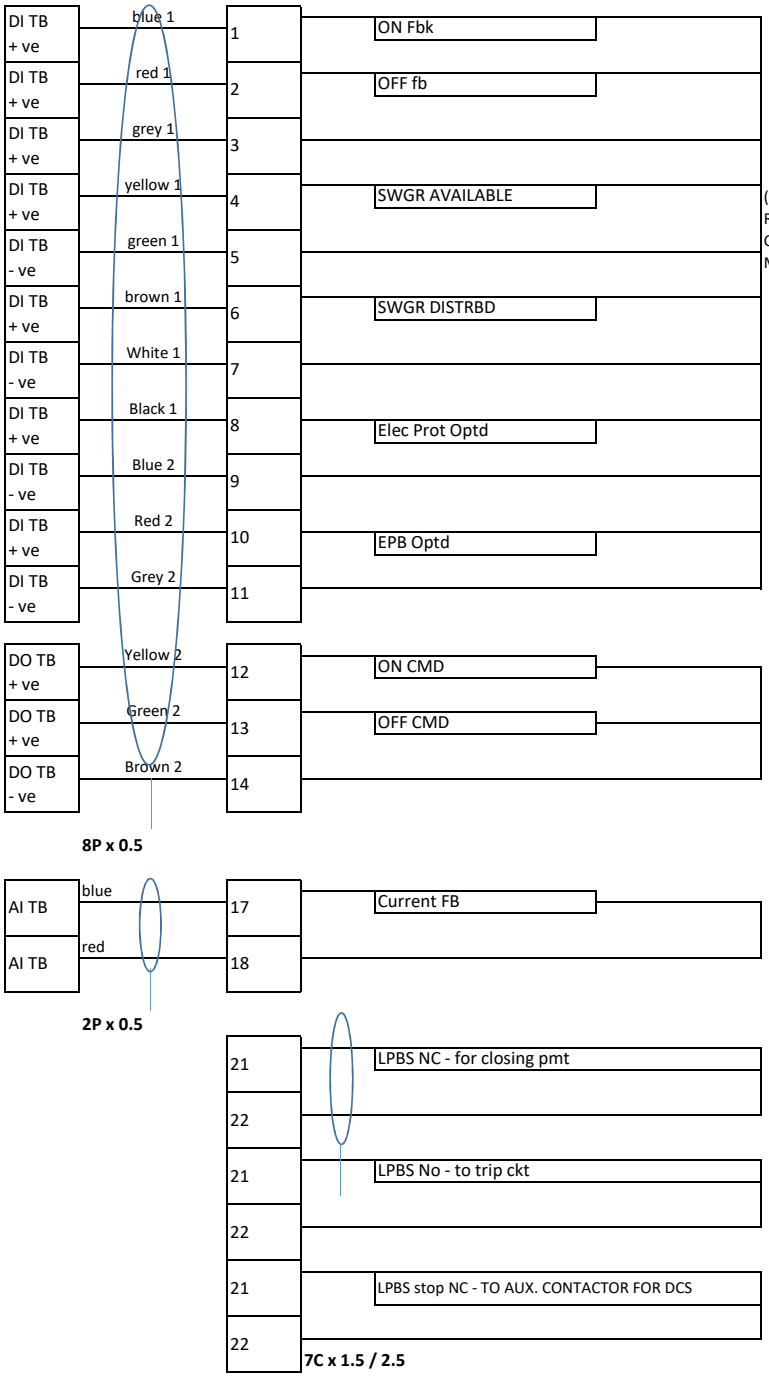
MCC DOL Feeder < 30Kw



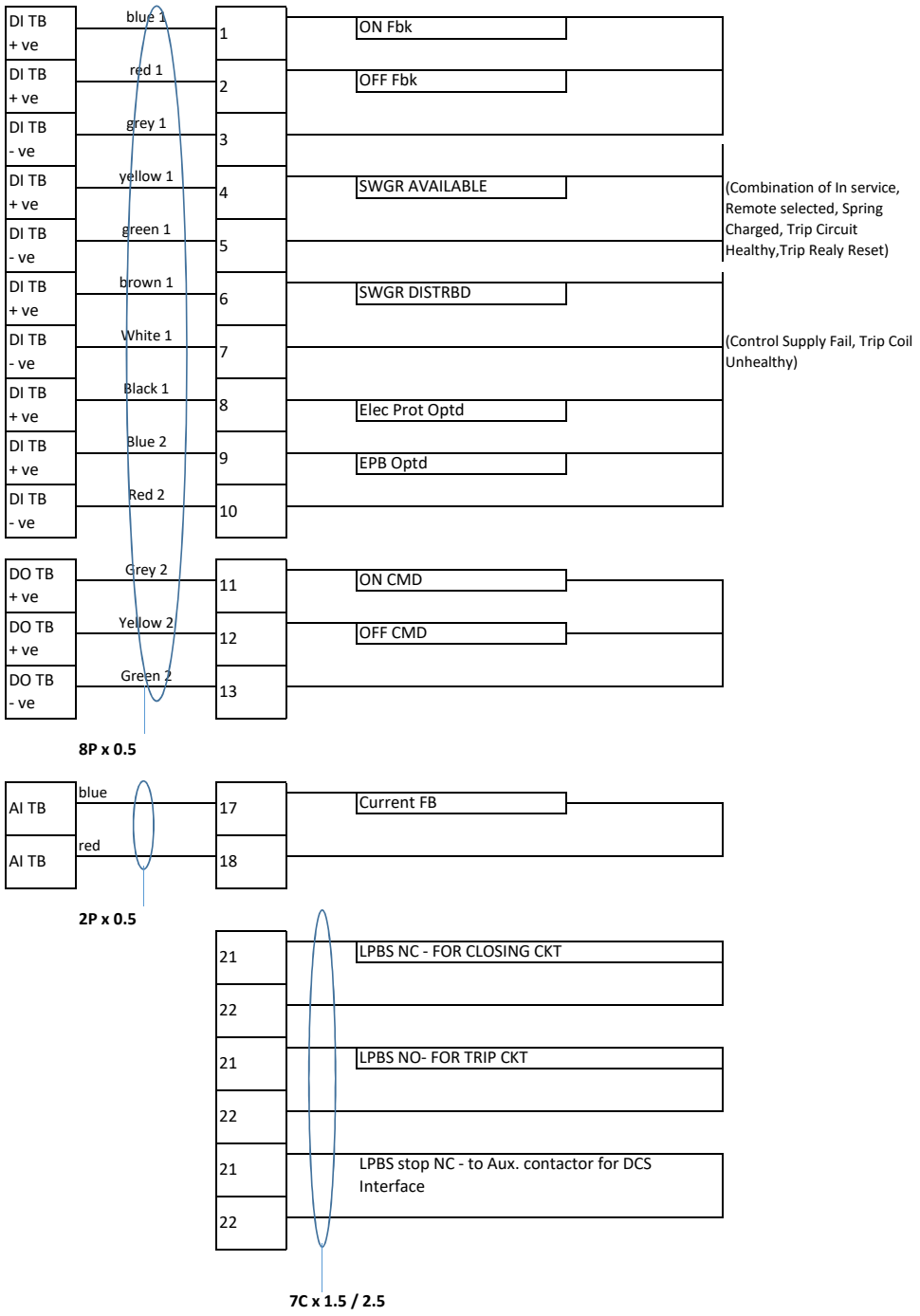
MCC DOL Feeder > =30Kw up to 55 KW



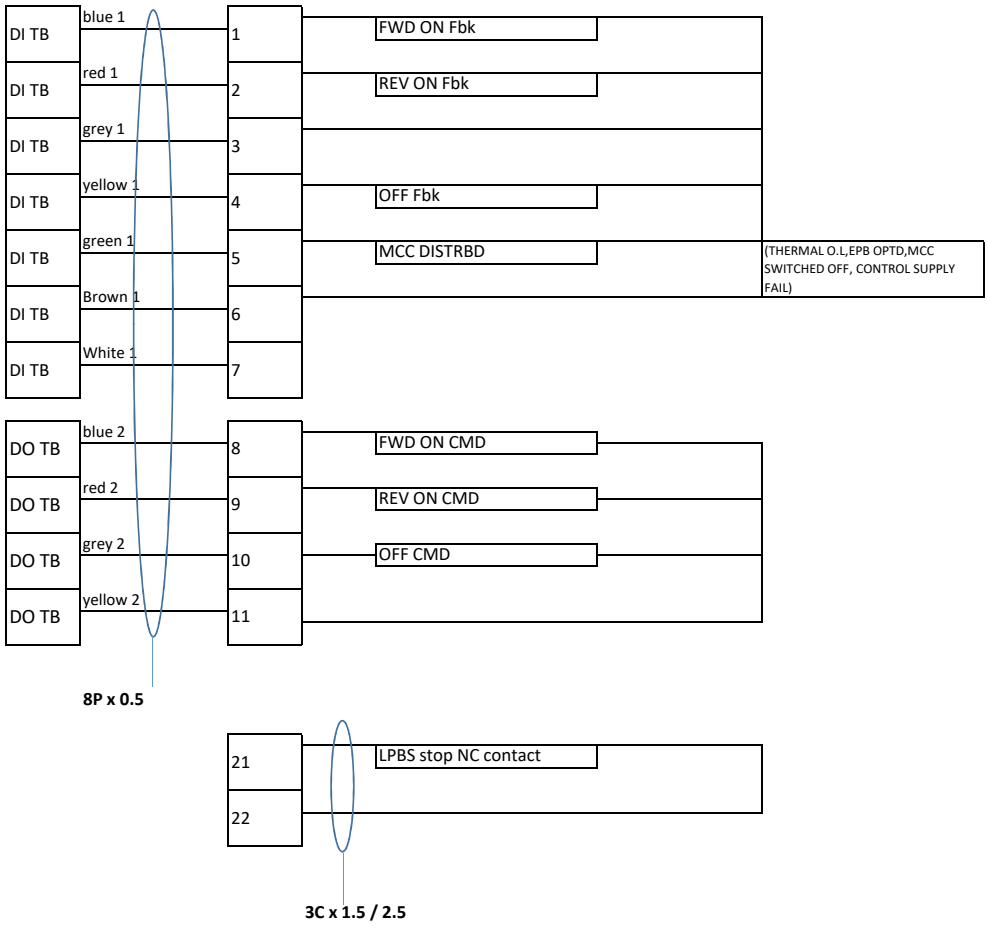
MCC ACB Feeder > 55 kW up to 160 kW



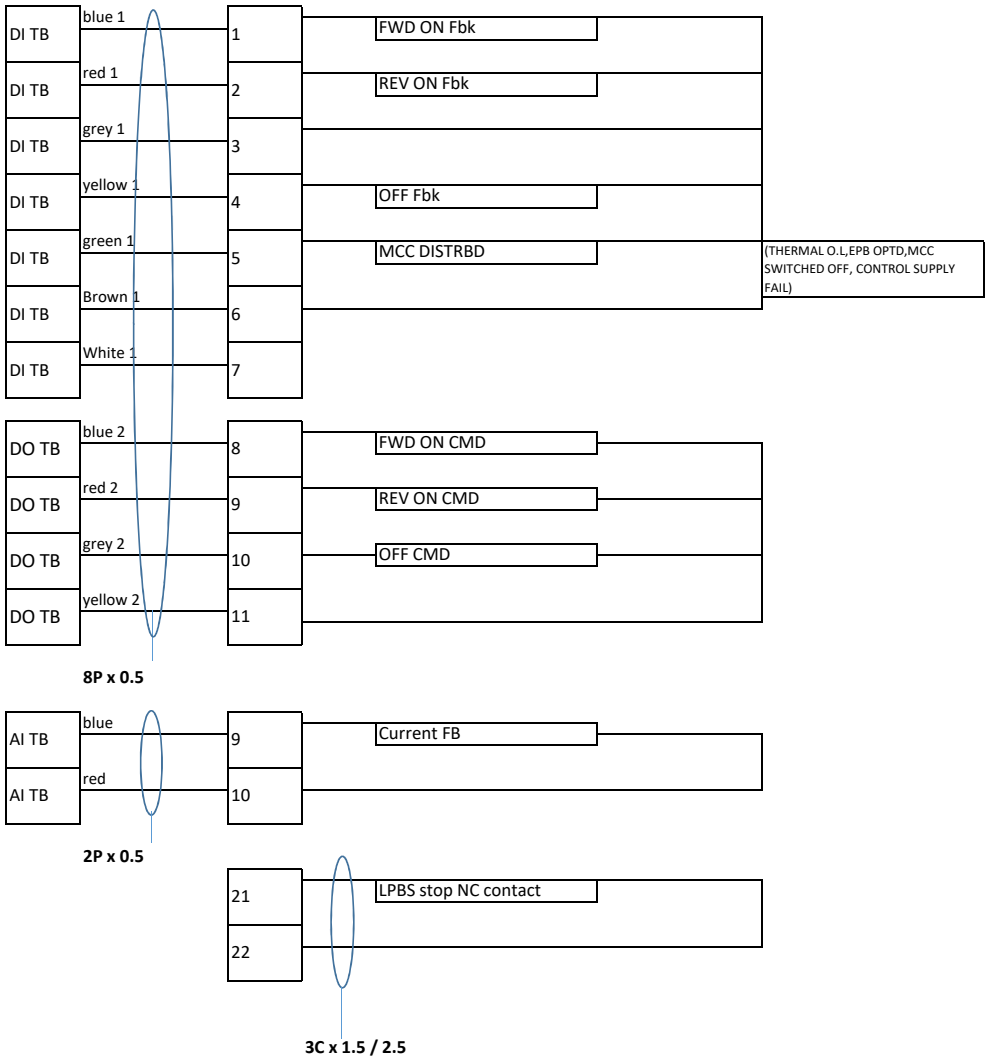
HT MTR Feeder



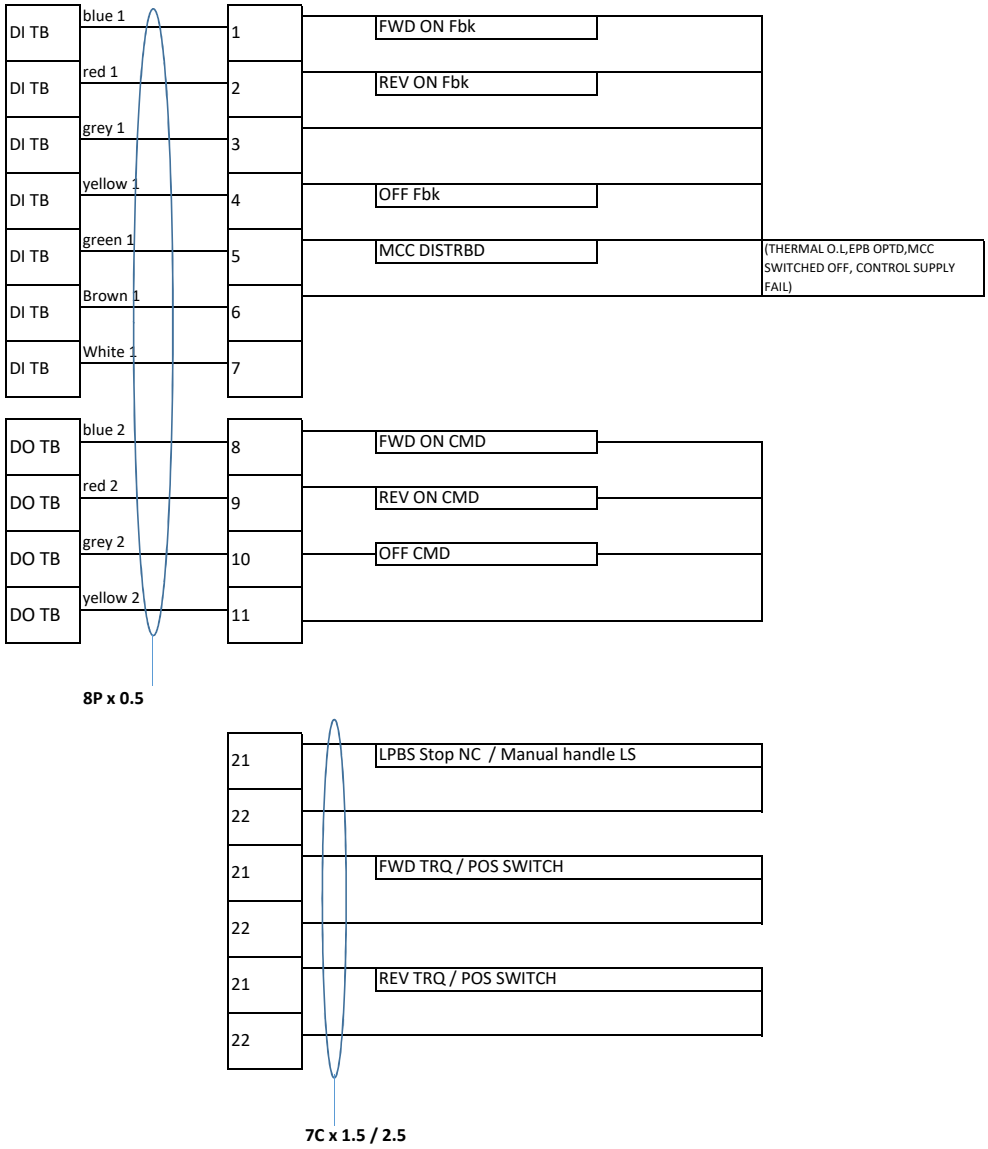
MCC RDOL Feeder < 30Kw



MCC RDOL Feeder > 30Kw up to 55 KW

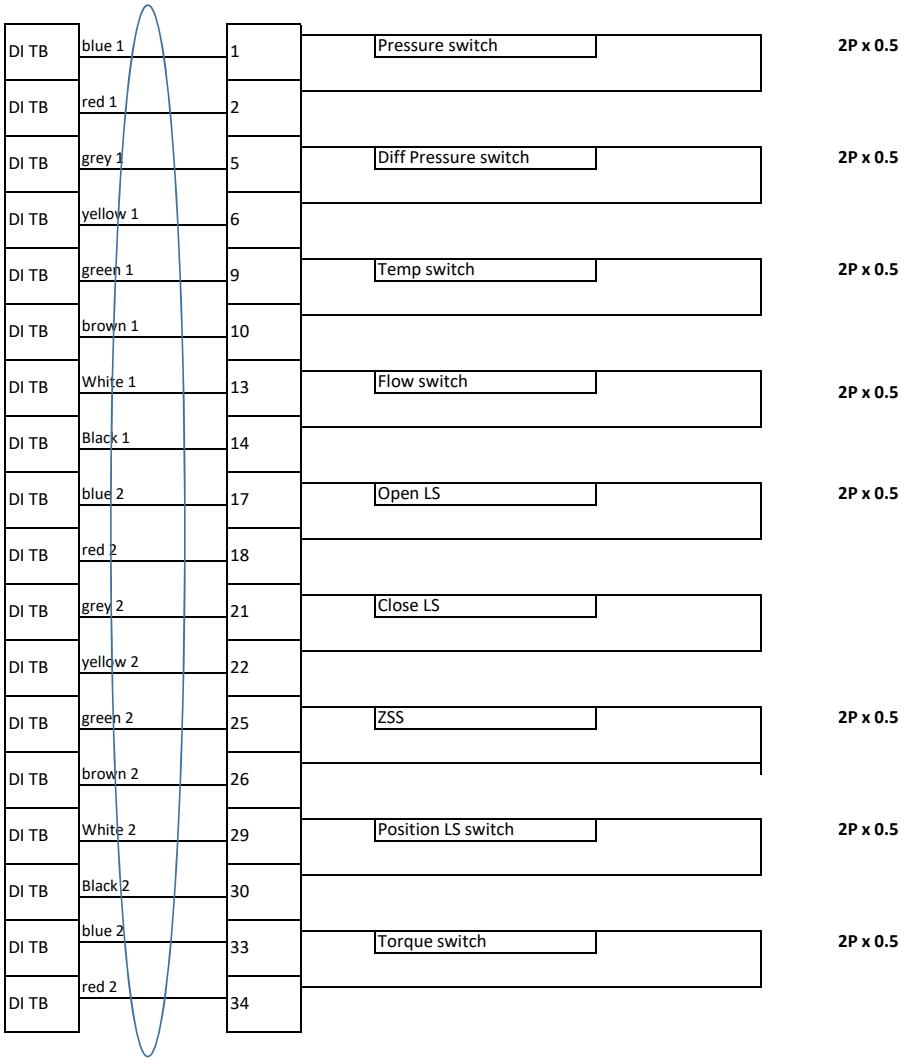


MCC RDOL Feeder < 30Kw (Inching type)



For LPBS, Wherever length is more , then a parallel RC circuit to be provided across the contactor for droping of picked up contactor due to capacitance of cable

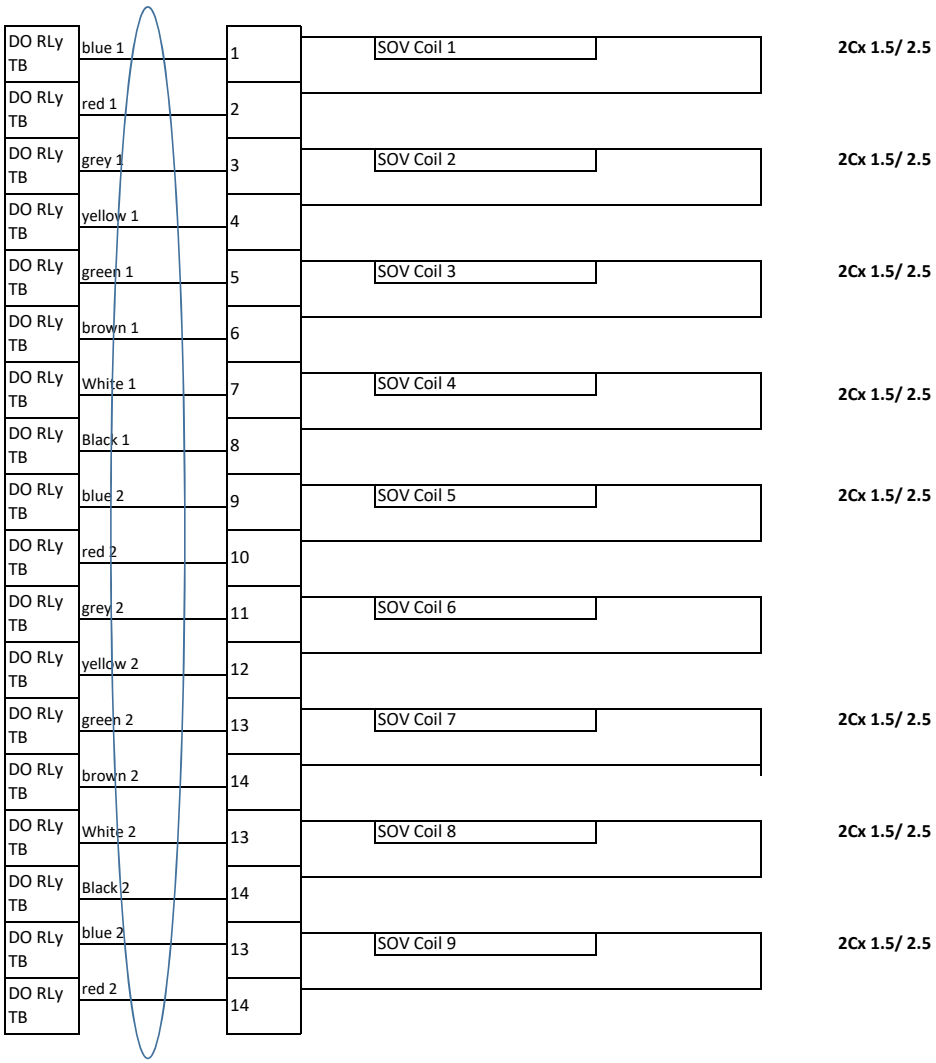
Digital Inputs - JB to Field Instruments / Pneumatic panel / Intermediate JB/LCP etc



Multi pair Plus spare cores as per spec

Each Instrument shall have separate Positive & negativ to DCS
For each cable, all cores to be terminated to be terminated in JB/LCP
20% spare TB's shall be provided

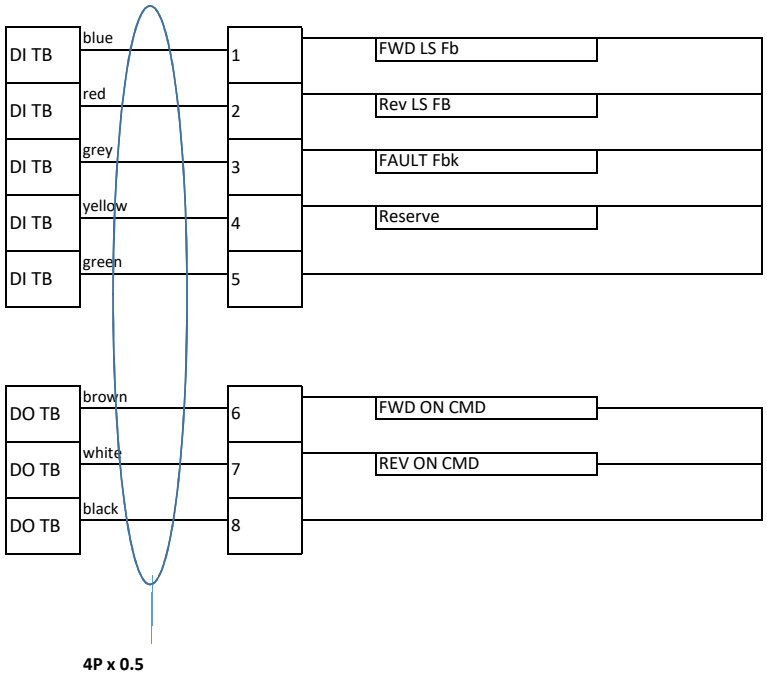
Digital Outputs - JB to SOV's



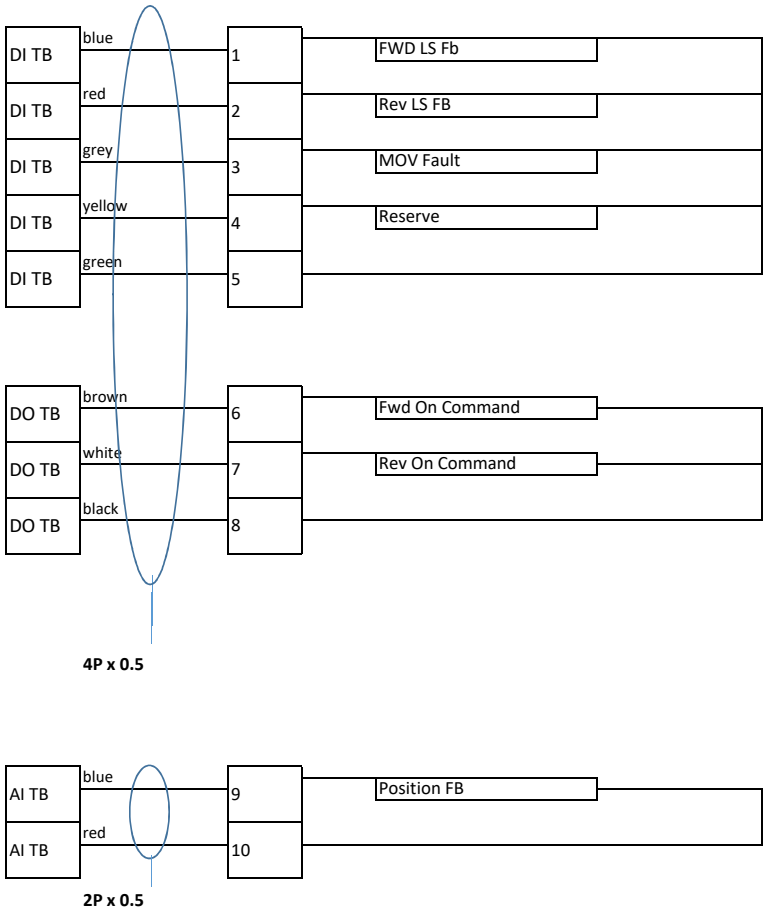
Multi core (1.5/ 2.5) Plus spare cores as per spec based on SOV rating & sizing

Each sov shall be provided individual return core

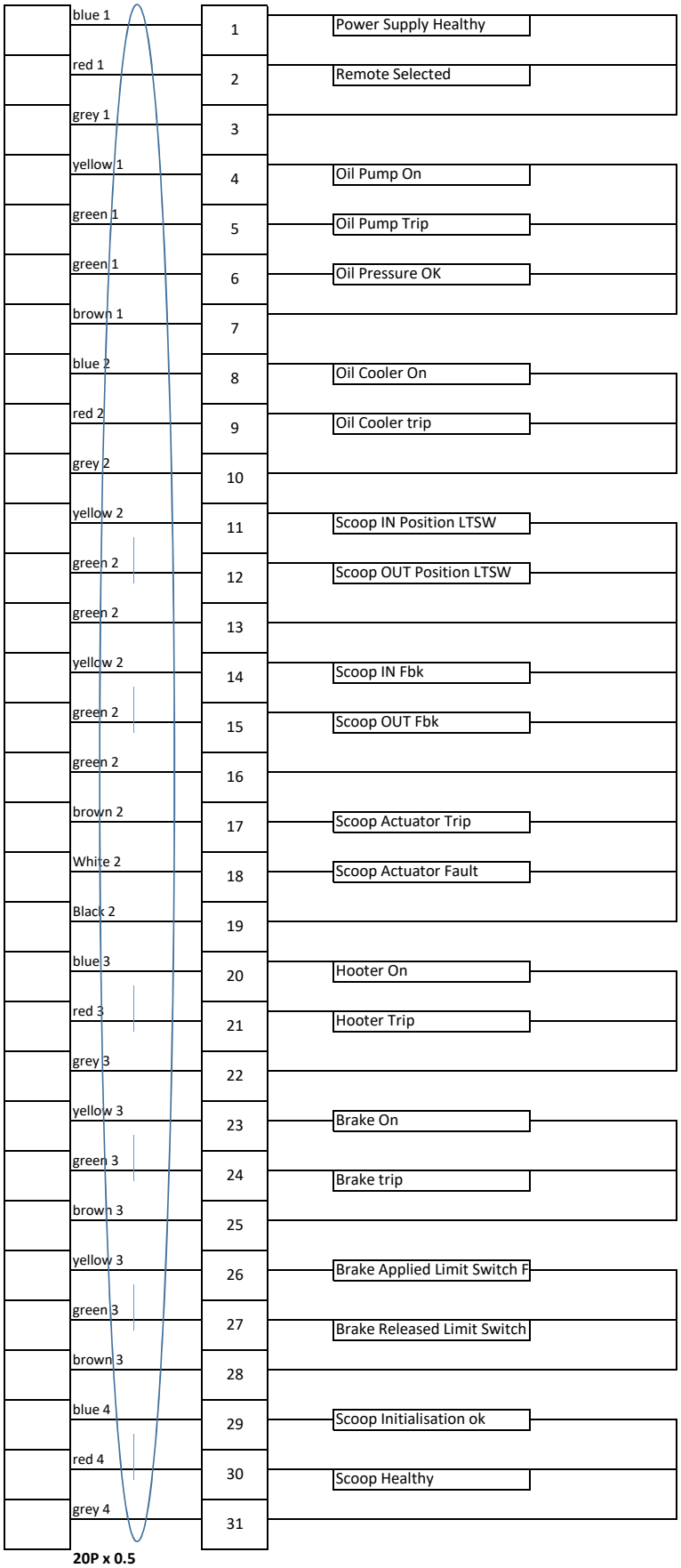
MOV type 1


DI TB
DI TB
DI TB
DI TB
DI TB
blue
red
grey
yellow
green
1
2
3
4
5
FWD LS Fb
Rev LS FB
FAULT Fbk
Reserve
DO TB
DO TB
DO TB
brown
white
black
6
7
8
FWD ON CMD
REV ON CMD
4P x 0.5

MOV type 2 (inching)

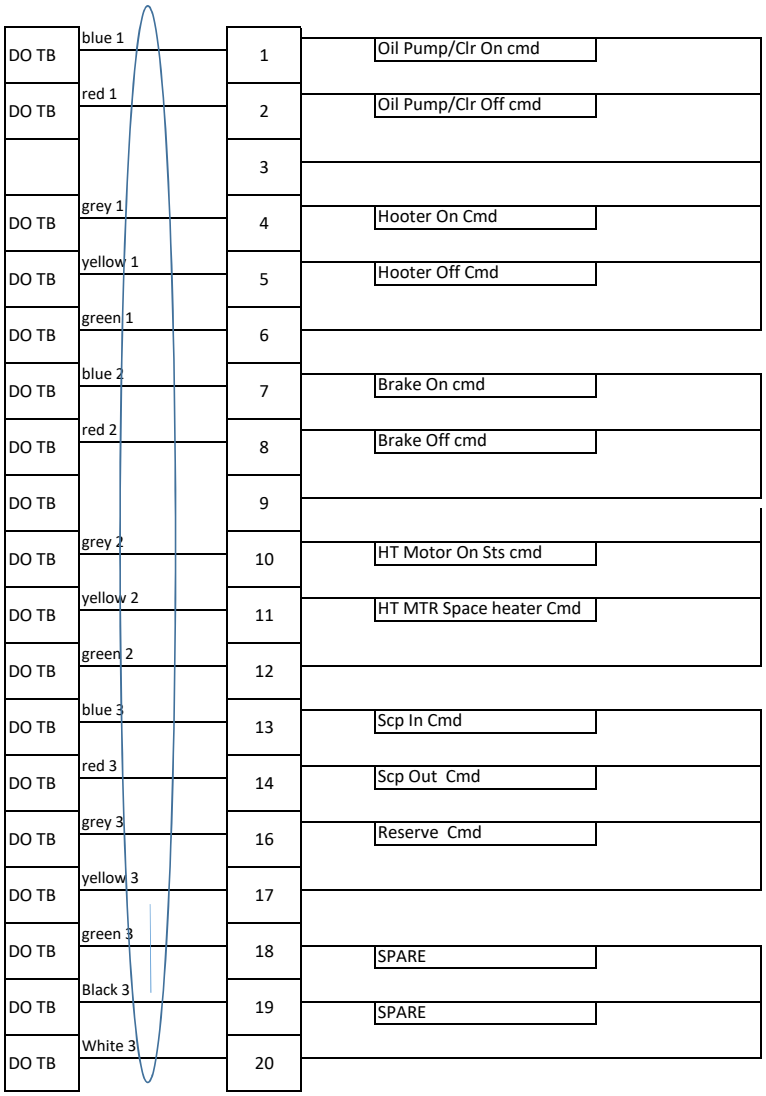


Scoop Coupling LCP for Conveyors & Crushers (DI)



20P x 0.5

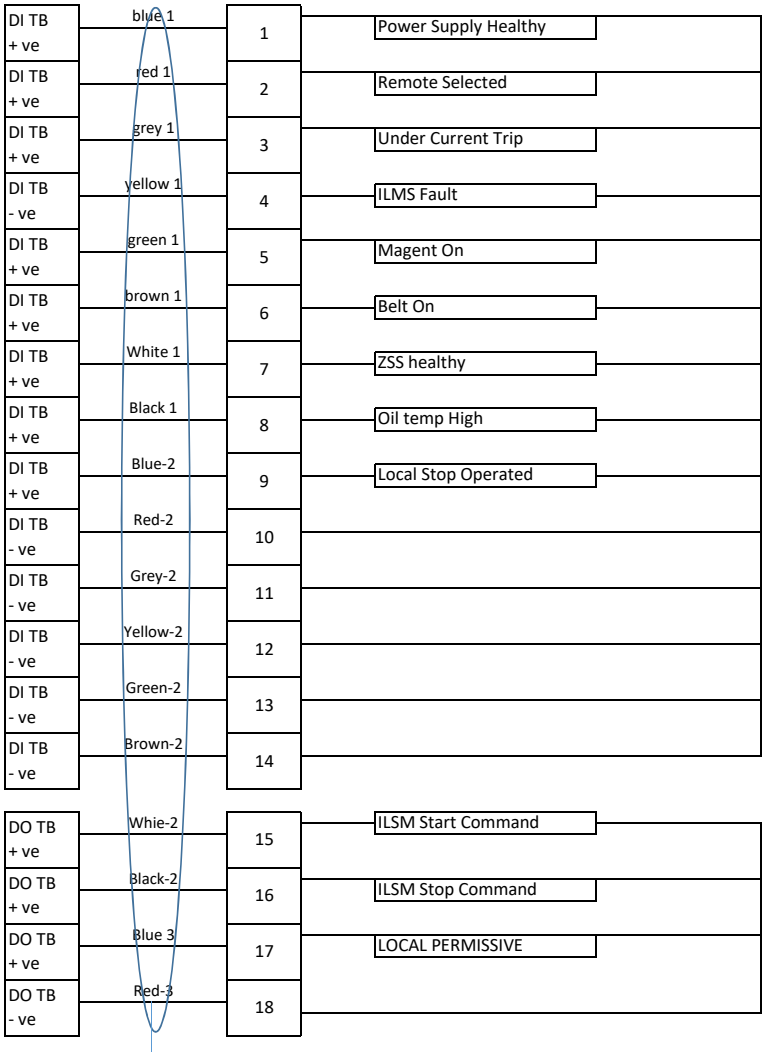
Scoop Coupling LCP for Conveyors & Crushers (DO)



12P x 0.5

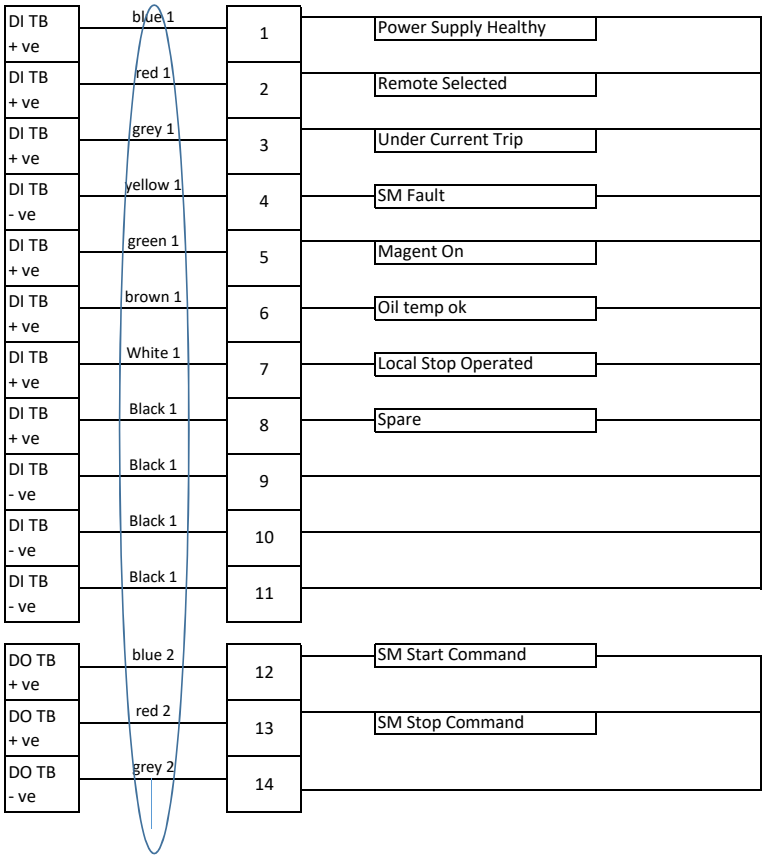
Note: Brake not applicable for Crusher

INLINE MAGNETIC SEPARATOR/CROSS BELT MAGNETIC SEPARATOR



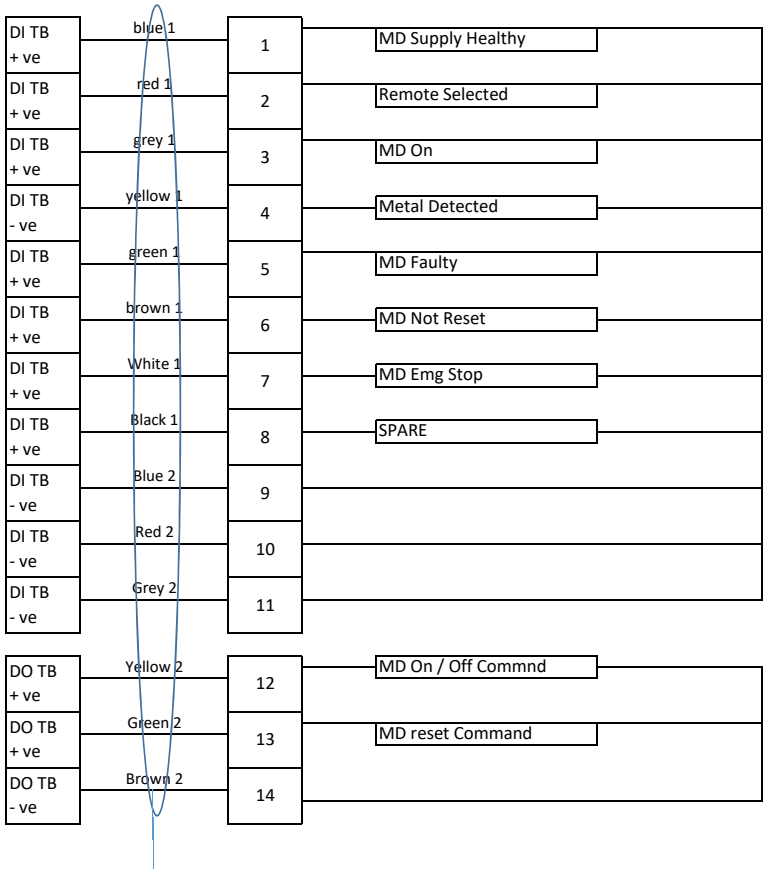
12P x 0.5

Suspended Magent



8P x 0.5

Metal Detector



8P x 0.5

ANNEXURE-Elec-01
2 YEARS O&M SPARE AND OTHER SPARES(E&I)

Annexure-Elec-01: 2 Years Spatre list for ELECTRICAL and C&I

SPARES: -

The Bidder shall include in their scope of supply all the necessary 2 years O&M spares, start up and commissioning spares and recommended spares. The general requirements pertaining to the supply of these spares is given below: -

2 YEARS O&M SPARES: -

The list of 2 years spares mentioned in Annexure-5A represents the minimum requirement to be supplied by the bidder. However, the bidder shall also supply, without any additional commercial implication to BHEL, any additional spares and consumables required over and above the specified list required for the initial 24 months of operation and maintenance (O&M).

START-UP & COMMISSIONING SPARES: -

Start-up and commissioning spares are those spares which may be required during the start-up and commissioning of the equipment/system. All spares used till the plant is handed over to the employer shall come under this category. The Contractor shall provide for an adequate stock of such start up and commissioning spares to be brought by him to the site for the plant erection and commissioning. They must be available at site before the equipment's are energized. The unused spares, if any, should be removed from there only after the issue of Taking Over certificate. All start-up spares which remain unused at the time shall remain the property of the Contractor.

No separate price schedule shall be applicable for Start-up and Commissioning Spares. The bidder shall include the cost of such spares in the total quoted price.

The general requirements pertaining to the supply of these spars is given below.

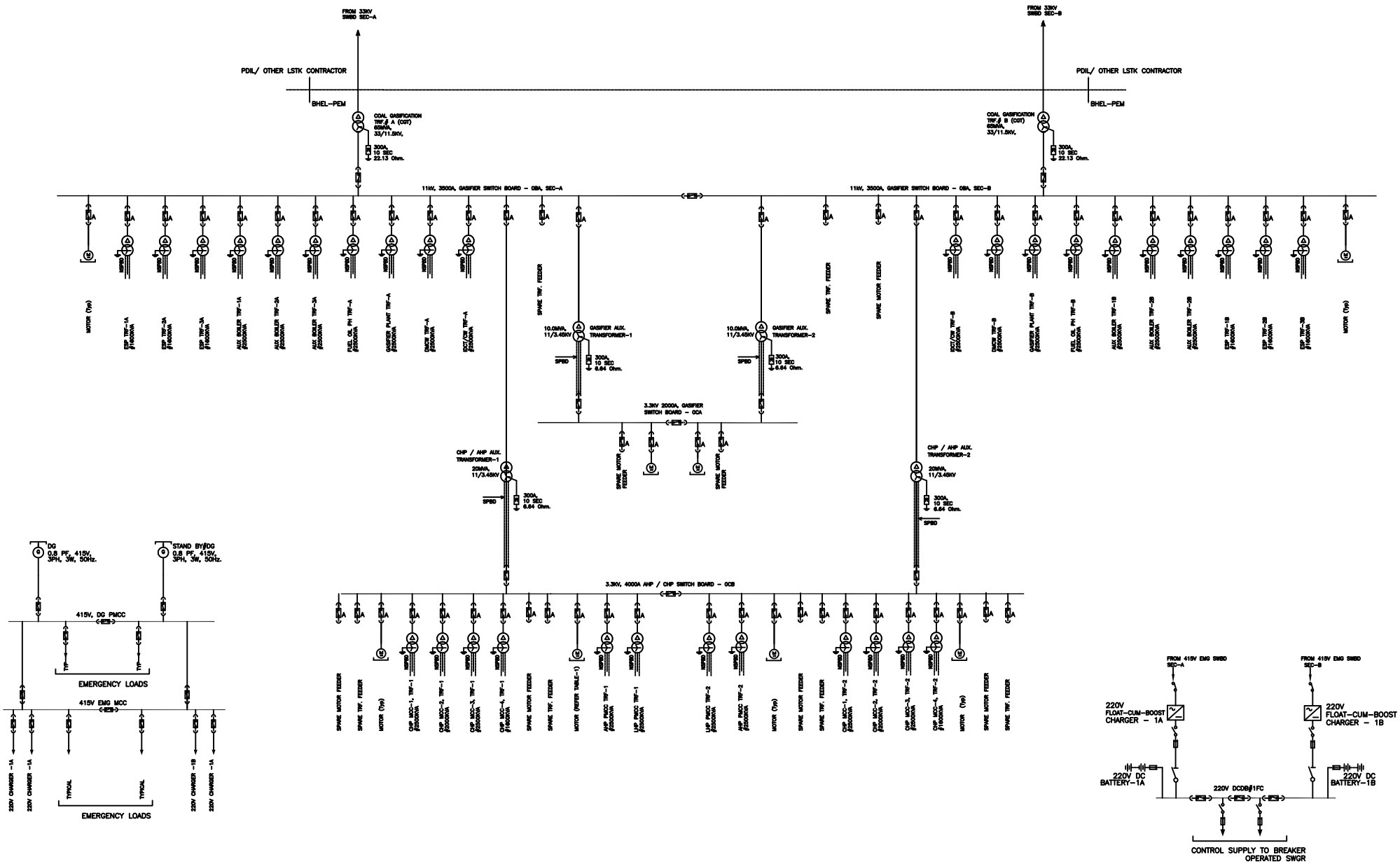
1. The Contractor shall indicate the service expectancy period for the spare's parts under normal operating conditions before replacement.
2. All spares supplied under this contract shall be strictly inter changeable with the parts for which they are intended for replacements. The spares shall be treated and packed for long storage under the climatic conditions prevailing at the site e.g. small items shall be packed in sealed transparent plastic with desecrator packs as necessary.
3. All the spares shall be manufactured along with the main equipment components as a continuous operation as per same specification and quality plan.
4. The contractor will provide Employer with cross-sectional drawings, catalogues, assembly drawings and other relevant documents so as to enable the Employer to identify and finalise order for recommended spares.
5. Each spares part shall be clearly marked or labelled on the outside of the packing with its description. When more than one spares part is packed in a single case, a general description of the content shall be shown on the outside of such case and a detailed list enclosed. All cases, containers and other packages must be suitably marked and numbered for the purposes of identification.
6. All cases, containers or other packages are to be opened for such examination as may be considered necessary by the Employer.
7. The Contractor shall warrant that all spares supplied will be new and in accordance with the contract Documents and will be free from defects in design, material and workmanship.
8. Material Codification: The bidder to provide datasheets/ assembly drawings of the manufacturer/ any other relevant document showing Bill of Material(s), Make, Model Number, Part Number etc. through which mandatory spares to be supplied can be uniquely identified. This would facilitate the Employer to assign a unique code to each of the mandatory spare as brought out in GCC. The bidder shall extend all necessary assistance in this regard.

2000 TPD COAL TO AMMONIUM NITRATE

Annexure-Ele-1: 2 Years Spatre list for ELECTRICAL and C&I for CHP LHP AHP

Sr. No.	Sub Sl No	Item Description	Quantity for 2 years
1		**220/110V DC BATTERY**	
	i)	Complete dry cell	5% or 10 Nos. whichever is more for each set of battery bank
	ii)	Inter-cell connectors with Hardware	5% or 5 Nos. whichever is more for each set of battery bank
	iii)	BHMS Spares	5% of installed capacity
2		**220/110V BATTERY CHARGER**	
	i)	Set of Electronic Cards / Modules	1 set of each type & rating
	ii)	Set of Auxiliary relays	1 set of each type & rating
	iii)	Set of Fuse Links and Glass Fuses	3 set of each type and rating
	iv)	3 phase Rectifier Bridge complete assembly	1 set of each type and rating
	v)	Rectifier Transformer	1 No. of each type & rating
	vi)	Control Transformers	1 No. of each type & rating
3		**ACDB /Local Starter panel/Local Control Panel**	
	i)	Control supply transformers	2 Nos. of each type and rating
	ii)	LEDs	5 Nos. of each type & color
	iii)	Control switches	2 Nos. of each type
	iv)	Selector switches	1 No. of each type
	v)	Push buttons (complete with contact elements)	5 Nos. of each type & colour
	vi)	Relays and Timer	10 Nos. of each type and rating
	vii)	Contactors	1 No of each type and Rating
	viii)	Ammeters and volt meters	1 No of each type and rating
	ix)	Auxiliary contactors and bimetallic overload relay set for panel	1 No of each type and rating
	x)	Control fuse base with carrier complete set for panel	1 No of each type and rating
	xi)	Any special meter	1 No. of each type
4		**Field Instruments (As applicable)**	
	i)	Indicators and meters (analog, digital etc)	10% or 1 no. of each type and model whichever is more.
	ii)	Thermocouple / RTD elements /temperature elements	10% or 1 no. of each type and model whichever is more.
	iii)	Actuators	10% or 1 no of each type , class , size and model whichever is more.
	iv)	Transmitters of all types and model no. (For the measurement of Pressure, differential pressure flow, level, temp etc.). This shall include magnetic/ electromagnetic flow meter, mass flow meter also.	10% or 1 no of each type and model whichever is more.
	v)	Process actuated switch (Includes all types of Pressure, differential pressure, flow, temperature, level switch Devices).	10% or 1 no. of each type and model
5		**HT motors**	
	i)	HT motors for CHP LHP AHP	1 nos. of each type and rating
	ii)	Set of bearing of HT Motor	1 set of each type of rating
6		**MICROPROCESSOR BASED/PLC BASED CONTROL/ELECTRONIC BASED CONTRAL PANEL (IF APPLICABLE)**	
	i)	Fully programmed controller of electronic modules of each type (as applicable)	1 No.
	ii)	Power supply module (if applicable)	1 No.
7		**Safety switches for conveyors**	
	i)	Belt Sway Switch assy	5 % of each type
	ii)	Pull cord switch assy.	15 % of each type
	iii)	Zero speed switch assy.	15 % of each type
	iv)	Chute Block switch assy.	15 % of each type
	v)	Position switches for trippers, paddle feeders	10 % of each type
	vi)	Sensor/probe for zero speed switch	20 %(min. 1 no)of each type and speed range
	vii)	Motor terminal block with studs for all motors	1 set. of each type and rating of motor
8		**LIGHTING**	
	i)	LED Fixture complete along with driver , LED lamps etc.	2% of total qty or 2nos which ever more(each type & rating offered)
	ii)	Lighting Panels	
	a	Timers 24 hours	3 Nos
	b	Power Contactors of each type & rating	5 nos
	c	MCCBs of each type & rating	5 nos
	d	Indicating lamps & holders (RED, Green , Yellow etc)	10 nos of each type & rating
	e	Auxiliary contactors od each type & rating	5 nos
	f	Rotary switches (Ammeter, voltmeter, Manual/Auto , Local / remote selector switches etc)of each type & rating	5 nos
	g	MCB of each type & rating	10 No's
	h	On / Off Isolators of each type & rating	5 nos
	iii)	20A receptacles complete with Plugs etc	10 nos
	iv)	Lighting Junction Boxes of each type	10 nos
	v)	63A welding receptacles complete with Plug etc	10 nos
	vi)	Volt meter of each type & size	2 nos
	vii)	Ammeter of each type & size	2 nos
9		**415V Busduct**	
	1	Support Insulators	5 No's

2000 TPD COAL TO AMMONIUM NITRATE			
Annexure-Ele-1: 2 Years Spatre list for ELECTRICAL and C&I for CHP LHP AHP			
Sr. No.	**Sub Sl No**	**Item Description**	**Quantity for 2 years**
	2	Three phase set of flexible terminal connectors for switchgear end of each type & rating	1 Set
	3	Three phase set of flexible terminal connectors for transformer end of each type & rating	1 Set
	4	Seal-off Bushings of each type and rating	1 No
10		**Dry type Transformers 630KVA to 20000 KVA TRANSFORMER(of each type & rating)**	
	1	HV Bushing (if applicable) 1 No.	1 No
	2	LV Bushing (if applicable) 1 No.	1 No
	3	LV Neutral Bushing (if applicable) 1 No.	1 No
	4	WTI (if applicable) 1 No.	1 No
	5	Set of Thermistor /RTD with associated leads complete for one transformer	3 Set
	6	Complete Winding Limb(HV and LV) 1 No.	1 No
11		**LT Switchgears(PMCC/EPMCC/APFC/PCC/MCC/ASDB/ DCDB/UPSDB/LSDB, LCP, PDB, WDB, MLDB, Any other Panel, LT Bus duct) (As applicable)**	
	1	Complete breaker of each rating	10 No's
	2	Numerical Relays of each type	5 No's
	3	Auxiliary Relays of each type	10 N's
	4	Horizontal busbar support Insulators	12 N's
	5	Vertical busbar dropper support insulators	12 N's
	6	Current transformer of each type & ratio	3 No's
	7	Voltage transformer of each type & ratio	3 No's
	8	Control supply transformer of each type & rating	3 No's
	9	Power Contactor of each type and rating 10	10 No's
	10	Coil for above contactor for each type and rating	10 No's
	11	MCCBs (equally divided for all ratings)	40 No's
	12	MPCBs (equally divided for all ratings)	40 No's
	13	Closing coil of each type of each rating	10 No's
	14	Trip coil of each type of each rating	10 No's
	15	Aux contact set of each type and Rating	6 Set's
	16	Fixed contact set of each type & rating	3 Set
	17	Moving contact set of each type & rating	3 Set
	18	Maintenance tools and accessories for maintenance of LT MCC	2 No's
12		**LT XLPE/ Screened/ Control**	**10% quantity of each type & rating**
13		**Local Control Station**	
	1	Trip – neutral – close switch	20%
	2	Auto Manual / Local -Remote switch	20%
	3	Ammeters of different ranges	20%
	4	Terminal block	20%
	5	Indicating Lamps of different type	20%
	6	Push Buttons of different type	20%
	7	Complete LCS of each type	20%
14		**Junction Box of each type**	**10 Sets**
15		**Variable Frequency Drives**	
	1	Set of fuses of all types & sizes used in system 5 Sets	5 Sets
	2	Controller Card of each type 1 Set	1 Set
	3	Power Devices of each type 2 Sets	2 Sets
	4	Software for parameter setting each type 1 Set	1 Set
Note:	**Set means complete replacement of particular part in one machine.**		
	The above spares do not includes commissioning spares and shall be purely warehouse spare.		
	Wherever "Each Type" is specified, it means "of the Type/make/model/size/rating and exactly replaceable"		
	Wherever "% qty." is specified, Bidder to quote in next higher rounded figure		
	Out of % age spares and minimum qty specified against each item - higher of the two shall be supplied.		
	Electrical EQUIPMENT which has not been mentioned in this table and needs spare parts, CONTRACTOR shall consider spare parts for them, the quantities for such spare parts shall then be APPROVED by OWNER/CONSULTANT. If any electrical equipment is not coming in this package, there shall be no spares for that equipment.		
	The Supplier shall provide spare parts and Consumables for Commissioning. They shall be listed and provided along with their bid according to Vendor experience. Cost of Spare Parts for commissioning shall be included in the total bid price.		
	Any other instruments which are not covered and is applicable for the system as per approved main drawing shall be supplied. Spares quantity shall be minimum 10% or 1 number each type		
	In case mandatory spares are duplicated or repeated across various clauses/sections of the Mechanical and Electrical/C&I specifications or lists, the bidder shall consider and include all such spares in the scope of supply. No exclusion on account of duplication or repetition shall be permitted.		



2000TPD COAL TO AMMONIUM NITRATE (LSTK-1)

ANNEXURE-Ele-03-ELECTRICAL, CONTROL AND INSTRUMENTATION SCOPE MATRIX FOR CHP & LHP Package						Coal to Ammonia Project	Rev: 01 Dated: 11.07.2026
SL. NO.	**SCOPE DETAILS**	**INPUT DETAILS**	**ENGINEERING / DESIGN**	**SUPPLY**	**RECEIPT, UNLOADING, STORAGE, ERECTION, TESTING, COMMISSIONING**	**REMARKS**	
1	Complete scope of Electrical and C&I System for CHP/LHP system(Refer Annexure-3A) is in bidders scope except for BHEL free issue equipment's as below 1) 3.3KV Switchboard 2) 3.3KV HT Motor 3) DCS 4) VMS 5) 11/3.3kV HT transformer 6) NGR 7) 3.3kV HT Busduct 8) 3.3/0.433kV dry type transformers 9) UPS for DCS Note: 1.All AC/DC/UPS/Aux Power supply required for BHEL free issue equipment's shall be in bidders scope. 2.O&M of BHEL Free issue equipment's shall be in bidders scope.	EPC Bidder	EPC Bidder	EPC Bidder	EPC Bidder	Supply and E&C of all HT/LT power, control, signal and communication cables, Cable trays, supports, earthing, electronic earthing material for BHEL free issue items shall be in Bidder's scope Bidder shall provide min. 2 Nos. uncabled feeders each of 250A, 100A, 63A, 32A, 16A rating (1 No in in I/C-1 and 1 No in I/C-2) in all 415V PMCC boards supplied by Bidder for BHEL use. Load of 50KVA for each MCC shall be considered for these loads while transformer sizing. **Bidder shall consider 500kVA load in LHP 415V MCC board with two nos of 1000A ACB uncabled feeder for BHEL use (Lime mill building system). This shall include space for BHEL tie Board (Length 14m Approx). Further tray & support arrangement, earthing including supply and E&C for BHEL facilities inside CHP MCC buiding shall be considered by CHP bidder (Tentative tray requirement : 600 Width ladder : 6 nos , 600 Width perforated : 1 nos)** **However the cable tray routing/cable rack from LHP MCC building exit to Lime Mill building load centres shall be in BHEL-PEM scope.** Complete Illumination, Earthing, Lightning protection for all areas of CHP/LHP is included in bidders scope. Bidders scope also includes illumination of all the roads marked as CHP/LHP/AHP in Annexure-3D (Tentative road Layout). Wherever integration of bidder supplied items with BHEL supplied system is involved, necessary integration shall be done by the bidder. Security of all equipment's including BHEL free supply till handing over to end customer is in scope of bidder. Obtaining Statutory clearance is in Bidders scope including BHEL free issue equipment's. Bidder to refer Annexure-Ele-03A: Broad Scope of supply of E&I equipments for CHP/LHP system	
Design for Equipment Layout of Electrical Swicthgear/Control room and associated cable rack connectivity for CHP and LHP area: This clause specifically covers the design of Electrical Swicthgear/Control room and electrical equipment layout.							
2A	MCC buildings/control rooms/ any other electrical building required as per scope of this package. Note: Cable tray, Earthing, Lightning, Illumination layout, Hoist, air conditioning, ventilation, firesealing of above buildings/Structures shall be in bidders scope (design, Supply & E&C)	EPC bidder	BHEL ISG	NA	NA	Quantity & location of CHP MCC building marked in plot plan is tentative except CHP MCC-1 near Crusher house. Final MCC location may undergo changes due to final plot plan approval & Bidder load inputs. Any impact on bidder design due to change in location of MCC buildings during Detailed engineering shall be absorbed by bidder without any commercial implication on BHEL. Bidder shall furnish the input details to BHEL for preparation of MCC building layouts (including transformer foundation details) within 2 months from the LOI. 3.3kV HT switch gear is Common for both CHP & AHP and shall be located at CHP MCC-1 near crusher house. Number of outgoing feeders & rating in 3.3kV Switchgear for AHP shall be as per Sl no 12. Further tray & support arrangement, earthing including supply and E&C for AHP facilities inside CHP MCC buiding shall be considered by CHP bidder (Tentative tray requirement : 600 Width ladder : 4 nos , 600 Width perforated : 1 nos) However the cable tray routing from CHP MCC building exit to AHP load centres shall be in AHP Biders scope. The interconnection between Bidders below ground earthing and Existing/Main earth grid is in Bidder scope. Soil resisitivity report will be shared to successfull bidder for reference by BHEL However bidder may carryout additional Soil resisitivity test if required without any extra cost and time to BHEL. Civil drawings for CHP MCC buildings shall be released by BHEL in line with project requirements. The bidder shall ensure that all necessary inputs required for the design of electrical switchgear/control rooms and associated cable rack connectivity are submitted to BHEL within three (3) months from the date of LOI. In case the bidder fails to provide the required inputs within the stipulated time, or if any changes are made to the submitted inputs after completion of the building design, any resulting modifications to the MCC buildings—such as changes in wall openings, floor cutouts, etc.—shall be carried out by the bidder at no additional cost to BHEL. For detailed scope demarcation of civil works pertaining to electrical facilities, please refer to Annexure-Elec-3C. Please refer plot plan for further details	
2B	Scope details : 1. Standalone Cable trestle/rack required for CHP/LHP 2. Any interconnection cable rack required for bidder equipment from BHEL buildings/facilities 3. Burried cable arrangment (if any) Note: Cable tray, Earthing, Lightning, Illumination layout, firesealing of above buildings/Structures including TP's crusher house , Silo complex, pump house , coneyor galleries , Lime handling facilties shall be in bidders scope (design, Supply & E&C)	EPC bidder	BHEL ISG	NA	NA	Bidder shall furnish the input details to BHEL for preparation of Cable rack drawing within 3 months from the LOI. Tentative routing shown in the plot plan and routing may undergo changes based on final plot plan and Bidder inputs . Any impact on bidder design due to change in location of MCC buildings during Detailed engineering shall be absorbed by bidder without any commercial implication on BHEL. Any burried cable arrangement for illumination shall be in bidders scope Bidder shall provide space provision for Cable trays (BHEL use) in Bidders Cable /pipe rack /Buildings etc . Details are as per Anexure -Elec-3B	

ANNEXURE-Ele-03-ELECTRICAL, CONTROL AND INSTRUMENTATION SCOPE MATRIX FOR CHP & LHP Package						Coal to Ammonia Project	Rev: 01 Dated: 11.07.2026
SL. NO.	**SCOPE DETAILS**	**INPUT DETAILS**	**ENGINEERING / DESIGN**	**SUPPLY**	**RECEIPT, UNLOADING, STORAGE, ERECTION, TESTING, COMMISSIONING**	**REMARKS**	
BHEL FREE ISSUE EQUIPMENTS							
3A	3.3KV Switchboard One number 3.3kV HT switchboards, with the maximum available outgoing feeders for 1. CHP - As mentioned in Sl No-12 2. AHP- As mentioned in Sl No-12 shall be provided to the bidder as a BHEL free issue equipment for the entire scope of work.	EPC Bidder	BHEL BHOPAL	BHEL BHOPAL	EPC Bidder	Bidder to refer Sl No 10 for 11kV power supply source availability. Bidder shall submit Electrical load list and transformer sizing within 3 months from LOI All Upstream/downstream tripping and interface/signal exchange between Sl No 10, 11, 12 shall be in the bidder's scope including the feeders reserved for AHP System. The bidder shall ensure that the maximum loading at the 11kV level does not exceed the maximum cut-off MVA specified in Sl. No. 10.	
3B	HT Bus Duct	EPC Bidder	BHEL RUDRAPUR	BHEL RUDRAPUR	EPC Bidder	During the engineering of the HT bus duct, interconnection between the BHEL-supplied 11/3.3 kV transformer and the BHEL free-issued 3.3 kV switchboard, the bidder shall ensure that relevant inputs are obtained from BHEL for the termination of the HT bus duct at the 3.3 kV switchgear end.	
3C	NGR	EPC Bidder	BHEL PEM	BHEL PEM	EPC Bidder		
3E	Common 11/3.3KV Transformer available for bidder for CHP/LHP application	EPC Bidder	BHEL JHANSI	BHEL JHANSI	EPC Bidder	Connection between oil retention pit of common 11/3.3KV AHP/CHP/LHP Transformer to common oil retention pit located in main plant area is in bidders scope.	
3E	3.3/0.415KV Transformer available for bidder for CHP/LHP application Bidder to refer Sl No 14 for List of BHEL free issue 3.3/0.415KV Trafo available to bidder	EPC Bidder	BHEL JHANSI	BHEL JHANSI	EPC Bidder		
4	HT Motors for Conveyor / Crusher application Bidder to refer Sl No 13 for List of BHEL free issue HT motors available to bidder	EPC Bidder	BHEL BHOPAL	BHEL BHOPAL	EPC Bidder	Bidder shall provide qty, rating, TS curve, speed, GD2 type of mounting and coupling details as input to BHEL within 4 months from LOI. Temperature measuring system, LPBS for all BHEL free issue HT motors shall be in the bidder's scope . The supply of consumables and lubrication for BHEL free issue HT motors is included in the bidder's scope. Before shifting motors from BHEL storage to bidders storage/facilities, the bidder shall conduct motor testing. In case any fault occurs during operation and BHEL recommends repair at the factory premises, the bidder shall decouple/remove the motor and shift it to the BHEL storage. After repair, the bidder shall again unload, erect and test the motor. If any EPC bidder designed equipment requires job motor during inspection of the equipment, then BHEL shall transport directly to manufacturers works. post inspection dispatch of motor directly to project site including loading, unloading storage is in bidders scope. Any damage during transit shall be dealt as per BHEL commercial terms and conditions	
5.A	Main CHP control system (DCS), software development and other equipment related to DCS (DCS panels, Network panels, LVS, PCs, Printers, furniture desk, Chairs, PC Consoles, Servers, EMS, OWS/OEWS/EWS)	EPC Bidder	BHEL EDN	BHEL EDN	EPC Bidder	Bidder's scope includes the following: 1. Detailed IO list including BHEL free issue items , KKS tagging, P&ID Diagram, set-points, Control Philosophy & write up, block logic diagram & HMI screens (for software development), Functional grouping. 2.Detailed IO list shall be submitted within 6 months of LOI in the format prescribed by BHEL which shall be shared to successful bidder . Any addition of IO's at later stage is not acceptable. 3. Bidder shall visit BHEL/Customer during software development, application testing , FAT and ensure the completeness of software for E&C. 4. Any logic modification during commissioning stage shall be executed by EPC bidder.	
5.B	230V UPS System and 24V DC System	EPC Bidder	BHEL EDN	BHEL EDN	EPC Bidder	24V DC and UPS system (Any load requirement for UPS load and 24V DC load applicable to bidder supplied equipments shall be shared by successful bidder during detailed engineering to BHEL-EDN to size the rating of UPS and DC system.	
6	Vibration Monitoring System	EPC Bidder	BHEL EDN	BHEL EDN/EPC Bidder	EPC Bidder	Bidder to provide sensor and key phasor mounting arrangement for bidder supplied equipment's as per contractual requirement. VMS Panel, Sensors, Prefab Sensor cables from sensor up to Field mounted local JB near Motor shall be supplied as free issue to Bidder. Balance items required for completeness of the system are in the scope of Bidder.	

ANNEXURE-Ele-03-ELECTRICAL, CONTROL AND INSTRUMENTATION SCOPE MATRIX FOR CHP & LHP Package						Coal to Ammonia Project	Rev: 01 Dated: 11.07.2026
SL. NO.	**SCOPE DETAILS**	**INPUT DETAILS**	**ENGINEERING / DESIGN**	**SUPPLY**	**RECEIPT, UNLOADING, STORAGE, ERECTION, TESTING, COMMISSIONING**	**REMARKS**	
BHEL Supply items which are to be located in Bidder's scope of buildings in addition to BHEL Free supply Items							
7	CCVM System	BHEL EDN / EPC BIDDER	BHEL EDN	BHEL EDN	BHEL PS REGION	Location of these equipment's shall be decided based on final layout engineering and space will be considered in switchgear building, control room, TP's, any other buildings. All other required civil facilities like anchor/kerb angles/insert plates/support structures/base frames/channels etc. shall be considered by bidder as required during Detailed ENGG. All AC/DC/UPS/Aux Power supply required for above equipment's shall be arranged by bidder.	
8	PA System	NA	NA	NA	NA		
9	Fire Fightign System	BHEL PE&SD/ EPC BIDDER	BHEL-PE&SD	BHEL-PE&SD	BHEL PS REGION		
Mentioned qty is maximum available offered as free supply to bidder, Any additional requirement shall be supplied by bidder as per bidder design requirement without any commercial implication to BHEL.							
10	List of uncabled 11KV source feeders available to bidder. a)Only 2 No of 11KV uncabled Feeder shall be provided by BHEL to bidder for Common CHP & AHP application at Main Plant MV Switchgear room					a) 11KV Outgoing feeder for 11/3.3kV HT Transformer - Maximum MVA Available 20MVA	Battery limit for Cable rack, cable trays,supports for 11KV Tie feeder from MV Switchgear room of Power house building to CHP MCC Building by EPC bidder
11	List of 11KV O/G feeders available to bidder. Location of switchboard : To be decided by Bidder					a) 11KV Transformer Feeder (11/3.3kV)- up to 20MVA	a) 2 Nos
12	List of 3.3KV O/G feeders available to bidder. Location of switchboard : To be decided by Bidder					a) 3.3KV Motor feeder b) 3.3KV Transformer Feeder	a) CHP - 6 / AHP - 12 Nos b) CHP, LHP - 8 / AHP - 2 Nos
13	BHEL free issue HT motors available to bidder					3.3KV Motor	CHP - 6 Nos
14	BHEL free issue 3.3/0.415KV Dry Type Trafo available to bidder					3.3/0.415KV Dry Type Trafo	CHP/LHP - 8 Nos

ANNEXURE-Ele-03-ELECTRICAL, CONTROL AND INSTRUMENTATION SCOPE MATRIX FOR CHP & LHP Package						Coal to Ammonia Project	Rev: 01 Dated: 11.07.2026
SL. NO.	**SCOPE DETAILS**	**INPUT DETAILS**	**ENGINEERING / DESIGN**	**SUPPLY**	**RECEIPT, UNLOADING, STORAGE, ERECTION, TESTING, COMMISSIONING**	**REMARKS**	
Name of BHEL UNIT for coordination with successful bidder of various system during Engineering							
Sl No	**System**					**BHEL-Unit**	
~~A~~	Plot Plan with Switchgear location, cable routing, earthing, illumination					BHEL-ISG/BHEL PEM	
B	Electrical and C&I system other than below listed					BHEL-ISG	
1	Design and integration of 3.3KV and 11KV system along with upstream breaker interface					BHEL-PEM/ BHEL-BHOPAL	
2	DCS, VMS, UPS, 24V DC System					BHEL-EDN	
3	HT Motors for conveyors & crusher					BHEL-Bhopal	
4	3.3/0.433kV Dry type transformer and 11/3.3kV Dry/Oil type transformer					BHEL-JHANSI	
5	HT Bus Duct					BHEL-RUDRAPUR	
6	NGR					BHEL-PEM	
7	CCVM System					BHEL-EDN	
8	PA System					NA	
9	Fire Fighting and FDA system					BHEL-PE&SD	

Annexure-Ele-03A: Broad Scope of supply of E&I equipments for CHP/LHP system			
Sl No	**Type of Equipment**	**Equipment Name**	**Scope of Supply**
1	**Switchboard**	11KV Board	BHEL
		11/3.3KV Trafo	BHEL
		HT Bus Duct	BHEL
		NGR	BHEL
		3.3KV Board	BHEL
		415V MCC	BIDDER
		LT Bus Duct	BIDDER
		3.3/0.433KV Trafo	BHEL
2	**Cables**	HT Power Cable	BIDDER
		LT Power cable	BIDDER
		Control Cable	BIDDER
		Signal Cable	BIDDER
		DP Cable	BIDDER
		PA Cable	BIDDER
		FO Cable	BIDDER
		ANY OTHER CABLE	BIDDER
3	**Earthing/Lightning**	Cable Tray	BIDDER
		Tray Support	BIDDER
		Earthing Materials	BIDDER
		Lightning Materials	BIDDER
		Fire Sealing	BIDDER
4	**Illumination**	MLDB	BIDDER
		LIGHTING PANELS	BIDDER
		Highmast/Poles	BIDDER
		Fixtures	BIDDER
		Conduits	BIDDER
		Wires	BIDDER
		Lighting JB	BIDDER
		Single Phase Receptacles	BIDDER
		Other Accessories	BIDDER
5	**DC System-220V DC**	Battery Charger	BIDDER
		Battery	BIDDER
		DCDB	BIDDER
		BHMS	BIDDER
6	**DC System-24V DC**	Battery Charger	BHEL
		Battery	BHEL
		DCDB	BHEL
		BHMS	BHEL
7	**UPS System-230V UPS**	Battery Charger	BHEL
		Battery	BHEL
		ACDB	BHEL
		BHMS	BHEL
8	**Welding Receptacles**	WDB	BIDDER
		63A Socket	BIDDER

Annexure-Ele-03A: Broad Scope of supply of E&I equipments for CHP/LHP system			
Sl No	**Type of Equipment**	**Equipment Name**	**Scope of Supply**
9	**Travelling Tripper**	LCP	BIDDER
		Limit Swicthes	BIDDER
		LM PJB/CJB	BIDDER
		Festoon/Drag Chain/CRD	BIDDER
		Over Speed swicth, Bunker Position Indicator	BIDDER
10	**Sampling Unit**	Switchgear	BIDDER
		PLC	BIDDER
		LOCAL CONTROL PANEL	BIDDER
11	**HT Conveyor**	Scoop Panel	BIDDER
		HT Motor	BHEL
12	**LT Conveyor/BF/RBF**	Motor	BIDDER
13	**DE System**	LCP	BIDDER
		Instruments-PS, DPS, Bag Filter, SOV, Seq Timer	BIDDER
		Compressor	BIDDER
		Motor	BIDDER
14	**DSS System**	LCP	BIDDER
		Instruments-PS, DPS, LS, LT, UBS, PT ETC	BIDDER
		Motor	BIDDER
		LPBS	BIDDER
		Compressor	BIDDER
		Sump Pump LCP	BIDDER
15	**AC System**	LCP	BIDDER
		Fire Damper	BIDDER
16	**VS System**	LCP	BIDDER
		Local Starter	BIDDER
		Motor	BIDDER
		Fire Damper	BIDDER
17	**Paddle Feeder**	LCP Cum PLC Cum VFD	BIDDER
		Motor	BIDDER
		LM PJB/CJB	BIDDER
		Drag Chain	BIDDER
18	**Safety Switches**	PCS	BIDDER
		BSS	BIDDER
		CBS	BIDDER
		ZSS	BIDDER
		BWP	BIDDER
		ANY OTHER	BIDDER
19	**Crusher**	ZSS	BIDDER
		Hydraulic Door panel	BIDDER
		Scoop Panel	BIDDER
		LT Motor	BIDDER
		HT Motor	BHEL

Annexure-Ele-03A: Broad Scope of supply of E&I equipments for CHP/LHP system			
Sl No	**Type of Equipment**	**Equipment Name**	**Scope of Supply**
20	**E Hoist**	LCP	BIDDER
		Land Mounted Isolation Box	BIDDER
21	**EOT Crane**	LCP	BIDDER
		Land Mounted Isolation Box	BIDDER
22	**Elevator**	LCP	BIDDER
		Land Mounted Isolation Box	BIDDER
23	**Temperature Transmitter**	TT JB	BIDDER
		Transmitter	BIDDER
		Instrument Rack	BIDDER
24	**VFD Panel**	Vibro Feeder	BIDDER
		Bio mass extractor	BIDDER
		Bucket Elevator	BIDDER
		ANY OTHER SYSTEM	BIDDER
25	**Common Items**	LPBS	BIDDER
		CJB	BIDDER
		PJB	BIDDER
26	**Electrics for EM Item**	Actuator	BIDDER
		BWS	BIDDER
		Weigh Bridge	BIDDER
		ILMS	BIDDER
		MD	BIDDER
		SM	BIDDER
27	**Sump Pump**	LCP	BIDDER
		Instruments	BIDDER
		Motor	BIDDER

Note:	Above list is not exhaustive, any equipments required for the completion of the system is in bidder's scope.

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ELECTRONIC FILE NAME : 544-100-M001.DGN

PLANT NORTH

WIND DIRECTION

HOLD

BM–1

ADHAPARA CHOWK

KHANDMAL VILLAGE

GREEN BELT(TYP.)

10M(MIN.)

DETAIL–1

PROP. QUARRY LIMIT L-B-L OCP

COAL ENTRY POINT

MATERIAL GATE

PLANT ENTRY GATE

PRODUCT GATE

GREEN BELT

SWITCH YARD (43)

LSTK -3 GAS YARD

CONST. WATER RESERVOIR (44)

NG SKID (45)

ASH POND (48)

COAL STORAGE STOCK PILE RAW WASHERY REJECT

STORAGE STOCK PILE RAW WASHED COAL

THESE FACILITIES ARE NOT IN LSTK-1 SCOPE

CONST. POWER SS (47)

LSTK -2 GAS YARD

LSTK 1 ETP

SRU (39)

(40)

(46)

MAIN SUBSTATION (90 M x 50 M) (35)

PLANT MAINT. OFFICE (19)

STORE CENTRAL (23)

BULK DIESEL STORAGE + EDG (42)

WORKSHOP (21)

BUILDING TECHNICAL (33)

BUILDING ADMINISTRATIVE (22)

OPERATION MANAGEMENT CENTRE (37)

CANTEEN (20)

LABTECH BUILDING (49)

FIRE STATION (36)

CCR (LSTK–1&2)

GAS CLEANING & PURIFICATION PLANT (3)

AIR SEPARATION UNIT (4)

IPDCT

CW PT (24)

AMMONIA TANK

AMMONIA PLANT

UTILITY SUBSTATION (14)

IA PLANT (58)

FIRE WATER STORAGE PUMP HOUSE (28)

RAW WATER STORAGE (18)

DM/CPU WATER PLANT (13)

RAW WATER TREATMENT PLANT (12)

FLARE STACK (16)

ETP+POND (25)

WEIGH BRIDGE

TRUCK PARKING AREA WITH DRIVER REST ROOM (17)

48643

62845

115460

51000

65163

35457

44000

N–1800.0M
N–1700.0M
N–1600.0M
N–1500.0M
N–1400.0M
N–1300.0M
N–1200.0M
N–1100.0M
N–1000.0M
N–900.0M
N–800.0M
N–700.0M
N–680.0M
N–600.0M
N–500.0M
N–400.0M
N–300.0M
N–200.0M
N–100.0M
N–000.0M

E–000.0M
E–100.0M
E–200.0M
E–300.0M
E–400.0M
E–500.0M
E–600.0M
E–700.0M
E–800.0M
E–900.0M
E–1000.0M
E–1100.0M
E–1200.0M
E–1300.0M
E–1400.0M
E–1500.0M
E–1600.0M

TABLE FOR FACILITIES/UNITS

SL.NO.	BLOCK DESCRIPTION	SIZE IN METER	REMARKS
1.	COAL & LIME STORAGE	PACKAGE	
2.	GASIFICATION PLANT	PACKAGE	
3.	GAS CLEANING & PURIFICATION PLANT	215 M x 115 M	
4.	AIR SEPARATION UNIT	250 M x 100 M	
5.	LSTK -3 (AMMONIA PLANT=AMMONIA STORAGE)	210 M x 165 M	
6.	~~NITRIC ACID PLANT~~	-	
7.	~~AMMONIUM NITRATE~~ PLANT WITH PRILLING	100 M x 80 M	
8.	~~NITRIC ACID STORAGE~~	-	
9.	DELETED	-	
10.	LSTK -4 (WNA+AN PLANT+ CT+ ASSOCIATED FACILITIES)	355 M x 285 M	
11.	STEAM GENERATION PLANT	PACKAGE	
12.	RAW WATER TREATMENT PLANT	150 M x 100 M	
13.	DM/CPU WATER PLANT	130 M x 80 M	
14.	UTILITY SUBSTATION	65 M x 35 M	
15.	LAB TECH BUILDING	30 M x 20 M	
16.	FLARE STACK	R 90M	
17.	TRUCK PARKING AREA WITH DRIVER REST ROOM	120 M x 55 M	
18.	RAW WATER STORAGE	57000 SQM.	
19.	PLANT MAINT. OFFICE	60 M X 45 M	
20.	CANTEEN	45 M x 30 M	
21.	WORKSHOP	100 M x 50 M	
22.	ADMINISTRATIVE BUILDING	70 M x 50 M	
23.	CENTRAL STORE	80 M x 50 M	
24.	COOLING TOWER FOR GASIFICATION AND UTILITY	160 M x 100 M	
25.	ETP+POND	140 M x 100 M	
26.	DELETED	-	
27.	NON-TECH. SUBSTATION	50 M x 30 M	
28.	FIRE WATER STORAGE+FWPH	120 M x 70 M	
29.	DELETED	-	
30.	~~LOADING BAY ANS~~	-	
31.	~~COOLING TOWER FOR AMMONIA, NITRIC ACID AND AN PLANT~~	-	
32.	CENTRAL CONTROL ROOM	DELETED	
33.	TECHNICAL BUILDING	60 M x 45 M	
34.	~~ANP STORAGE, BAGGING & TRUCK LOADING~~	-	
35.	MAIN SUB-STATION	80 M x 60 M	
36.	FIRE STATION	80 M x 50 M	
37.	ASH SILO	PACKAGE	
38.	IA PLANT	40 M x 40 M	
39.	SRU UNIT	35 M x 25 M	
40.	MAGNESIUM NITRATE, CAUSTIC, SULPHURIC ACID STORAGE	30 M x 15 M	
41.	~~ANS STORAGE~~	-	
42.	BULK DIESEL STORAGE + EDG	-	
43.	SWITCHYARD	135 M x 75 M	
44.	CONSTRUCTION WATER RESERVOIR	30M x 30M	
45.	NG SKID	55 M x 30 M	
46.	SULPHUR PIT	20 M x 20 M	
47.	CONSTRUCTION POWER SUB-STATION	30 M x 15 M	
48.	ASH POND	150 M x 60 M	
49.	~~LOADING/UNLOADING BAY FOR NITRIC ACID~~	-	
50.	LOADING/UNLOADING BAY FOR AMMONIA	48 M x 15 M	

NOTES:–

1. ALL DIMENSIONS AND COORDINATES ARE IN METERS UNLESS OTHERWISE SPECIFIED.
2. REFERENCE BENCH MARK (⊕) POINTS IS W.R.T GLOBAL CO–ORDINATES HAVING N–2405091.480 & E–793109.852 (GRID COORDINATES N–1700.0M, E–000.0M).
3. BLOCK SIZE OF FACILITIES ARE TO BE FINALIZED AFTER GETTING VENDOR INFO.
4. * INDICATES HOLD.

LEGEND :~

OFFSITE FACILITIES
LSTK-1 FACILITIES
LSTK-2 FACILITIES
LSTK-3 FACILITIES
LSTK-4 FACILITIES

GREEN BELT AREA

TOTAL PLANT AREA WITH GREEN BELT = 350.00 ACRE (APPROX.)
PLANT AREA = 195.00 ACRE (APPROX.)
GREENBELT AREA = 155.00 ACRE (APPROX.)

REV.	DATE	ALTD	CHD	APPD	REV.	DATE	ALTD	CHD	APPD

JOB NO. 544
STATUS CONTRACT
DISTRIBUTION

PROJECT: COAL TO 2000 TPD AMMONIUM NITRATE PROJECT OF M/S BCGCL AT LAKHANPUR (ODISHA) INDIA.

CUSTOMER: Bharat Coal Gasification and Chemicals Limited

CONSULTANT: PROJECTS & DEVELOPMENT INDIA LIMITED

CONTRACTOR: BHARAT HEAVY ELECTRICALS LTD
POWER SECTOR
PROJECT ENGINEERING MANAGEMENT
NOIDA

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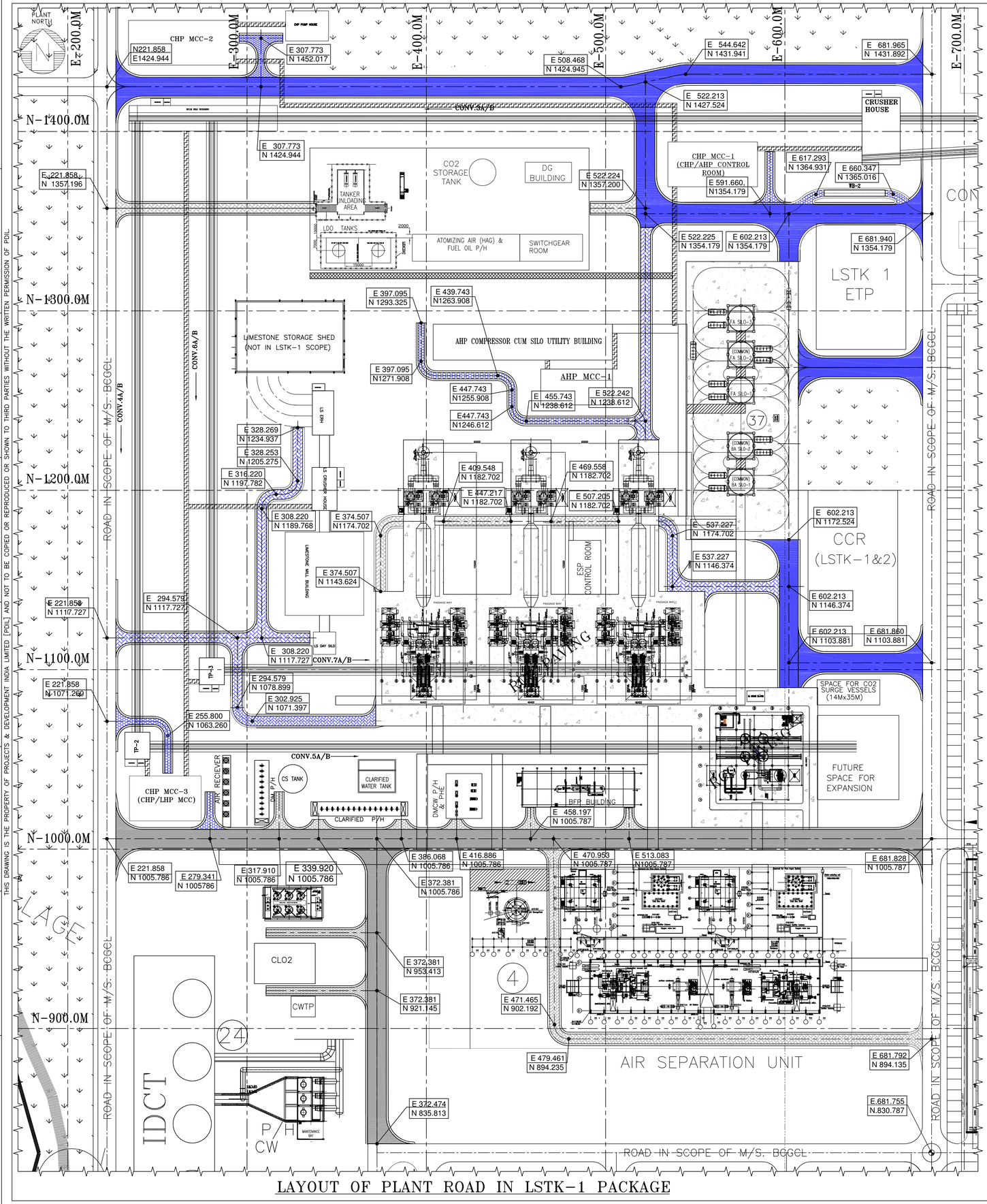
DEPT CODE		NAME	SIGN	DATE
M	DRN	RDP		02.03.2026
	DESN	RDJ		02.03.2026
	CHD	RDJ		02.03.2026
	APPD	RKA		02.03.2026

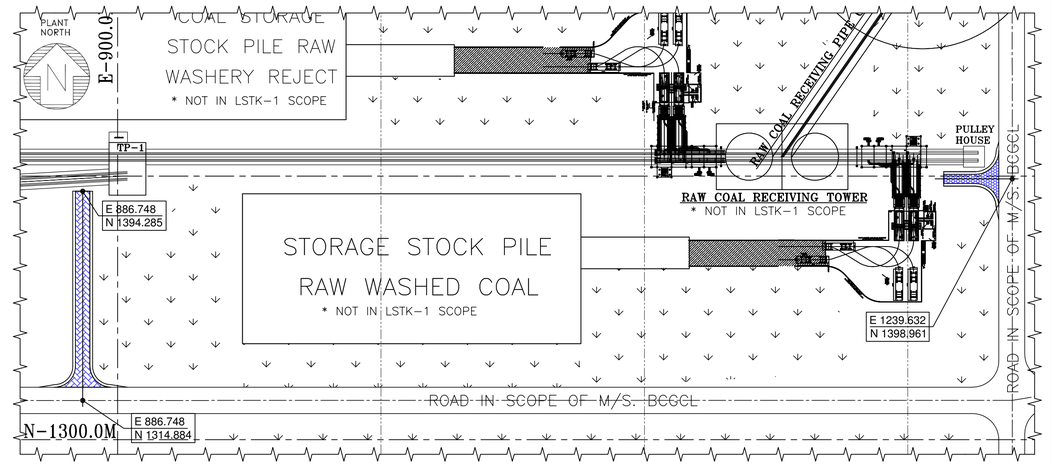
TITLE: GENERAL LAYOUT OF COAL BASED AMMONIUM NITRATE PLANT

DEPT. | SCALE 1:2500 | DRAWING NO. PE–DG–544–100–M001
SIGN | SHEET 1 OF 1 | REV. 00

SIZE-A0

Annexure-Elec-3C : Scope Demarcation of minor civil works pertaining to Electrical/C&I facilities					Rev 0 04.05.2026
Sl.no	**Description**	**Scope of Input Details/Design**	**Scope of Supply**	**Supervision/Checking**	**Scope of Fixing & Erection**
1	All embedded pipes (GI/PVC)	**EPC bidder**	BHEL (PS-Region)	**EPC bidder**	BHEL (PS-Region)
2	Hume pipes used for laying cables for road crossing	**EPC bidder**	BHEL (PS-Region)	**EPC bidder**	BHEL (PS-Region)
3	Inserts on the wall/roof/grade slab etc	**EPC bidder**	BHEL (PS-Region)	**EPC bidder**	BHEL (PS-Region)
4	Channels for panel erection on the trench/cellar/any floor where Electrical/C&I equipments are placed	**EPC bidder**	**EPC bidder**	**EPC bidder**	**EPC bidder**
5	Chequered plates with supporting channels in switchgear/control rooms, any other buildings/structures	**EPC bidder**	BHEL (PS-Region)	**EPC bidder**	BHEL (PS-Region)
6	Rails with fixtures / insert plates for transformer foundation (outdoor)	**EPC bidder**	BHEL (PS-Region)	**EPC bidder**	BHEL (PS-Region)
7	Rails with fixtures / insert plates for transformer foundation (indoor)	**EPC bidder**	BHEL (PS-Region)	**EPC bidder**	BHEL (PS-Region)
8	Lighting mast foundation - Civil Works	**EPC bidder**	BHEL (PS-Region)	**EPC bidder**	BHEL (PS-Region)
9	Lighting mast foundation bolts	**EPC bidder**	**EPC bidder**	**EPC bidder**	BHEL (PS-Region)
10	Foundation Bolts for any Electrical Equipment (if any)	**EPC bidder**	**EPC bidder**	**EPC bidder**	BHEL (PS-Region)
11	Street lighting - Civil Works	**EPC bidder**	**EPC bidder**	**EPC bidder**	**EPC bidder**
12	Civil work for burried cables as applicable	**EPC bidder**	BHEL (PS-Region)	**EPC bidder**	BHEL (PS-Region)
13	Cable slits	**EPC bidder**	BHEL (PS-Region)	**EPC bidder**	BHEL (PS-Region)
14	Cable duct bank	**EPC bidder**	BHEL (PS-Region)	**EPC bidder**	BHEL (PS-Region)
15	Structural Steel supports (MS) for cable tray & electrical equipment erection - In Cable racks, MCC/control rooms, TP's, crusher house, pump house, any other buildings/structures	**EPC bidder**	**EPC bidder**	**EPC bidder**	**EPC bidder**
16	Below ground earthing (burried)	**EPC bidder**	**EPC bidder**	**EPC bidder**	BHEL (PS-Region)
17	Civil work for earth pits	**EPC bidder**	**EPC bidder**	**EPC bidder**	**EPC bidder**
18	Grouting (as applicable)	**EPC bidder**	BHEL (PS-Region)	EPC bidder	BHEL (PS-Region)
Note:	*Bidder shall provide the requisite inputs details during detailed Engineering for the above. In case the bidder fails to provide the required inputs within the stipulated time, or if any changes are made to the submitted inputs after completion of the building design, any resulting modifications in civil works pertianing to the above —such as changes shall be carried out by the bidder at no additional cost to BHEL.*				
	This Annexure shall be read in conjunction with ANNEXURE-Elec-03-ELECTRICAL, CONTROL AND INSTRUMENTATION SCOPE MATRIX				





LAYOUT OF PLANT ROAD IN LSTK-1 PACKAGE

(FOR PULLEY HOUSE & TP-1)

ISSUED FOR TENDER PURPOSE .

ROAD LAYOUT SUBJECTED TO CHANGE BASED ON CUSTOMER APPROVAL, BIDDER INPUTS.
BIDDER TO CONSIDER ROAD ILLUMINATION ACCORDINGLY WITHOUT ANY COST IMPLICATION TO BHEL

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETER & ELEVATIONS IN METER, UNLESS STATED OTHERWISE.
2. ALL ELEVATIONS ARE MARKED AS REDUCED LEVEL(RL).
3. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH BHEL DRAWING # IS-1-CE-786-603-C002 TITLED "PLANT ROAD CROSS SECTION AND DETAILS" & IS-1-CE-786-603-C003 TITLED "PLANT DRAINS & CULVERT LAYOUT".
4. WIDTH OF ROAD INDICATED IN DRAWING CORRESPONDS TO ACTUAL WIDTH EXCLUDING SHOULDER WIDTH/ FOOTPATH.
5. COORDINATES OF ROAD INDICATED IN THE DRAWING IS THE CL OF THE ROAD U.N.O.
6. AT ALL INTERSECTION OF ROADS, THE ELEVATION OF ROAD SHALL BE MAINTAINED CONSTANT BETWEEN THE EDGES OF THE CURVE, UNLESS OTHERWISE SPECIFIED.
7. ROAD CONSTRUCTION SHALL BE AS PER IRC: 15-2011 & MORTH SPECIFICATIONS.
8. LONGITUDINAL SLOPE OF ROAD SHALL NOT MORE THAN 1V:30H.
9. INTERNAL ROADS/APPROACH ROADS SHALL BE SHOWN IN RESPECTIVE FACILITIES/BUILDING AREA DRAWING AND SHALL BE UPDATED PROGRESSIVELY.
10. SITE TO ENSURE LAYING OF STP/ETP NETWORK & FIRE PROTECTION TRENCHES/PIPES THROUGH RCC NP-3 PIPE BEFORE CONSTRUCTION OF ROAD.
11. R.C.C CIRCULAR PIPE (NP3) OF DIA 200 ENCASED IN RCC SHALL BE LAID AT SPACING OF 100.M INTERVAL ACROSS ROAD FOR CABLE/PIPE CROSSING AT SUITABLE DEPTH BELOW GROUND.
12. THIS DRAWING SHALL BE READ ALONG WITH LAYOUT / DETAILS DRAWINGS OF STORM WATER DRAINS, EFFLUENT DRAINS, FIRE WATER LINES, SEWER LINES, ELECTRIC CABLE LINES ETC.
13. ALL SERVICE AND UTILITY LIKE FIRE WATER LINE, SEWERAGE LINE, ELECTRIC CABLES LINE ETC. CROSSING THE ROAD SHALL BE TAKEN THROUGH NP3 CLASS RCC HUME PIPE. THESE PIPES SHALL BE ENCASED AS PER SPECIFICATION REQUIREMENT. HUME PIPE SHALL BE LAID BEFORE ROAD WORK SO THAT THE ROAD SHALL NOT BE DAMAGED.

REFERENCE DRAWINGS:

1.	PLOT PLAN	– PE-DG-544-100-M001
2.	PLANT ROAD CROSS SECTION AND DETAILS	– IS-1-CE-786-603-C002
3.	PLANT DRAINS & CULVERT LAYOUT	– IS-1-CE-786-603-C003
4.	PLANT DRAINS & CULVERT DETAILS	– IS-1-CE-786-603-C004
5.	GASIFIER AREA: GA & RC DETAILS OF GRADE SLAB / PAVING	– IS-1-CE-786-617-C008
6.	BOILER AREA: GA & RC DETAILS OF GRADE SLAB / PAVING	– IS-1-CE-786-617-C018
7.	ESP AREA: GA & RC DETAILS OF GRADE SLAB	– IS-1-CE-786-617-C024

LEGEND:

- ----- 10.500 M ROAD
- ----- 5.500 M ROAD
- ----- 3.500 M ROAD
- ----- RCC PAVING

LEGEND(CHP/LHP/AHP):

- ----- 10.500 M ROAD
- ----- 5.500 M ROAD
- ----- 3.500 M ROAD

BHEL-INDUSTRIAL SYSTEMS GROUP (CIVIL)	
THIS DRAWING MARKED(✓) IS RELEASED FOR	
☑ COMMENTS/APPROVAL	☐ FABRICATION
☐ PLANNING	☐ INFORMATION
☐ CONSTRUCTION	☐ AS BUILT DRAWING
STAMP ALL PREVIOUS REVISION AS SUPERSEDED	
ISSUED BY	
NAME	RAVI KUMAR PONNA
SIGNATURE	---sd---
DATE	7 May 2026

REV NO.	DATE	DESCRIPTION	PRPD.	CKD.	APPD.
R0	07.05.2026	FOR APPROVAL	VIPIN	VIKRAM	RKPO

OWNER :	BCGCL	BHARAT COAL GASIFICATION AND CHEMICALS LIMITED
PMC :	PDIL	PROJECTS & DEVELOPMENT INDIA LIMITED
PROJECT :		2000 TPD COAL TO AMMONIUM NITRATE PROJECT OF M/S BCGCL AT LAKHANPUR (ODISHA) INDIA.
LOCATION :		LAKHANPUR – JHARSUGUDA (ODISHA)
PLANT :		COAL GASIFICATION & RAW SYNGAS CLEANING PLANT (LSTK PACKAGE#1)
SECTION/ UNIT :		INDUSTRIAL SYSTEMS GROUP, BENGALURU
TITLE :		PLANT ROAD LAYOUT
SUB-VENDOR/ EQUIPMENT OEM :		---
LSTK :		BHARAT HEAVY ELECTRICALS LIMITED

BHEL PROJECT CODE:	IS-1-25-2002
SHEET NO.	1 OF 1
REV. NO.	0
SCALE :–	1: 1000
DRG. SIZE:	A1
BHEL DRAWING NUMBER:	IS-1-CE-786-603-C001

PRPD.	CKD.	APPD.
VIPIN	VIKRAM	RKPO