SUB-SECTION-II-E7

VFD

VFD

1.00.00 **GENERAL**

The Design, manufacture, erection, testing and performance of items and services provided under this specification shall comply with the latest edition including all applicable official amendments and revisions as on date of award of the following standards. In case of conflict between this specification and code (IS Code, standards, etc.) referred herein, the former shall prevail. All work shall be carried out as per the following codes and standards.

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 controlgear; Pt.102: Alternating current disconnectors and earthing switches	IEC 62271-102
High-voltage switchgear and controlgear; Pt.200: AC metal-enclosed switchgear and controlgear 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	IEC 60034-18-41 &42, IEC60034 / NEMA 30 & 31,
Contactor/Switches/Fuses etc.	IEC:60947, IS: 13947
Harmonics & EM compatibility	IEEE:519/IEC: 61000
VFD	IEC: 60034/ IEC: 61800

Equipment complying with other internationally accepted standards 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 amendments

and revision in force as on date of opening of bid and shall clearly bring out the salient features for comparison.

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 auxiliary AC voltage supply arrangement shall have 11/6.6/3.3kV and 415V systems (as applicable). It shall be designed to limit voltage variations as given below under worst operating condition:

1. 11kV/ 3.3 kV/ 6.6 KV : +/- 6%
2. 415V : +/- 10%

Note: The Voltage level mentioned above is the Nominal Voltage available at the input of the VFD System from the MCC/ Switchgear/transformer, based on the system requirement/Availability.

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 IGBT
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	IGBT

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.

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 with minimum Twelve (12) pulse design. For drives less than 100 KW Six (6) pulse can be offered meeting all other requirements.

5.03.00 The system shall be fully digital, PLC/Microprocessor based, energy efficient, and shall provide very high reliability, high power factor, low harmonic distortion and low vibration and wear and noise. It shall be easy to install in minimum time and expense and no special tools shall be required for routine maintenance.

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. All the Motors which are to be driven by VFDs will be of Inverter duty type. Also these motors shall comply the requirements stipulated in IEC: 60034-18-41 and IEC: 60034-18-42 as applicable. 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. At least 30 time tagged fault messages shall be stored in the drive's fault history.

6.14.00	The VFD cubicles shall be placed in air conditioned environment. However if VFDs of less than 100 kW are designed to operate in non-air condition environment the same shall also be acceptable.
6.15.00	The 3-Phase IGBT 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 IGBT 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 (OPTIONAL, IF SPECIFIED)**
8.01.00	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 (OPTIONAL, IF SPECIFIED)**
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 shall be minimum 96.5% for LV VFD and minimum 94 % 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	The VFD shall be designed to operate indoor under temperature range of 0 deg C to 50 deg C and relative humidity of 95 %(at 40 deg C).
11.02.00	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).
11.03.00	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.
11.04.00	Air cooled VFDs shall be provided with cooling fans mounted integral to the VFD/ enclosure. The VFD shall include air-flow pressure switches and temperature detectors 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 natural 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.
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:	Winding temperature rise shall be as per applicable IEC.

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):**
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 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. In case dry type transformer is provided inside VFD panels, the enclosure and in its frame thickness shall be same as indicated in this para.
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	**PAINTING**

Paint shade shall be as follows

a)	VFD transformer reactor enclosure	:	RAL 5012 (Blue), legend in black letter
b)	Motors	:	RAL 5012 (Blue)
c)	VFD Panels	:	Front and rear panels in Grey (RAL9002). End panel sides in blue (RAL 5012)

19.00.00	**HT SWITCHGEAR**
19.01.00	The technical requirements of HT switchgear shall be as per chapter of HT switchgear in Part-B of Technical specifications.
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.
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.
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 one flat TFT monitor with keyboard (password protected) in the VFD room and a color laser printer for system alarm and monitoring located 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 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	**STORAGE AND PRESERVATION**
27.01.00	The Contractor shall be responsible for the storage and preservation of all the equipments to be supplied under the VFD System, till the time of successful installation and commissioning. The equipment should be suitable for storage for long periods before installation. Contractor should take adequate measures to ensure that no damage happens to the VFD System due to storage and preservation.
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**
28.02.01	The Contractor shall carry out the type tests as listed in this specification on the equipment to be supplied under this contract. The bidder shall indicate the charges for each of these type tests separately in the relevant schedule and the same shall be considered for the evaluation of the bids. The type tests charges shall be paid only for the test(s) actually conducted successfully under this contract and upon certification by the employer's engineer.
28.02.02	The type tests shall be carried out in presence of the employer's representative, for which minimum 15 days' notice shall be given by the Contractor. The Contractor

	shall obtain the employer's approval for the type test procedure before conducting the type test. The type test procedure shall clearly specify the test set–up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.
28.02.03	In case the Contractor has conducted such specified type test(s) within last ten years as on the date of bid opening, he may submit during detailed engineering the type test reports to the Employer for waival of conductance of such test(s). These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client. The Employer reserves the right to waive conducting of any or all the specified type test(s) under this contract. In case type tests are waived, the type test charges shall not be payable to the Contractor.
28.02.04	Further the Contractor shall only submit the reports of the type tests as listed in "LIST OF TESTS FOR WHICH REPORTS HAVE TO BE SUBMITTED" and carried out within last ten 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. However if 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 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 Employer either at third party lab or in presence of client/Employers representative and submit the reports for approval.
28.03.00	**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)
28.04.00	**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)** 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 (In case of non-integrated type)

i. As per requirements mentioned in subsection for Transformer chapter in technical specifications.

SUB-SECTION-II-E8

HT SWITCHGEAR

1.00.00 **DESIGN CRITERIA FOR MV SWITCHGEARS**

Sizing Criteria

The Sizing criteria for MV Switchgears shall be the short time fault withstand levels, impulse withstand levels, Continuous Current rating for the MV Switchboards and Modules**.**

Sizing For fault Conditions

Fault Level shall be the basic selection Criteria for MV switchgears. Typical Fault ratings are as detailed under Technical parameters (sub-section-II-E1).

Sizing For Load Current Duty

a) The sizing Criteria for a Typical MV Switchboard shall be determined by the size of the transformer feeding the board. As a design Philosophy the Board continuous Current shall be selected as (1.1) * (Full load current at rated voltage on the Transformer's secondary) at 50 deg. C Ambient.

b) 3.3KV supply System shall be designed for supplying power to MV drives at 3.3 KV level. Each of the switchgear shall have two incomers and bus sections. Each bus section and transformer is rated for 100 % capacity, so that incoming cable fault etc. does not necessitate complete outage of entire switchgear. Interconnection between transformer and 3.3 KV Switchgear shall be by bus ducts.

Design of Outgoing feeders:

The various outgoing feeders shall be Feeders for Motors, Auxiliary Transformers, Tie feeders and Supply feeders. While sizing the outgoing feeder the rating is calculated based on the following:

Motor Feeder: KW Rating/ [System Vol * 1.732 * (Eff) *(Pf)] *1.1 (at least)

Transformer feeder: Transformer KVA/ primary [Voltage * 1.732] *1.1 (at least)

Tie feeder: As per system requirement

Incomer feeders: Generally same as the Board rating

Bus Couplers: Generally 2/3 of the Incomer Feeder rating.

Standard MV Switchgear Modules and their Selection Criteria

MV feeders shall be categorized into standard Modules. The module defines the feeder type, Protections, Feeder schematics and metering and monitoring requirements. The Standard Modules are listed in table below:

S No	Module Type	Application	Applicability
1	DA	Motor Feeder	MV Motor Feeders < 2 MW

2	DAF	Motor Feeder with Differential Protections	MV Motor Feeders >= 2 MW
3	DB	Transformer Feeder	Transformer feeder < 5 MVA
4	DBF	Transformer Feeder with Differential Protections	Transformer feeder >= 5 MVA
5	DC	Incomer Feeder	MV Incomer Module
6	DD	Bus Coupler Feeder	Bus Coupler Module for MV Boards
7	DE	Tie Feeder	Tie Between boards
8	G	Bus PT	Bus PT on each Section

Plant control cable Interconnections

a) Standard control cable sizes shall be 1.5 mm^2

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 1.5mm^2 size per phase

d) Separate control cables shall be used for current transformers.

e) - Separate control cables shall be laid for EPB (Emergency/Local Push Button) status from EPB to Switchgear for the Switchgear and PLC/DCS.

2.00.00 CODES AND STANDARDS

All standards, specification and codes of practices 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 and codes

a)	IS: 722	AC electricity meters.
b)	IS: 996	Single phase small AC and universal electrical motors.
c)	IS: 1248	Direct Acting indicating analogue electrical measuring instruments and Accessories.
d)	IS/IEC: 60947	Degree of protection provided by enclosures for low voltage switchgear and control gear.
e)	IS: 2544	Porcelain post insulators for systems with nominal voltages greater than 1000 Volts.
f)	IS: 2705	Current transformers.
g)	IS: 3156	Voltage Transformers
h)	IS: 6005	Code of practice for phosphating of iron and steel.
i)	IS: 3427	Metal enclosed switchgear and control gear
j)	IS: 5082	Specification for wrought aluminum and aluminum alloy bars, rods, tubes and selections for electrical purposes.
k)	IEC: 61850	Communication Standard for Numerical relays

l)	IEC: 61131-3	Automation Standard for Numerical relays
m)	IS: 9046	AC contactors for voltages above 1000 volts and upto and including 11000 Volts.
n)	IS: 13703	Low voltage fuses
o)	IS: 9385	HV fuses
p)	IS: 9431	Specification for indoor post insulators of organic material for system with nominal voltages greater than 1000 volts upto and including 300 kV
q)	IS: 9921	A.C. disconnectors (isolators) and Earthing switches for voltages above 1000 V
r)	IS: 11353	Guide for uniform system of marking and identification of conductors and apparatus terminals.
s)	IS: 13118	Specification for high voltage AC circuit breakers.
t)	IEC: 60099-4	Metal oxide surge arrestor without gap for AC system
u)	IEC: 62271-100	High voltage alternating current circuit breakers.
v)	IS/IEC: 62271-200	High voltage metal enclosed switchgear and control gear.
w)	IEC: 60947-7-1	Terminal blocks for copper conductors
(x)	IS :513 (2008)	Cold Rolled Low Carbon Steel Sheets and Strips

2.1.00 Installation shall conform to Indian Electricity Act and Indian Electricity Rules as amended upto date. The Indian Electricity Act and Indian Electricity Rules can be obtained from :

Kitab Mahal
State Emporium Building,
Baba Kharag Singh Marg,
New Delhi - 110 001
INDIA.

2.2.00 Equipment conforming to any other internationally accepted standards will also be considered if they ensure performance and constructional features equivalent or superior to the standards listed above. In such case, the contractor shall clearly indicate the standard(s) adopted. The contractor shall furnish copy in English of the latest revision of the standards along with the 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.

3.00.00 TECHNICAL PARAMETERS (AS APPLICABLE)

A)	**SYSTEM PARAMETERS**				
1	Nominal System voltage	33 kV	11 kV	6.6 kV	3.3 kV
2	Highest System voltage	36 kV	12 kV	7.2 kV	3.6 kV
3	Rated Frequency	50 Hz	50 Hz	50 Hz	50 Hz
4	Number of phases/ poles	Three	Three	Three	Three
5	System neutral earthing	Solidly Grounded	Earthed through Resistance to limit fault current to		

			600A	600 A	600A
6	One minute power frequency withstand voltage				
	- for Type tests	70	28	20	10
	- for Routine tests	70	28	20	10
7	1.2/50 microsecond Impulse withstand voltage	170 kV (peak)	75 kV (peak)	60 kV (peak)	40 kV(peak)
8	Maximum system fault level including initial motor contribution	21 kA (rms)	40 kA (rms)	40 kA (rms)	40 kA (rms)
9	Short time rating for bus bars, ckt. breakers, current transformers and swgr. Assembly.	21 kA (rms) for one (1) sec.	40 kA (rms) for one (1) sec.	40 kA (rms) for one (1) sec.	40 kA (rms) for one (1) sec.
10	Dynamic withstand rating	52.5 kA (peak)	100 kA (peak)	100 kA (peak)	100 kA (peak)
11	IAC Rating	-	40 kA, 1 sec		
12	Control supply voltage				
	- Trip and closing coils	240V DC/120V DC	240V DC/120V DC	240V DC/120V DC	240V DC/120V DC
	- Spring charging motor	240V DC/120V DC	240V DC/120V DC	240V DC/120V DC	240V DC/120V DC
	- Space heaters	240 V AC single phase with neutral solidly earthed			
13	Maximum ambient air temperature	50 deg. C	50 deg. C	50 deg. C	50 deg. C
b)	**BUS BARS**				
1.	Continuous current rating at 50 ^{0}C ambient:	As Per System requirements			
2.	Temper Rise allowed above ambient	40 ^{0}C for plain joints 55 ^{0}C for Silver plated joints			
c)	**SWGR. CUBICLE CONSTRUCTIONAL REQUIREMENTS**				
1.	Color finish				
	Exterior	RAL9002 (Main body) RAL 5012 (Extreme end covers)			
2.	Cable entry				

	a)	Power Cables		Bottom	
	b)	Control Cables		Bottom	
3.	Busduct entry	Top			
4.	Earthing conductor	Galvanized steel strip			
5	Service Continuity of swgrs(as per IS/IEC 62271-200)	LSC2B-PM			

d) CIRCUIT BREAKERS

1.	The circuit breakers current rating shall be selected from the load current given in SLD which is at an ambient of 50^0 C.				
2.	Short circuit breaker Current	33 kV	11 kV	6.6 kV	3.3 kV
	a) A.C. component	21 kA	40 kA	40 kA	40 kA
	b) D.C. component	As per IS: 13118 or IEC-62271			
3.	Short Circuit making current	52.5 kA (peak)	100 kA (peak)	100 kA (peak)	100 kA (peak)
4.	Operating Duty	O-3min-CO-3min-CO			
5.	Total break time	Not more than 4 cycles			
6.	Total make time	Not more than 5 cycles			
7.	Operating Mechanism	Motor wound spring charged stored energy type as per IEC-62271			

e) CURRENT TRANSFORMER

1.	Secondary Current	1A
2.	Class of Insulation	Class E or better
3.	Rated output	Adequate for the relays and devices connected, but not less than five (5) VA.
4.	Accuracy class	
	Protection	Class PS for differential, REF and Core Balance CTs (CBCT); 5P20 for other protection CTs
	Measurement	0.2s for Station & Unit Incomers and any other defined feeders as marked in SLD.
5.	Minimum primary earth fault current to be detected by CBCT	3 Amperes
6.	Instrument Security Factor for Measurement CTs	5

f) VOLTAGE TRANSFORMERS

1.	Rated Voltage Factor	1.2 continuous for all VTs, and 1.9 for 30 seconds for star connected VTs.	
2.	Class of insulation	Class E or better	
3.	Other parameters	BUS PT-0.5 Class,VA req. adequate for application. Line PT-0.5 Class for sync./3P for door interlocks, VA req. adequate for application.	
g)	**H.V. FUSES**		
1.	Voltage class	6.6kV	3.3kV
2.	Rupturing Capacity	Adequate for 100 kA (peak)	Adequate for 100 kA (peak)
3.	Rated current	As per application	As per application

h) SURGE ARRESTERS (FOR MOTOR FEEDERS)

		6.6 kV	11 kV	3.3kV
1.	Nominal discharge Current (8x20 µs)	5kA	5kA	5kA
2.	Max. system voltage (rms)	7.2 kV	12 kV	3.6kV
3.	Rated Voltage of Surge arrestor(line-line)	7.5 kV	12 kV	4.5 kV
4.	Max allowable Residual voltage at nominal discharge current	25 kV	40 kV	15kV
5.	Mounting	Inside panel	Inside panel	Inside panel

i) CONTACTORS :

1.	Nominal System Voltage	6.6 kV	3.3kV
2.	Highest System Voltage	7.2 kV	3.6kV
3.	Rated Frequency	50 HZ	
4.	Rated Continuous Current at 50^0C ambient	Current rating shall be selected appropriate for the load current	
5.	Control Supply Voltage	240V DC / 120V DC unearthed	
6.	Utilisation category	AC-3	

4.00.00 **GENERAL TECHNICAL REQUIREMENTS**

4.1.00 **Switchgear Panel**

(a) The switchgear boards shall have a single front, single tier, fully compartmentalized, metal enclosed construction complying with clause No. 3.102 of IEC 62271-200, comprising of a row of free standing floor mounted panels. Each circuit shall have a separate vertical panel with distinct compartments for circuit breaker / contactor truck, cable termination, main busbars and auxiliary control devices. The adjacent panels shall be completely separated by steel/aluzinc sheets except in busbar compartments where insulated barriers shall be provided to segregate adjacent panels. The Service Class Continuity of Switchgears shall be LSC 2B-PM (as per IS/ IEC 62271-200). However, manufacturer's standard switchgear designs without inter panel barriers in busbar compartment may also be considered.

(b) The circuit breakers / contactors and bus VTs shall be mounted on withdraw able trucks which shall roll out horizontally from service position to isolated position. For complete withdrawal from the panel, the truck shall rollout on the floor or shall roll out on telescopic rails. In case the later arrangement is offered, suitable trolley shall be provided by the Contractor for withdrawal and insertion of the truck from and into the panel. The number of trolleys to be provided shall be as specified. Testing of the breaker / contactor shall be possible in Isolated position by keeping the control plug connected.

(c) The trucks shall have distinct SERVICE and ISOLATED positions. It shall be possible to close the breaker / contactor compartment door in isolated position also, so that the switchgear retains its specified degree of protection. Circuit Breaker rack-in and rack-out from Service to Test, Test to Isolated position, or vice-versa shall be possible only in the compartment door closed condition**.** While switchboard designs with doors for breaker / contactor compartments would be preferred, standard designs of reputed switchgear manufacturers where the truck front serves as the compartment cover may also be considered provided the breaker / contactor compartment is completely sealed from all other compartments and retains the IP-4X degree of protection in the Isolated position. In case the latter arrangement is offered, the Contractor shall explain how this sealing is achieved and shall include blanking covers one for each size of panel per switchboard.

(d) The switchgear assembly shall be dust, moisture, rodent and vermin proof, with the truck in any position SERVICE, ISOLATED or removed, and all doors and covers closed. All doors, removable covers and glass windows shall have gaskets all round with Steel Reinforced EPDM/PU Foam.

(e) The VT/ relay compartments shall have degree of protection not less than IP 5X in accordance with IS/IEC 60947. However, remaining compartments can have a degree of protection of IP 4X. All louvers, if provided, shall have very fine brass or GI mesh screen. Tight fitting gourmet / gaskets are to be provided at all openings in relay compartment. Numerical Relays shall be fully Flush mounted on the switchgear panels at a suitable height.

(f) The Switchgear shall have an Internal Arc Classification of IAC FLR 40KA, 1 sec. The switchgear construction shall be such that the operating personnel are not endangered

by breaker operation and internal explosions, and the front of the panels shall be specially designed to withstand these. Pressure relief device shall be provided in each high voltage compartment of a panel, so that in case of a fault in a compartment, the gases produced are safely vented out, thereby minimizing the possibility of its spreading to other compartments and panels. The pressure relief device shall not however reduce the degree of protection of panels under normal working conditions. To demonstrate that the pressure relief device operates satisfactorily the Contractor shall submit the type test report in line with IEC 62271-200 Annex - A. Wherever louvers are provided, the construction of louvers shall be such that the IAC requirements are satisfied. Further, viewing glass windows shall have the same strength as that of enclosure against internal Arc.

(g) Enclosure shall be constructed with rolled steel/aluzinc sections. The doors and covers shall be constructed from cold rolled steel sheets of 2.0 mm or higher thickness. Gland plates shall be 2.5 mm thick made out of hot rolled or cold rolled steel sheets and for non magnetic material it shall be 3.0 mm.

(h) The switchgear shall be cooled by natural air flow and forced cooling is allowed only for the panels rated above 3000A.

(i) Total height of the switchgear panels shall not exceed 2700 mm. The height of switches, pushbuttons and other hand operated devices shall not exceed 1800 mm and shall not be less than 700 mm.

(j) Necessary guide channels shall be provided in the breaker compartments for proper alignment of plug and socket contacts when truck is being moved to SERVICE position. A crank or lever arrangement shall preferably be provided for smooth and positive movement of truck between Service and Isolated positions.

(k) Safety shutters complying with IEC 62271-200 shall be provided to cover up the fixed high voltage contacts on busbar and cable sides when the truck is moved to ISOLATED position. The shutters shall move automatically, through a linkage with the movement of the truck. Preferably it shall however, be possible to open the shutters of busbar side and cable side individually against spring pressure for testing purpose after defeating the interlock with truck movement deliberately. In case, insulating shutters are provided, these shall meet the requirements of IEC 62271-200 and necessary tests as per IEC 62271-200 Clause 5.103.3.3 shall be carried out. A clearly visible warning label "Isolate elsewhere before earthing" shall be provided on the shutters of incoming and tie connections which could be energised from other end.

(l) Switchgear construction shall have a bushing or other sealing arrangement between the circuit breaker / Contactor compartment and the busbar / cable compartments, so that there is no air communication around the isolating contacts in the shutter area with the truck in service position.

(m) The breaker / contactor and the auxiliary compartments provided on the front side shall have strong hinged doors. Busbar and cabling compartments provided on the rear side shall have separate bolted covers with self retaining bolts for easy maintenance and safety. Breaker / Contactor compartment doors shall have locking facility and shall be provided with single shot latch type handle. Suitable interlock shall be provided, which will ensure that breaker is OFF before opening the bolted covers /back doors. For Incomer/Tie panels suitable interlock shall be provided to prevent opening of any compartment doors which has any of the MV (33kV/11kV/6.6kV/3.3kV) equipment, in case the incoming supply is ON.

(n) In the Service position, the truck shall be so secured that it is not displaced by short circuit forces. Busbars, jumpers and other components of the switchgear shall also be properly supported to withstand all possible short circuit forces corresponding to the short circuit rating specified.

(o) Suitable base frames made out of steel channels shall be supplied along with necessary anchor bolts and other hardware, for mounting of the switchgear panels. These shall be dispatched in advance so that they may be installed and leveled when the flooring is being done, welding of base frame to the insert plates as per approved installation drawings shall be in Contractor's scope.

(p) The switchboard shall have the facility of extension on both sides. Adopter panels and dummy panels required to meet the various busbar arrangements, cable / busduct termination and layouts shall be included in Contractor's scope of work.

4.2.00 **Circuit Breakers**

a) The circuit breakers shall be of Vacuum type.
They shall comprise of three separate, identical single pole interrupting units, operated through a common shaft by a sturdy operating mechanism.

b) Outgoing breakers shall be suitable for switching transformers and motors at any load. They shall be capable of being used for frequent direct-on-line starting of squirrel cage induction motors:

c) Circuit breaker shall be restrike free, stored energy operated and trip free type. Motor wound closing spring charging shall only be acceptable. An antipumping relay shall be provided for each breaker, even if it has built-in mechanical anti-pumping features. An arrangement of two breakers in parallel to meet a specified current rating shall not be acceptable.

d) During closing, main poles shall not rebound objectionably and mechanism shall not require adjustments. Necessary dampers shall be provided to withstand the impact at the end of opening stroke. Slow closing facility shall preferably be provided for checking and adjustment of arc chutes and poles when the breaker is completely withdrawn and isolated.

e) Plug and socket isolating Contacts for main power circuit shall be silver plated, of self aligning type, of robust design and capable of withstanding the specified short circuit currents. They shall preferably be shrouded with an insulating material. Plug and socket contacts for auxiliary circuits shall also be silver plated, sturdy and of self aligning type having a high degree of reliability. Thickness of silver plating shall not be less than 10 microns.

f) All working part of the mechanism shall be of corrosion resisting material. Bearings which require greasing shall be equipped with pressure type grease fittings. Bearing pins, bolts, nuts and other parts shall be adequately secured and locked to prevent loosening or change in adjustment due to repeated operation of the breaker and the mechanism.

g) The operating mechanism shall be such that failure of any auxiliary spring shall not prevent tripping and shall not lead to closing or tripping of circuit breaker. Failure of any auxiliary spring shall also not cause damage to the circuit breaker or endanger the operator.

h) Mechanical indicators shall be provided on the breaker trucks to indicate OPEN / CLOSED conditions of the circuit breaker, and CHARGED / DISCHARGED conditions of the closing spring. An operation counter shall also be provided. These shall be visible without opening the breaker compartment door.

i) The rated control supply voltage shall be as mentioned elsewhere under Technical parameters. The closing coil and spring charging motor shall operate satisfactorily at all values of control supply voltage between 187V-242V/93.5V-121 V DC. The shunt trip coil shall operate satisfactorily under all operating conditions of the circuit breaker up to its rated short circuit breaking current at all values of control supply voltage between 154-242V DC /77 V-121 V DC. The trip coil shall be so designed that it does not get energized when its healthiness is monitored by two indicating lamps (Red) and one trip coil supervision relay.

j) The time taken for charging of closing spring shall not exceed 30 seconds. The spring charging shall take place automatically preferably after a closing operation. Breaker operation shall be independent of the spring charging motor which shall only charge the closing spring. Opening spring shall get charged automatically during closing operation. As long as power supply is available to the charging motor a continuous sequence of closing and opening operations shall be possible. One open-close- open operation of the circuit breaker shall be possible after failure of power supply to the motor. Spring charging motors shall be capable of starting and charging the closing spring twice in quick succession without exceeding acceptable winding temperature when the control supply voltage is any where between 187V-242V/93.5V-121 V DC. The initial temperature shall be as prevalent in the switchgear panel during full load operation with 50 deg. C ambient air temperature. The motor shall be provided with short circuit protection.

k) Motor windings shall be provided with class E insulation or better. The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in a hot, humid and tropical climate.

l) Circuit breaker shall be provided with inter pole barriers of insulating materials. The use of inflammable materials like Hylam shall not be acceptable.

4.3.00 **Contactor**

(a) The Contractor shall offer only HRC fuse backed, mechanically latched type contactor for outgoing motor feeder panels (designated as module type CC) for drives with frequent start / stop.

(b) The medium voltage contactors shall be of AC-3 utilization category and shall be vacuum type. The fuse and contactor assembly shall be mounted on a withdrawable truck. Circuits shall be provided with suitable single phasing protection. If required the contactor coil shall have a suitable economy resistor in series and shall be rated for satisfactory operation at 187V-242V/93.5V-121 V DC.

(c) The fuse and overload relay shall be fully coordinated, so that the contactor operates only for a fault current less than its interrupting capability. The fuses shall be provided with mechanical trip indication.

(d) The contactors shall close satisfactorily with a control voltage between 187V-242V/93.5V-121 V DC trip satisfactorily with a control voltage 154-242V DC /77 V-121 V DC. Mechanical indication of contactor open / closed shall be provided. An anti-pumping relay shall be provided even if it has mechanical anti-pumping feature.

4.4.00	**Surge Arrestor**
	The surge arrestors shall be provided for all motor feeders and shall be metal oxide, gapless type generally in accordance with IEC 60099-4 and suitable for indoor duty. These shall be mounted within the switchgear cubicle between line and earth, preferably in the cable compartment. Surge arrestor selected shall be suitable for non-effectively earthed system and rating shall be in such a way that the value of steep fronted switching over voltage generated at the switchgear terminals shall be limited to the requirements of switchgear.
4.5.00	**Control and Interlocks**
4.5.1	The circuit breaker / contactor will normally be controlled from remote control panels (PLC/DCS) (via Numerical Relays) through closing and shunt trip coils. The Local control console of the relay flush mounted on the switchgear would normally be used only for testing of circuit breaker / contactor in isolated position. Provision for closing & tripping of the circuit breaker shall be possible locally from laptop / relay HMI through serial port shall be possible to facilitate commissioning activities.
4.5.2	The basic control scheme shall be developed as per the schematic logics in the relay. The schematics shall be developed in soft inside the relay.
4.5.3	Facilities shall be provided for mechanical tripping of the breaker/ contactor and for manual charging of the stored energy mechanism for a complete duty cycle, in an emergency in closed door condition.
4.5.4	Each panel shall have two separate limit switches, one for the Service position and the other for isolated position. Each of these limit switches shall have at least four (4) contacts which shall close in the respective positions.
4.5.5	Auxiliary Contacts of breaker / contactor may be mounted in the fixed portion or in the withdrawable truck as per the standard practice of the manufacturer, and shall be directly operated by the breaker / contactor operating mechanism.
4.5.6	Auxiliary contacts mounted in the fixed portion shall not be operable by the operating mechanism, once the truck is withdrawn from the service position, but remain in the position corresponding to breaker / contactor open position. Auxiliary contacts mounted on the truck portion, and dedicated for PLC/DCS use shall be wired out in series with a contact denoting breaker / contactor service position. With truck withdrawn, the auxiliary contacts shall be operable by hand for testing.
4.5.7	The contacts of all limit switches and all breaker / contactor auxiliary contacts located on truck portion and fixed portion shall be silver plated, rated to make, carry and break 1.0A 240V DC (Inductive) / 10A 240V AC. Contacts of control plug and socket shall be capable of carrying the above current continuously.
4.5.8	Movement of truck between SERVICE and ISOLATED positions shall be mechanically prevented when the breaker / contactor is closed. An attempt to withdraw a closed breaker / contactor shall not trip it.
4.5.9	Closing of the breaker / contactor shall be possible only when truck is either in ISOLATED or in SERVICE position and shall not be possible when truck is in between. Further, closing shall be possible only when the auxiliary circuits to breaker / contactor truck have been connected up, and closing spring is fully charged.

4.5.10 It shall be possible to easily insert breaker / contactor of one typical rating into any one of the panels meant for same rating but at the same time shall be prevented from inserting it into panels meant for a different type or rating.

4.5.11 Indications shall be provided in the relay console flush mounted on the panel front as brought out in the specification elsewhere. It shall be possible to easily make out whether the truck in SERVICE OR ISOLATED POSITION even when the compartment door is closed.

4.6.00 **Busbars and Insulators**

(a) All busbar and jumper connections shall be of high conductivity aluminium alloy. They shall be adequately supported on insulators to withstand electrical and mechanical stresses due to specified short circuit currents.

Busbar cross-section shall be uniform throughout the length of switchgear. Busbars and other high voltage connection shall be sufficiently corona free at maximum working voltage.

Contact surfaces at all joints shall be silver plated or properly cleaned and non-oxide grease applied to ensure an efficient and trouble free connection. All bolted joints shall have necessary plain and spring washers. All connection hardware shall have high corrosion resistance. Bimetallic connectors or any other technically proven method shall be used for aluminum to copper connections.

(b) Busbar insulators shall be of arc and track resistant, high strength, non-hygroscopic, non-combustible type and shall be suitable to withstand stresses due to over-voltages, and short circuit current. Busbar shall be supported on the insulators such that the conductor expansion and contraction are allowed without straining the insulators. In case of organic insulator partial discharge shall be limited to 100pico coulomb at rated voltage x 1.1 / $\sqrt{3}$. Use of insulators and barriers of in-flammable material such as Hylam shall not be accepted.

(c) The Contractor shall furnish calculation establishing adequacy of busbar sizes for the specified continuous and short time current ratings.

(d) All busbars shall be color coded. All busbars shall be provided with non-halogen based heat shrinkable polymer sleeves having excellent performance in high voltage environments and reduces the noxious and corrosive effects in fire situations. Busbar sleeves shall be of tested design as per relevant IEC/ASTM/equivalent standard.

(e) The temperature of the busbar and all other equipment, when carrying the rated current continuously shall be limited as per the stipulations of relevant Indian Standards, duly considering the specified ambient temperature (50 deg. C). The temperature rise of the horizontal and vertical busbars when carrying the rated current shall in no case exceed 55 deg. C for silver plated joints and 40 deg. C for all other type of joints. The temperature rise at the switchgear terminals intended for external cable termination shall not exceed 40 deg. C. Further the switchgear parts handled by the operator shall not exceed a rise of 5 deg. C .The temperature rise of the accessible parts / external enclosure expected to be touched in normal operation shall not exceed 20 deg. C.

4.7.00 **Earthing and Earthing Devices**

a) A copper / galvanized steel earthing bus shall be provided at the bottom and shall extend through out the length of each switch board. It shall be bolted/ welded to the framework of each panel and each breaker / contactor earthing contact bar.

b) The earth bus shall have sufficient cross section to carry the momentary short-circuit and short time fault currents to earth as indicated under switchgear parameters without exceeding the allowable temperature rise.

c) Suitable arrangement shall be provided at each end of the earth bus for bolting to earthing conductors. All joint splices to the earth bus shall be made through at least two bolts and taps by proper lug and bolt connection.

d) All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus. Electrical continuity of the whole switchgear enclosure frame work and the truck shall be maintained even after painting.

e) The truck and breaker / contactor frame shall get earthed while the truck is being inserted in the panel and positive earthing of the truck and breaker / contactor frame shall be maintained in all positions i.e. SERVICE and ISOLATED as well as throughout the intermediate travel. The truck shall also get and remain earthed when the control plug is connected irrespective of its position.

f) 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. Insulation colour code of earthing wires shall be green. Earthing wires shall be connected to terminals with suitable clamp connectors and soldering shall not be acceptable. Looping of earth connections which would result in loss of earth connection to other devices, when a device is removed is not acceptable. However, looping of earth connections between equipment to provide alternative paths of earth bus is acceptable.

g) VT and CT secondary neutral point earthing shall be at one place only on the terminal block. Such earthing shall be made through links so that earthing of one secondary circuit may be removed without disturbing the earthing of other circuits.

h) Separate earthing trucks shall be provided by the Contractor for maintenance work. These trucks shall be suitable for earthing the switchgear busbars as well as outgoing / incoming cables or busducts. The trucks shall have a voltage transformer and an interlock to prevent earthing of any live connection. The earthing trucks shall in addition have a visual and audible annunciation to warn the operator against earthing of live connections.

   As an alternative to separate earthing trucks the Contractor may also offer built-in earthing facilities for the busbars and outgoing / incoming connections, in case such facilities are available in their standard proven switchgear design. The inbuilt earthing switches shall have provision for short circuiting and earthing a circuit intended to be earthed. These switches shall be quick make type, independent of the action of the operator and shall be operable from the front of the switchgear panel. These switches shall have facility for padlocking in the earthed condition.

i) Interlocks shall be provided to prevent :

   1) Closing of the earthing switch if the associated circuit breaker truck is in Service position.

   2) Insertion of the breaker truck to Service position if earthing switch is in closed position.

   3) Closing of the earth switch on a live connection. Three (3) nos. voltage

capacitive dividers shall be provided on each phase of the section intended for earthing and three (3) nos. "RED" neon lamps connected to these on the panel front for visual indication.

4) Energizing an earthed Section.

Complete details of arrangement offered shall be included in the bid, describing the safety features and interlocks.

j) The earthing device (truck / switch) shall have the short circuit withstand capability equal to that of associated switchgear panel. 4 NO + 4 NC of auxiliary contacts of the earthing device shall be provided for interlocking purpose.

k) All hinged doors shall be earthed through flexible earthing braid.

4.8.00 **Painting**

All sheet steel work shall be pretreated, 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 owner. 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.

4.9.00 **Instrument Transformers**

(a) All single-section switchboards shall be provided with two numbers of separate bus VT panels complete with all accessories.

(b) All current and voltage transformers shall be completely encapsulated cast resin insulated type, suitable for continuous operation at the ambient temperature prevailing inside the switchgear enclosure, when the switchboard is operating at its rated load and the outside ambient temperature is 50 deg. C. The class of insulation shall be E or better.

(c) All instrument transformers shall withstand the power frequency and impulse test voltage specified for the switchgear assembly. The current transformer shall further have the dynamic and short time ratings at least equal to those specified for the associated switchgear and shall safely withstand the thermal and mechanical stress produced by maximum fault currents specified when mounted inside the switchgear for circuit breaker modules. However, current transformer mounted in fuse backed contactor module shall have the dynamic and short time rating compatible with the let through current of the fuses.

(d) The parameters of instrument transformers specified in this specification are tentative and shall be finalized by the owner in due course duly considering the actual burden of various relays and other devices finally selected. In case the Contractor finds that the specified ratings are not adequate for the relays and other devices offered by him, he shall offer instrument transformer of adequate ratings and shall bring out this fact clearly in his bid.

(e) All instrument transformers shall have clear indelible polarity markings. All secondary terminals shall be wired to separate terminals on an accessible terminal block.

(f) Current transformers may be multi or single core and shall be located in the cable termination compartment. All voltage transformers shall be single phase type. The bus VTs shall be housed in a separate panel on a truck so as to be fully withdrawable.

(g) Core balance CTs (CBCT) shall be provided on all outgoing motor and transformer feeders. These CBCTs shall be mounted inside the switchgear panel. The window size of CBCTs shall be based on the overall diameter of the cables, to be finalised during detailed engineering. The CBCT shall be of circular window type.

(h) All voltage transformers shall have suitable HRC current limiting fuses on both primary and secondary sides. Primary fuses shall be mounted on the withdrawable portion. Replacement of the primary fuses shall be possible with VT truck in ISOLATED position. The secondary fuses shall be mounted on the fixed portion and the fuse replacement shall be possible without drawing out the VT truck from Service position. All voltage transformers shall be designed and manufactured for 0.8 Tesla operating point on B-H curve. VT shall be fully insulated type (i.e. double pole construction and neutral side fully insulated to rated BIL). VT shall be manufactured without any joint in secondary winding.

4.10.00 Control Supply and Space Heater Supply

(a) Bus PT Panel shall house the control & space heater supply distribution system and other LV equipment common for the board.

(b) Each switchboard section shall be provided with two (2) Nos. of 240V DC / 120V DC feeders for the control supply.

(c) The arrangement for receiving the above supply and distributing it to individual panels shall be provided by the Contractor in line with the drawing No. 0000-205-POE-A-013 enclosed. The diodes shall have a peak inverse voltage of 1000 Volts. Diode details like rated current, heat sink sizing & temperature, etc. shall be submitted for review and approval.

(d) Contractor shall provide one 240V/63A single phase to neutral AC supply feeder per switchboard/Switchboard section for space heater supply. Contractor shall provide necessary switch and fuse to receive, isolate and distribute to each panel.

(e) Power Supply to Numerical Relay shall be an independent circuit with switch and fuse tapped from the panel DC supply. Exact scheme for segregation of switchgear & numerical relay DC supplies shall be finalized during detailed engineering.

(f) Each sub circuit shall have separate fuses. Fuse size shall be determined so as to achieve selective clearance between main circuit and sub circuit in case of fault. Potential circuits for protection and metering shall also be protected by separate fuse.

(g) All fuses shall be of HRC link type conforming to IS: 13703 / 9385 mounted on suitable fuse bases. Fuses shall have operation indicators for indicating blown fuse condition. Fuse carrier base shall have imprints of the fuse rating and voltage. All accessible live connection to fuse bases shall be adequately shrouded.

(h) All DC circuits shall be fused on both poles. Single phase AC circuits shall have fuses on line and link on neutral.

4.11.00 **Space Heater**

(a) Each switchgear panel shall be equipped with thermostatically controlled space heater(s), suitably located in breaker / contactor and cable compartments to prevent condensation within the enclosure. The space heater shall be connected to 240V single phase AC auxiliary supply available in the switchgear, through switches and fuses provided separately for each panel.

(b) For motor space heater supply, one breaker / contactor normally closed (NC) auxiliary contact of each motor feeder shall be wired out in series of switch fuse upto terminals block in the respective panels of switch boards. The motor space heater supply shall be taken from Panel space heater supply given to switch board. For DAF module the space heater circuit & its components shall be rated for min. 16A.

(c) A 240V single phase 50 Hz AC plug point shall be provided in the interior of each cubicle with ON-OFF switch for connection of hand lamp.

4.12.00 Terminal Blocks

(a.) 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.

(b.) 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.

(c.) At least 10% spare terminals for external connections shall be provided on each panel and these spare terminals shall be uniformly distributed on all terminal blocks. Space for adding another 10% spare terminals shall also be available in each panel.

(d.) There shall be minimum clearances of 250 mm between the terminal blocks and the cable gland plate and 150 mm between two rows of terminal blocks.

(e.) All panel wring for external connections shall terminate on separate terminal blocks which shall be suitable for connecting two (2) stranded copper conductors of 2.5 sq. mm on each side, or alternatively, the terminal blocks shall have the possibility of double shorting space to facilitate looping.

(f.) DIN Rail shall conform to DIN EN 60715/ Equivalent Standard, with base metal of cold rolled low carbon steel according to DIN EN 10130/Equivalent Standard, surface coating /trivalent chromate passivation in accordance with EN 12329/ Equivalent Standard. Salt Spray Test withstand minimum 130hrs (while rust) and 300hrs (red rust). The DIN Rail shall be RoHS compliant.

4.13.00 Switchgear Wiring

(a.) All Switchgear panels shall be supplied completely wired internally upto the terminal block ready to receive external cabling. All inter cubicle wiring and connections between panels of same switchboard including all bus wiring for AC and DC supplies shall be provided / done by the Contractor.

(b.) All internal wiring shall be carried out with 650 V grade, single core, 1.5 sq. mm. stranded copper wires having minimum of seven strands per conductor and color coded, PVC insulation. CT circuits shall be wired with 2.5 sq. mm. wires which otherwise are similar to the above. CT & VT connections shall be done with ring type lugs. Extra flexible wires shall be used for wiring between fixed and moving parts such as hinged doors.

(c.) All wiring shall be properly supported neatly arranged, readily accessible and securely connected to equipment, terminals and terminal blocks. Wiring troughs or gutters be used for this purpose.

(d) Inter-panel wiring for distribution of space heater supply shall be done with copper wires of adequate cross-section to carry the total current of all panel as well as motor space heaters

(e) Internal wire terminals shall be made with solderless crimping type tinned copper lugs which shall firmly grip the conductor. Insulation sleeves shall be provided over the exposed parts of lugs.

(f) 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.

(g) Interconnection to adjacent panels shall be brought out to a separate set of terminal blocks located near the slots or holes, meant for the interconnecting wires. Arrangement shall permit neat layout and easy interconnections to adjacent panels at site and wires for this purpose shall be provided by Contractor looped and bunched properly inside the panels.

(h) Contractor shall be fully responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipment.

(i) The Contractor shall provide the necessary clamps wiring troughs etc. for all wiring in side the switchgear enclosed including the Contractor's power and control cables.

(j) Wiring Duct shall be Halogen Free complying to 1) VDE 0472/815 or equivalent standard 2) UL94 flammability rating of V-0 for continuous use upto 95 degree Celsius and 3)RoHS (lead Free) Compliant.

4.14.00 **Power Cable Termination**

(a.) Cable termination compartment shall receive the Contractor's stranded Aluminium conductor, XLPE insulated, shielded, armored / unarmored, PVC jacketed, single core / three core, unearthed / earthed grade power cable(s).

(b.) A minimum clearance of approx. 600 mm shall be kept between the cable lug and gland plates for stress cone formation for XLPE cables. Interphase clearance in the cable termination compartment shall be adequate to meet electrical and mechanical requirement besides facilitating easy connections and disconnection of cables. Dimensional drawing of cable connection compartment showing the location of lug,

glands, CTs, gland plates etc. and the electrical clearances available shall be submitted for owner's approval during detail engineering.

(c.) Cable termination compartment shall have provision for termination of power cables of sizes as indicated during detailed engineering with removable undrilled gland plates. For all single core cables gland plates shall be of nonmagnetic material. Cable entry shall be from bottom. Any change will be intimated later.

4.15.00 **Name Plates and Labels**

a. Each switch board shall have a name plate for its identification. All enclosure mounted equipment hall be provided with individual engraved name plates for clear equipment identification. All panels shall be identified on front as well as backside by large engraved name plates giving the distinct feeder description along with panel numbers. Back side name plates shall be fixed in panel frame and not on the rear removable cover.

b. Name plate shall be of non-rusting metal or 3-ply lamicoid with white engraved letterings, on black background. Letter size shall be of at least 10cm height.

c. Suitable stenciled paint mark shall be provided for identification of all equipment, located inside the enclosure, as well as for door mounted equipment, from the back side in addition to plastic sticker labels, if provided. These labels shall be located directly by the side of the respective equipment, shall be clearly visible and shall not be hidden by equipment wiring. Labels shall have device number as mentioned in wiring drawings. Type of labels and fixing of labels shall be such that they are not likely to peel off / fall off during prolonged use.

4.15.1 **Circuit Breaker Module**

All circuit breaker modules shall have the following accessories:

- Current / Voltage transformers as per requirement
- Relays as per relevant clauses / single line diagrams
- Spring charging motor, with its protection and control
- Auxiliary contacts.
- Terminal blocks
- Refer module tender drawings at Page No. 28 of 38 to 38 of 38

4.15.2 **P.T. Module Type - G**

Item Description	**Module G**
1 phase VT*	3
Fuses (VT Primary)	3
Fuses (VT Secondary)	6

	* 3.3 kV System the VT ratio is 3.3/ $\sqrt{3}$ KV / 110/ $\sqrt{3}$ V * 11kV System the VT ratio is 11/ $\sqrt{3}$ KV / 110/ $\sqrt{3}$ V
4.15.3	**Contactor Module – CC**
	All Contactor modules shall have the following accessories: - Power Contactors with HRC Fuses - Current / Voltage transformers as per requirement - Numerical Relays as per relevant clauses / single line diagrams - Spring charging motor, with its protection and control - Auxiliary contacts. - Terminal blocks
5.00.00	**NUMERICAL RELAYS**
5.1.00	**General requirements**
5.1.1	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 to the satisfaction of the Employer.
5.1.2	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. Contacts for breaker / vacuum contactor close and trip commands shall be so rated as to be used directly used in the closing and tripping circuits of breaker / vacuum contactor 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.
5.1.3	One minute power frequency withstand test voltage for all numerical relays shall at least be 2kV (rms).
5.1.4	All IEDs shall have freely programmable optically isolated binary inputs (BI) and potential free binary output (BO) contacts, the minimum quantity of which is as follows. (a) Motor feeder – 10 BI + 8 BO (b) Transformer feeder – 12 BI + 6 BO (c) Incomer, Bus-coupler, Tie feeder – 14BI + 8 BO The above quantities are only indicative and shall be finalized during detailed engineering .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.

5.1.5	Failure of a control supply and de-energization of a relay shall not initiate any circuit breaker / vacuum contactor operation.
5.1.6	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.
5.1.7	All the numerical relays shall have communications on two ports, local front port for communication to laptop and one RJ45 port on IEC 61850.
5.1.8	All Numerical relays shall have features for electrical measurements including voltage, current, power (active & reactive), frequency, power-factor and energy parameters.
5.1.9	Relays shall have event recording feature, recording of abnormalities and operating parameters with time stamping.
5.1.10	Master trip (86) and non-86 trips shall be software configurable to output contacts and no separate master trip relay shall be used.
5.1.11	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. Relays for transformer feeders without differential shall have 5 CT inputs (3 – Phase, 1 – CBCT, 1 – REF). Relays for transformer feeders with differential protection shall have 9 CT inputs (6 – Phase, 1 – CBCT, 1 – REF, 1 – Standby Earth Fault). Motor relays shall have 4 & 7 CT inputs for non-differential & differential application respectively. 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.
5.1.12	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.
5.1.13	All numerical relays shall have key pad / 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. Relay to be self or hand reset shall be software selectable. Manual resetting shall be possible from remote.
5.1.14	Relays shall have suitable output contact for circuit breaker failure protection (CBFP).
5.1.15	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.
5.1.16	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.
5.1.17	Design of the relay must be immune to any kind of electromagnetic interference. Vendor to submit all related type test reports for the offered model along with the offer.
5.1.18	All cards/ hardware of numerical relays shall be suitable for operation in Harsh Environmental conditions with respect to high temperature, humidity & dust.
5.2.00	**Protections: Relay Types & Protections**
5.2.1	**Motor Feeder Protections (Module Type DA/DAF/CC)** The Motor protection relay shall be suitable for providing the following protections

a) Thermal Overload Protection (49)

The relay shall have adjustable thermal curve as per parameters. Separate prior alarm and trip outputs shall be available.

b) Short Circuit Protection (50)

The relay shall have instantaneous short-circuit protection. Provision for blocking of short-circuit protection shall be available to make relay suitable for contactor-controlled motors.

The short circuit protection shall also have cold load pick up (doubling) / group-changeover feature to allow higher setting during motor start and lower setting during normal running condition.

c) Earth Fault Protection (50N)

The relay shall have instantaneous as well as time delayed earth fault protection. With CBCT the relay shall be suitable for detection of earth fault currents in the range of 1% (10mA). Provision should be provided to block earth fault element in case of phase current exceeding 4 times of full load current when used for contactor-controlled motors.

d) Negative Phase Sequence Protection (46)

The relay shall have negative phase sequence (unbalance) protection to protect the motor against overheating caused by phase unbalance / negative sequence current.

e) Locked Rotor Protection (50LR)

The relay shall have locked rotor protection to take care of stalling of motor during motor start up. The protection shall take care of the prolonged motor start up time under bus low-voltage conditions. The relay shall have provision to accept speed switch input to enable to use relay for applications where the safe stall time of motor is shorter than the start-up time of the motor.

f) Motor start monitoring & Restart inhibit feature

The relay shall have a function block for monitoring motor start-up condition with suitable outputs for use in various logics. A thermal based restart inhibit feature with separate settings shall be provided. It shall be possible to configure the output of this function to block closing command during restart inhibit period. Estimated time to the next motor restart should be available for display.

g) Number of starts limitation (66)

The relay should have repetitive start protection to protect the motor against overheating caused by too frequent start-up attempts. The output of this function block should be routed to restart inhibit output.

h) Under Voltage protection with time delay (27M)

The relay should have under voltage protection with built in variable timer. The protection should be sensed through bus VT voltage provided to relay.

i) Motor Differential protection (87M)

Differential protection for motors rating 2MW and above shall be provided with high stability circulating current differential protection with harmonic restraint having pick up setting range of 10 to 40 % of CT secondary. Necessary series stabilizing resistors and metrosils shall also be provided.

j) VT Fuse-fail protection (60)

Built in fuse fail protection should be available in relay, which should block under

voltage protection in the event of fuse fail. The relay should have built in Lockout feature.

5.2.2 Transformer Feeder Protections (Module Type DB/DBF)

The Transformer protection relay shall be suitable for providing the following protections.

a) Three Phase Over current and Earth Fault protection (50 & 50N)

The relay shall have instantaneous as well as time delayed over current and earth fault protections. The over current element should have the minimum setting adjustable between 250-2000% of CT secondary rated current. The short circuit protection shall also have cold load pick up (doubling) / group-changeover feature to allow higher setting during transformer charging (inrush) and lower setting during normal operating condition.

With CBCT the relay shall be suitable for detection of earth fault currents in the range of 10mA secondary.

b) Restricted Earth Fault protection (64R)

Restricted earth fault protection (64R) shall be provided with high stability circulating current principle having pick up setting range of 10 to 40 % of CT secondary. Necessary stabilizing resistors shall be provided.

c) Stand by earth fault protection (51N)

For transformers of rating 5MVA and above, definite time delayed Stand by earth fault protection shall be provided having a pick up setting range of 10% to 40% with a timer delay of 0.3 sec to 3 sec.

d) Transformer Differential protection (87T)

Differential protection for transformers (87T) of rating 5MVA and above shall be provided with stabilized biased differential relay. The differential protection shall be provided with harmonic restraint during switching and over fluxing condition. No ICT shall be provided either for ratio correction or for transformer primary and secondary correction. The necessary correction shall be programmable at offered numerical relay. Sensitive phase current and phase angle displays should be available to facilitate the commissioning and checking of the measurement circuit connection and vector group matching.

e) Transformer trouble trips

Transformer troubles like Buchholz, Winding temperature, Oil temperature & Pressure Relief Device trips shall be wired to separate binary inputs of the relay and shall be configured to issue trip command to the breaker.

f) Transformer trouble Alarm

Alarm contacts of the above transformer troubles shall be wired to separate binary inputs of the relay for communication to HMI / DDCMIS.

5.2.3 Protections for Incomers, Bus-couplers and Tie feeders (Module Type DC/DE/DD)

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)

The over current element should have the minimum setting adjustable between 250-2000% of CT secondary rated current. The earth fault element should be suitable for residually connected CT input. The relay shall be suitable for detection of earth fault currents in the range of 5% to 10% of the CT rated current.

	b) Synchronizing Check (25) Synchronizing check feature as a part of manual live change over and dead bus closing feature shall be provided. **c) Bus No-volt** Bus no volt signal shall be configured in the relay for use in control logics.
5.3.00	**Other Protections and Control features**
5.3.1	Control of breakers / vacuum contactors shall be carried out from PLC/DCS 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.
5.3.2	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.
5.3.3	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.
5.3.4	The numerical relay shall be able to provide supervisory functions such as trip circuit monitoring, circuit breaker status monitoring, VT and CT supervision.
5.3.5	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.
5.3.6	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.
5.3.7	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
5.3.8	Sequence of events shall have 1ms resolution at device level.
5.3.9	Measurement accuracy shall be 1 % for rated RMS Current and voltage
5.3.10	It shall be possible to carryout open / close operation of breakers from a laptop by interfacing from the relay front port during initial commissioning.
5.3.11	4-20mA analog output (current signal) for use- in PLC/DCS shall be provided in all breakers. This may be provided as analog output from the Numerical relay or may be generated using a suitable CT & Current transducer. In case analog output is not available in the relay, the same may be achieved using external I/O device of same make complying with the requirement stated elsewhere in this specification. In addition, any other requirement of digital & analog signals for process controls shall be taken care.
6.00.00	**TESTS**
6.1.00	**Type Tests**
	GENERAL

(a.) All equipments to be supplied shall be of type tested design. The Contractor shall submit for owner's approval the reports of all the type tests as listed in this specification and carried out not earlier than ten 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 ten 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/owner's representative and submit the reports for approval.

(c.) All routine tests as per the specification and relevant standards shall be carried out..

a) The following type test reports on circuit breaker / circuit breaker panels, of each voltage class and current rating shall be submitted

1) Short circuit duty test on circuit breaker, mounted inside the panel offered along with CTs, bushing and separators.

2) Short time withstand test on circuit breaker, mounted inside panel offered together with CTs, bushings and separators.

3) Power frequency withstand test on breaker mounted in side panel.

4) Lightning impulse withstand test on breaker mounted in side panel.

5) Temperature rise test on breaker and panel together. For this test, the test set up shall include three panels with breakers, the test breaker and panel being placed in the centre.

The adjacent panels shall also be loaded to their rated current capacity. Alternatively the test panel may be suitably insulated at the sides, which will be adjoining to other panels in actual site configuration

6) Internal Arc Test as per IEC 62271-200

7) Measurement of resistance of main circuit.

8) Mechanical operation test.

b) The following type tests reports on Contactor and Contactor panels of each type and rating shall be submitted.

1) Verification of rated making and breaking capacities of the contactor.

2) Short time withstand test of panel.

3) Power frequency test on the contactor mounted in side panel.

4) Lightning impulse voltage withstand test of the contactor mounted in side panel.

5) Measurement of resistance of main circuit.

6) Test to confirm coordination between fuse and contactor.

c) Short circuit withstand test of earthing device (truck / switch).

For all important components like Surge Arrestors and Numerical relays, the contractor shall submit the reports of all the type tests as per applicable standards and carried out not earlier than ten 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 not earlier than ten 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 to the owner either at third party lab or in presence of client/owner's representative and submit the reports for approval.

6.2.00 Two (2) protected soft copies on CD-ROM of the approved test results shall be furnished with the equipment . These shall include complete reports and results of the routine tests and type tests (if the latter is carried out) on equipment. If the type tests are not conducted, the CDs shall contain copies of the results of type tests carried out on identical equipment earlier.

6.3.00 Testing to observe compliance to degree of protection, shall be checked for each switch board enclosure and busbar chambers during routine inspection shall be as under.

(a.) IP -4X It shall not be possible to insert a one (1) mm. dia steel wire into the enclosure from any direction, without using force.

(b.) IP-5X It shall not be possible to insert a thin sheet of paper under gaskets and through enclosure joints.

6.4.00 Routine Tests

All acceptance and routine tests as per the specification and relevant standards IEC 62271-200 & IEC 62271-100 shall be carried out.

An indicative lists of tests / checks is mentioned as QA chapter on HT switchgear. However, the manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

6.5.00 Commissioning Checks / Tests

After installation of panels, power and Control wiring and connections, Contractor shall perform commissioning checks as listed below to verify proper operation of switchgear / panels and correctness of all equipment in all respects.

In addition the Contractor shall carry out all other checks and tests recommended by the manufacturers.

6.5.1 General

(a) Check name plate details according to specification.

(b) Check for physical damage

(c) Check tightness of all bolts, clamps and connecting terminals

(d) Check earth connections.

(e) Check cleanliness of insulators and bushings

(f) Check heaters are provided

(g) H.V. test on complete switchboard with CT & breaker / contactor in position.

(h) Check all moving parts are properly lubricated.

(i) Check for alignment of busbars with the insulators to ensure alignment and fitness of insulators.

(j) Check for interchange ability of breakers / contactors.

(k) Check continuity and IR value of space heater.

(l) Check earth continuity for the complete switchgear board.

6.5.2 Circuit Breaker / Contactors

(a) Check alignment of trucks for free movement.

(b) Check correct operation of shutters.

(c) Check slow closing operation (if provided)

(d) Check control wiring for correctness of connections, continuity and IR values.

(e) Manual operation of breakers completely assembled.

(f) Power closing / opening operation, manually and electrically at extreme condition of control supply voltage.

(g) Closing and tripping time.

(h) Trip free and anti-pumping operation.

(i) IR values, resistance and minimum pick up voltage of coils.

(j) Simultaneous closing of all the three phases.

(k) Check electrical and mechanical interlocks provided.

(l) Checks on spring charging motor, correct operation of limit switches and time of charging

(m) Check vacuum

(n) All functional checks.

6.5.3 **Current Transformers**

(a) Megger between windings and winding terminals to body.
(b) Polarity tests.

(c) Ratio identification checking of all ratios on all cores by primary injection of current.

(d) Magnetisation characteristics & secondary winding resistance.

(e) Spare CT cores, if any to be shorted and earthed.

6.5.4 **Voltage Transformers**

(a) Insulation resistance test.

(b) Ratio test on all cores.

(c) Polarity test.

(d) Line connections as per connection diagram.

6.5.5 **Cubicle Wiring**

(a) Check all switch developments.

(b) It should be made sure that the wiring is as per relevant drawings. All interconnections between panels shall similarly be checked.

(c) All the wires shall be meggered to earth.

(d) Functional checking of all control circuit e.g. closing, tripping interlock, supervision and alarm circuit including proper functioning of component / equipment.

(e) Check terminations and connections.

(f) Wire ducting

(g) Gap sealing and cable bunching

7.0.0 Training workshop at site for Switchgear

Workshop Training at site shall aim for familiarization of Site Engineers for commissioning and day to day O & M of MV Switchgears.

The scope shall include one number of MV Switchgear workshop and Training for a batch of 20 Engineers and a separate batch of 20 supervisors/technicians for two (2) days at Project site. One day shall be for class-room training & One day shall be for hands-on training on MV Switchgears. The workshop shall be organized before the commissioning of First MV Switchboard. Employer shall provide the required Infrastructure such as Training Conference room, Projection systems etc.

8.0.0 Training workshop at site for Numerical Relay

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.

The scope shall include one number of Numerical Relay workshops and Training for a batch of 20 Engineers at Project Site for 2 days at project site. One day shall be for class-room training & One day shall be for hands-on training on Numerical Relays. The workshop shall be organized before the commissioning of First MV Switchboard. Employer shall provide the required Infrastructure such as Training Conference room, Projection systems etc.

9.0.0 **Insulating Mat**

Insulating mat supplied for laying in front of MV Switchgears in switchgear rooms shall be as per IS:15652.

LEGEND	DESCRIPTION
52	CIRCUIT BREAKER
42	CONTACTOR
S.A.	SURGE ARRESTOR
	CURRENT TRANSFORMER
	CORE BALANCE CURRENT TRANSFORMER
	VOLTAGE TRANSFORMER
50	TRIPLE POLE INSTANTENIOUS O/C PROTN.
51	TRIPLE POLE IDMTL/DMT O/C PROTECTION
50N	INSTANTENIOUS E/F PROTECTION
51N	IDMTL / DMT SENSITIVE E/F PROTECTION
49	THREE PHASE THERMAL O/L PROTN. WITH O/L ALARM & RESTART INHIBITE FUNCTION
50L/R	STALLING / LOCKED ROTOR PROTECTION
46	THREE PHASE NEGATIVE PHASE SEQUENCE PROTECTION
66	NUMBER OF START LIMITATION/REPATETIVE START PROTECTION
2	TIME DELAY RELAY
60	FUSE FAILURE PROTECTION
87M	3 PHASE MOTOR DIFFERENTIAL PROTECTION

LEGEND	DESCRIPTION
64R	RESTRICTED EARTH FAULT PROTECTION
51G	STAND BY EARTH FAULT PROTECTION
87T	3 PHASE BIASED TRANSFORMER DIFFERENTIAL PROTECTION
27M	3 PHASE UNDER VOLTAGE PROTECTION FOR MOTOR TRIPPING
27U	3 PHASE BUS UNDER VOLTAGE
27N	BUS NO VOLT PROTECTION
50BF	CIRCUIT BREAKER FAILURE PROTECTION
86	LOCKOUT FUNCTION
3I	3 PHASE CURRENT MEASUREMENT
Io	NEUTRAL CURRENT MEASUREMENT
3U	3 PHASE VOLTAGE MEASUREMENT
Uo	RESIDUAL VOLTAGE MEASUREMENT
P	ACTIVE POWER MEASUREMENT
Q	REACTIVE POWER MEASUREMENT
E	ENERGY MEASUREMENT
PF	POWER FACTOR MEASUREMENT
HZ	FREQUENCY MEASUREMENT
HM	HOUR RUN MEATER

FOR TENDER PURPOSE ONLY

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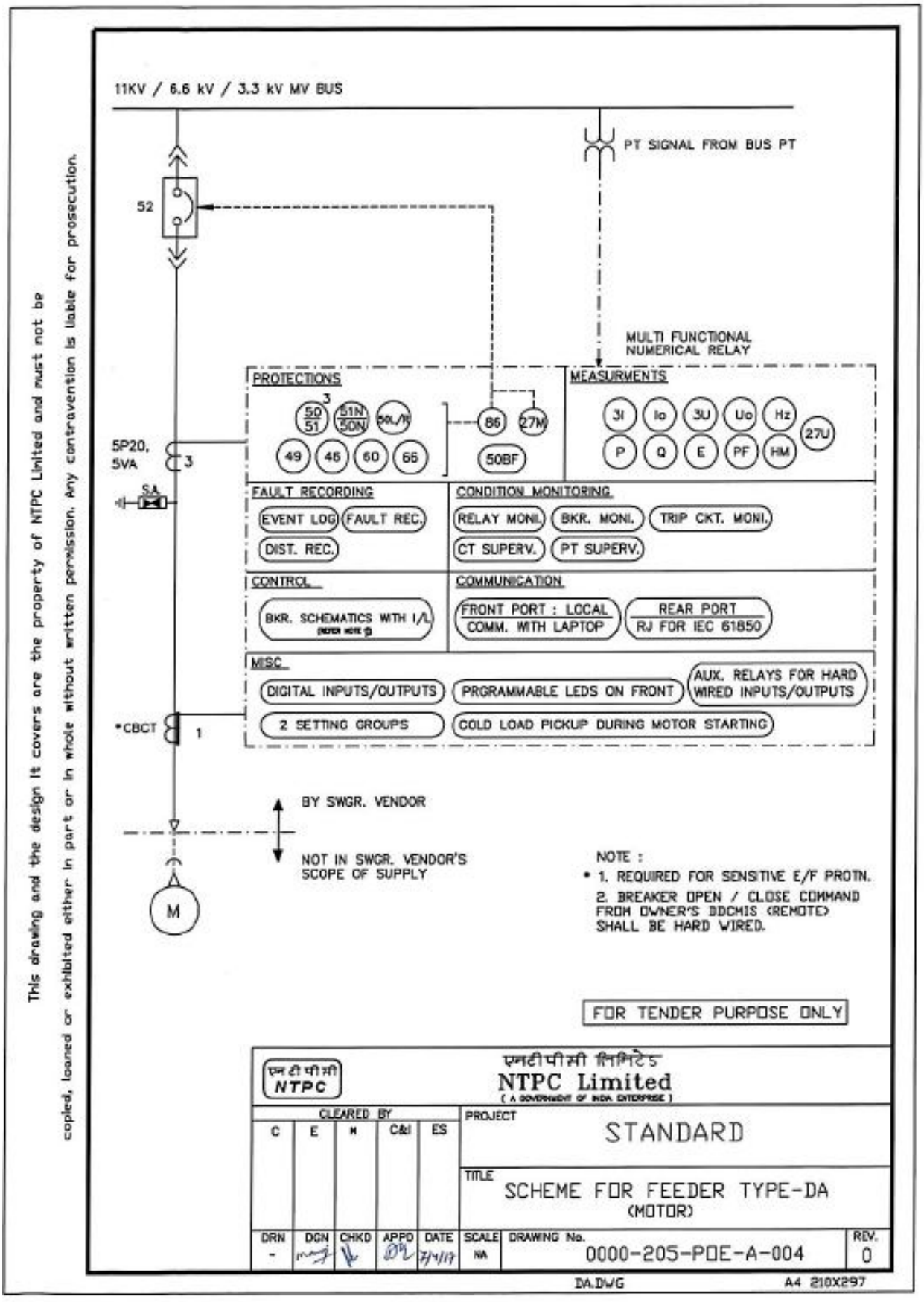
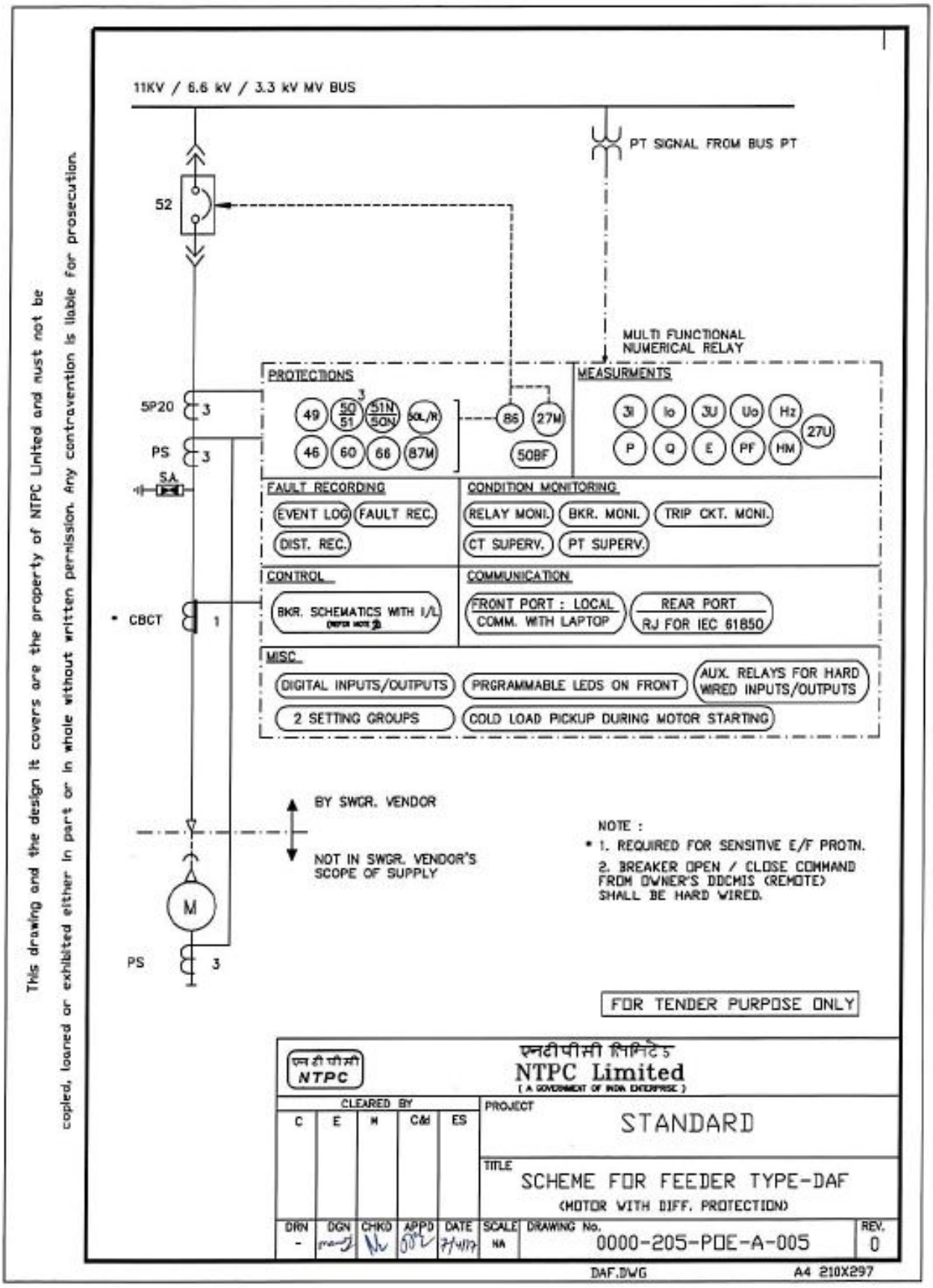
NTPC Limited
(A GOVERNMENT OF INDIA ENTERPRISE)

CLEARED BY					PROJECT
C	E	M	C&I	ES	STANDARD
					TITLE: LEGEND DETAILS

DRN	DGN	CHKD	APPD	DATE	SCALE	DRAWING No.	REV.
-				10/01/07	NA	0000-205-POE-A-003	0

LEGEND.DWG A4 210X297




11KV / 6.6 kV / 3.3 kV MV BUS
PT SIGNAL FROM BUS PT
52
MULTI FUNCTIONAL NUMERICAL RELAY
PROTECTIONS
MEASURMENTS
5P20
PS
SA
49
50/51
51N/50N
50L/R
86
27M
46
60
66
87M
50BF
3I
Io
3U
Uo
Hz
27U
P
Q
E
PF
HM
FAULT RECORDING
EVENT LOG
FAULT REC.
DIST. REC.
CONDITION MONITORING
RELAY MONI.
BKR. MONI.
TRIP CKT. MONI.
CT SUPERV.
PT SUPERV.
CONTROL
BKR. SCHEMATICS WITH I/L
COMMUNICATION
FRONT PORT : LOCAL COMM. WITH LAPTOP
REAR PORT RJ FOR IEC 61850
MISC.
DIGITAL INPUTS/OUTPUTS
PROGRAMMABLE LEDS ON FRONT
AUX. RELAYS FOR HARD WIRED INPUTS/OUTPUTS
2 SETTING GROUPS
COLD LOAD PICKUP DURING MOTOR STARTING
* CBCT
BY SWGR. VENDOR
NOT IN SWGR. VENDOR'S SCOPE OF SUPPLY
M
NOTE :
* 1. REQUIRED FOR SENSITIVE E/F PROTN.
2. BREAKER OPEN / CLOSE COMMAND FROM OWNER'S DDCMIS (REMOTE) SHALL BE HARD WIRED.
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CLEARED BY
C E M C&I ES
PROJECT
STANDARD
TITLE
SCHEME FOR FEEDER TYPE-DAF
(MOTOR WITH DIFF. PROTECTION)
DRN DGN CHKD APPD DATE SCALE DRAWING No. REV.
- NA 0000-205-PDE-A-005 0
DAF.DWG A4 210X297
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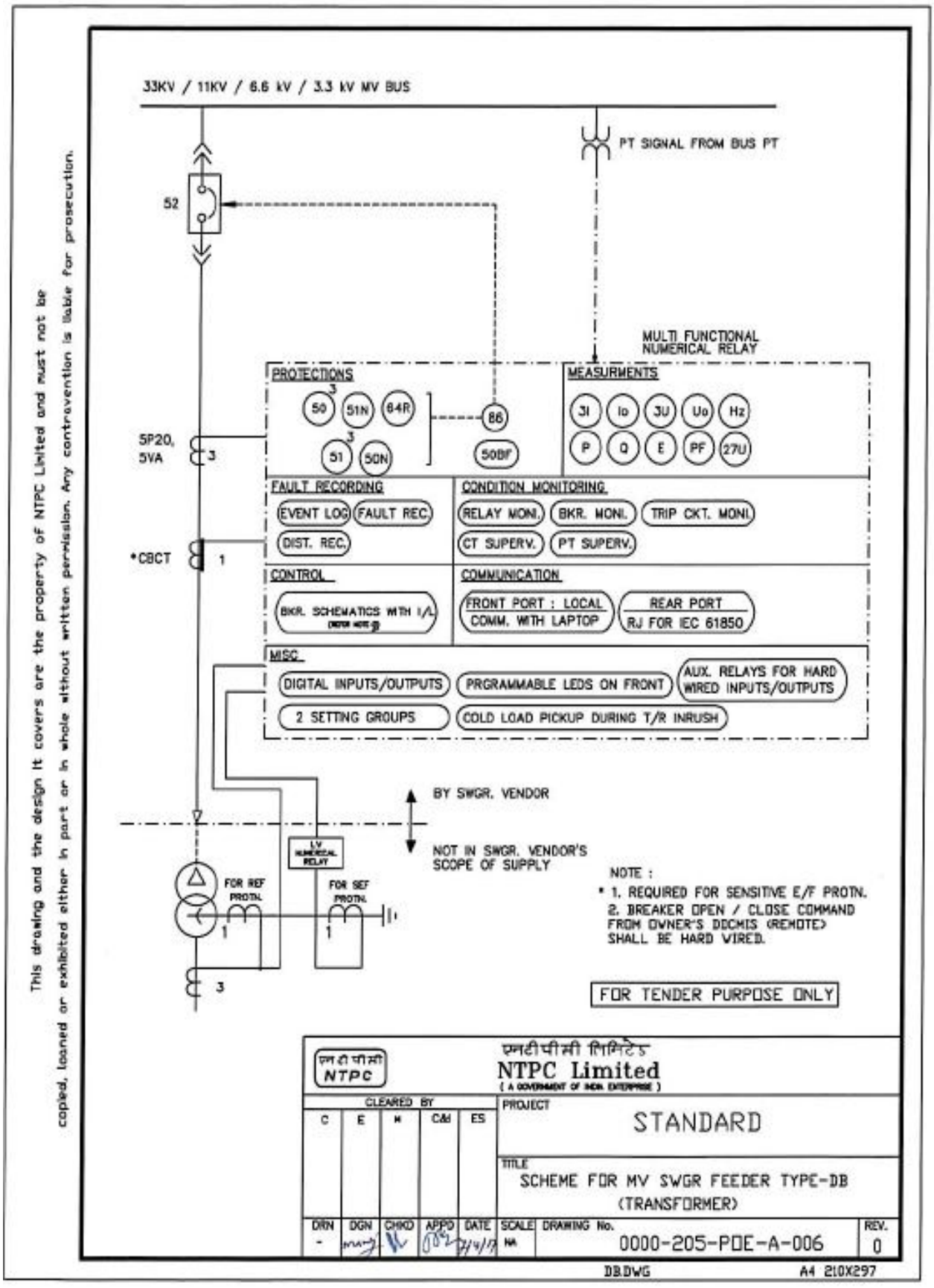

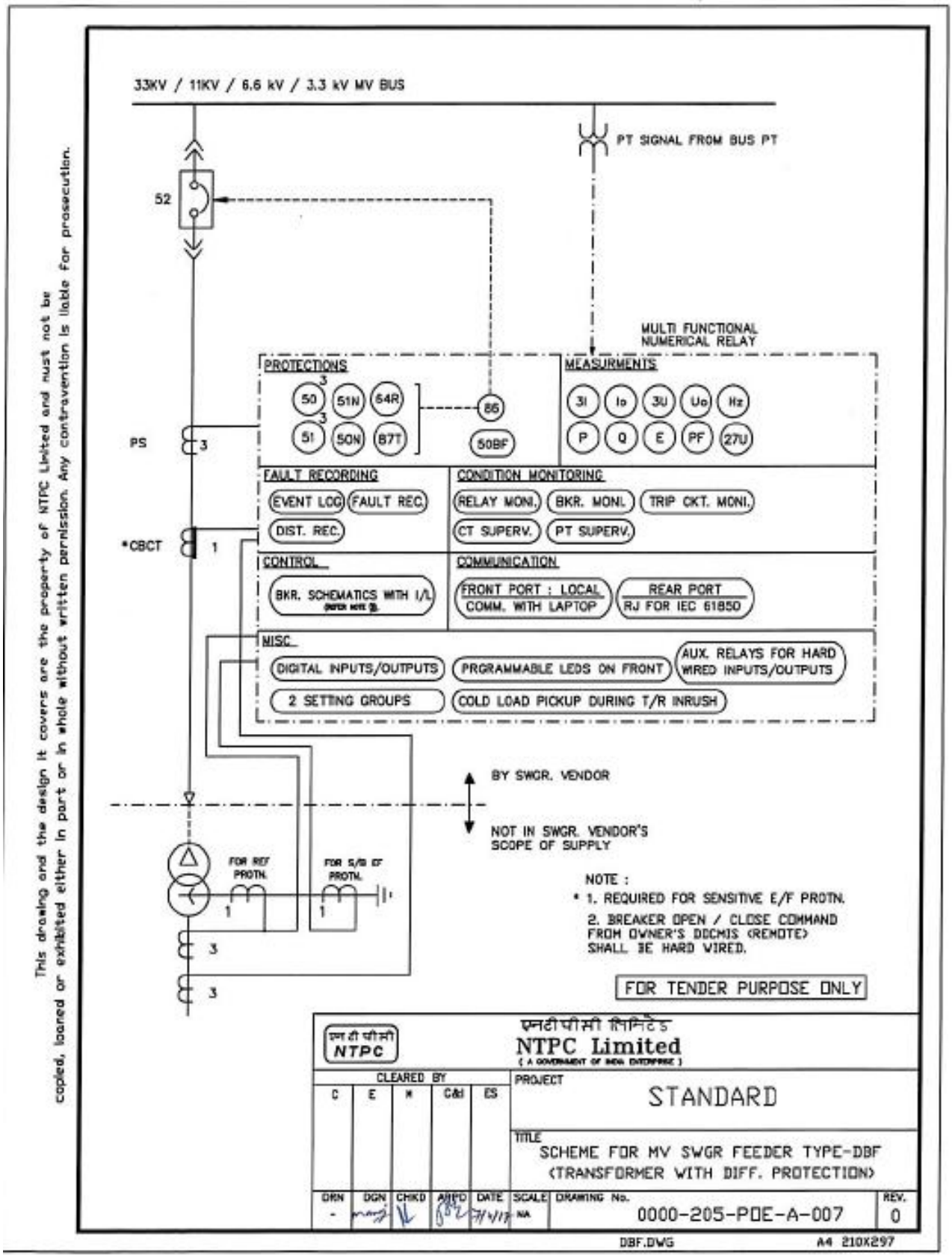

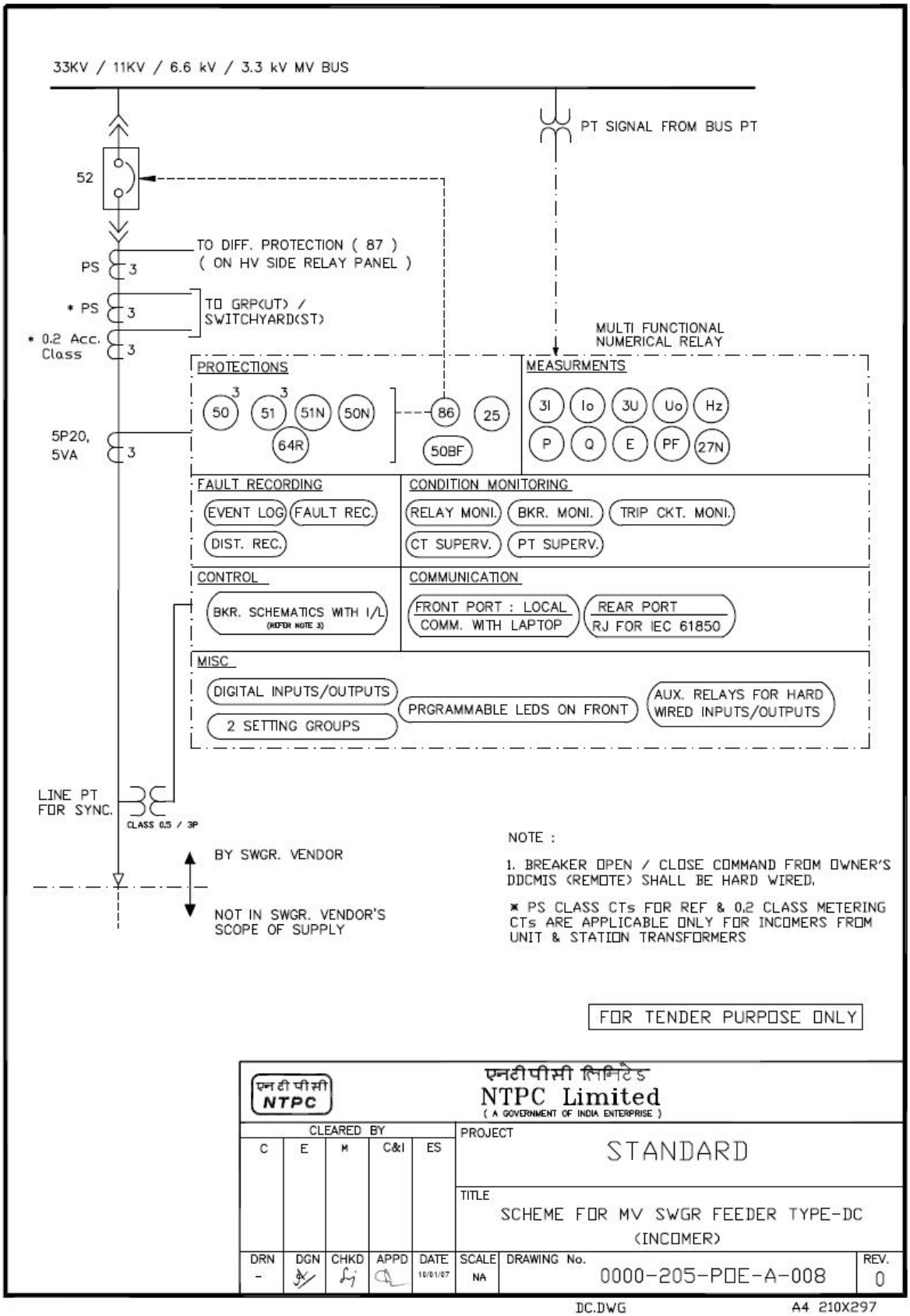

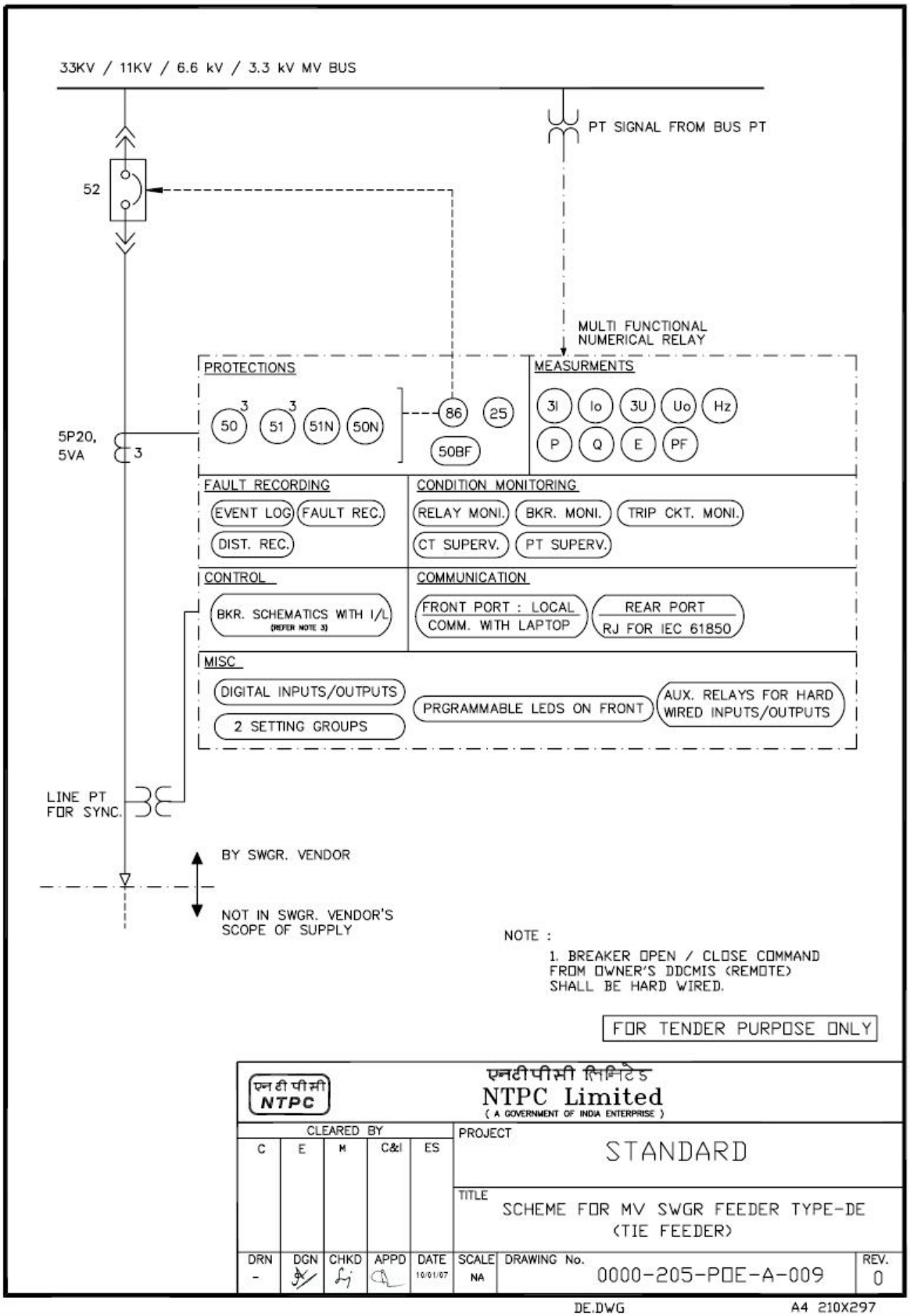

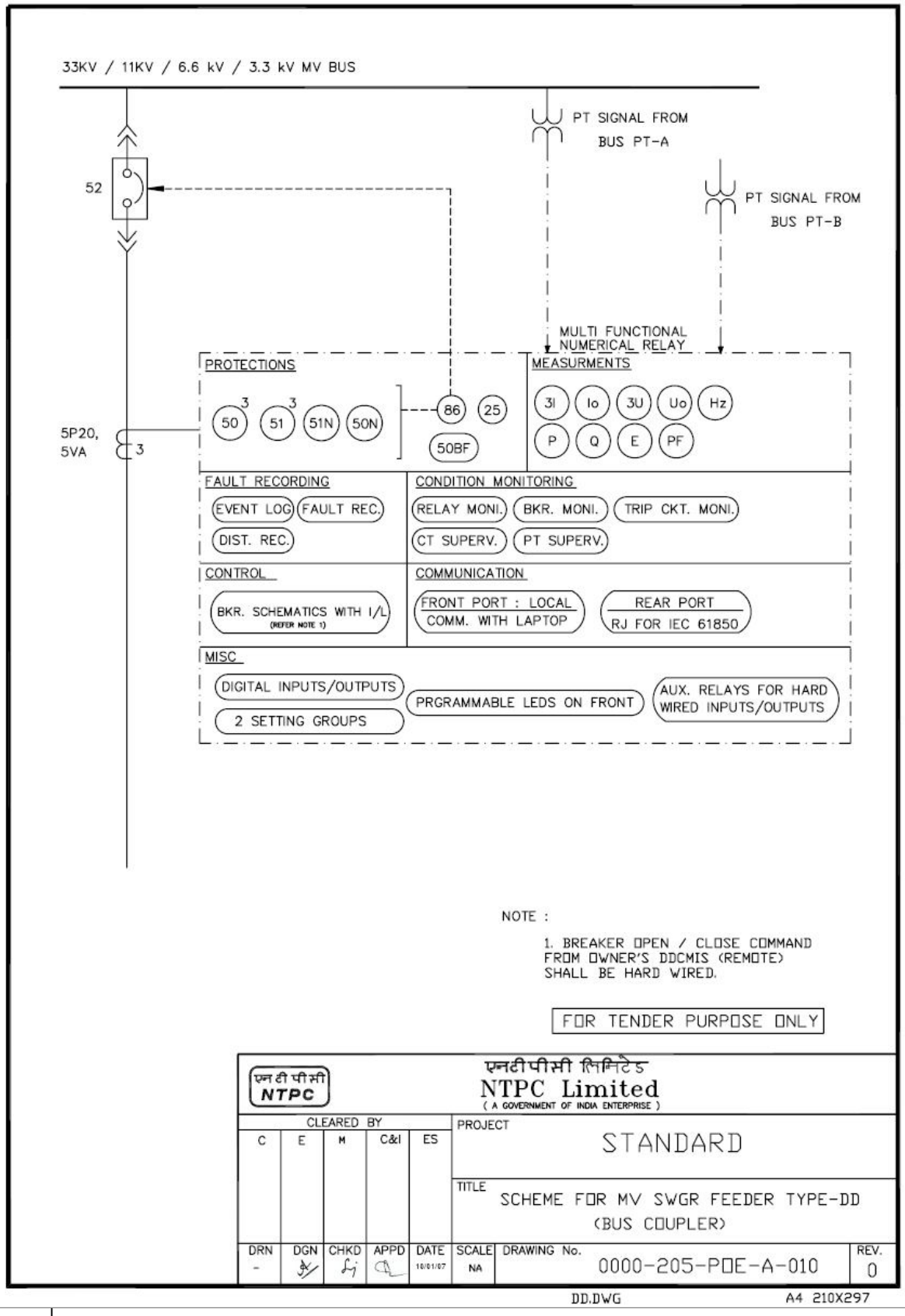

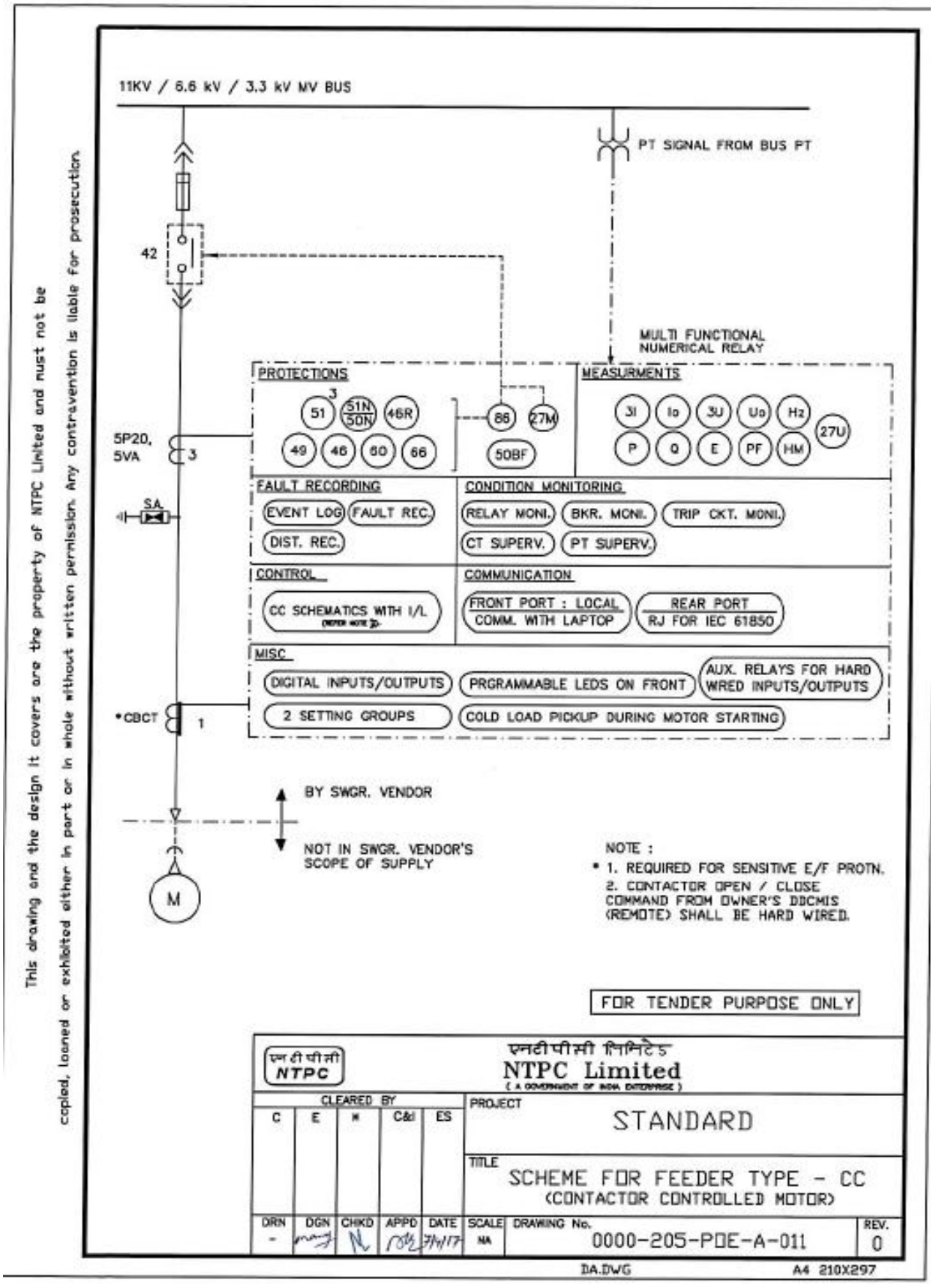

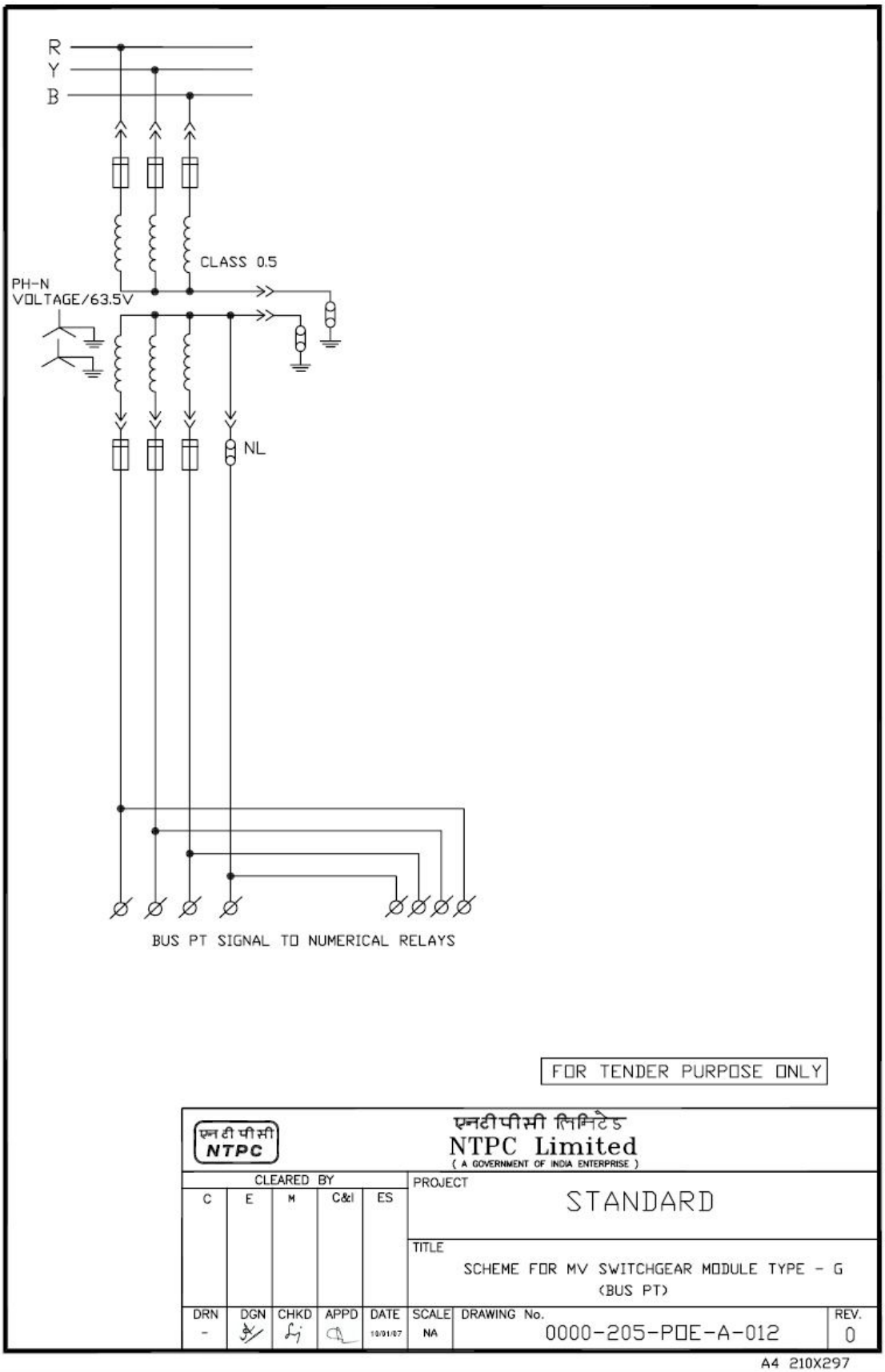

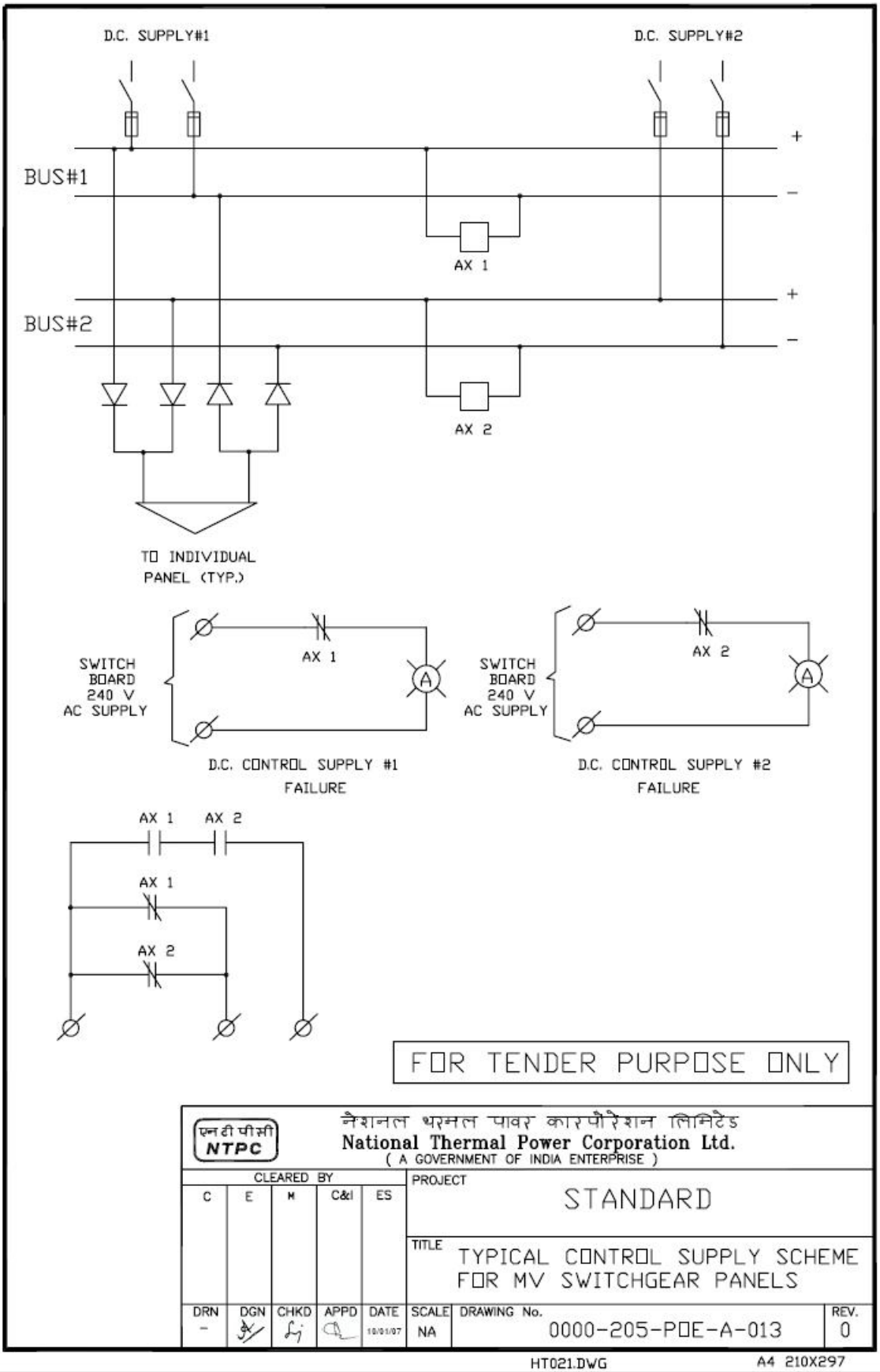

SUB-SECTION-II-E9

LT SWITCHGEAR & LT BUSDUCT

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:**

1.01.01 **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 for continuous loads and as 0.1 for intermittent load like crane, hoist, etc.

   Efficiency and power factor of LT motors shall be considered as per IS 12615.

b) The Finally selected Busbar ratings for Switchboards, MCCs, ACDBs and Busducts shall include a 10% margin over the calculated values.

c) Lighting load of 50 kVA (Minimum) shall be considered on each section of main switchgears with incomer from transformer as indicated in the tender SLD.

d) 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.

e) Welding sockets shall be connected from Welding DBs, which shall be fed through 1X100% Welding transformers.

f) ESP consumption for 100% BMCR operation shall be considered and further this load shall be uniformly divided among ESP Switchgears.

g) 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 either by 2x100% or 3x50% transformers/feeders and, these shall be rated to carry the maximum load expected to be imposed. Each of the above boards shall be sectionalized.

h) The sizing of FGD Emergency boards shall be in according to the DG rating. The FGD Emergency board shall have tie to FGD Service Switchgear for catering emergency loads.

i) Each Lighting DB shall have 2X100% transformers.

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 **Standardization**

It shall be preferred to follow a standardization of Terminal Numbers across all LV Modules for ease of Interconnection and maintenance.

1.04.00 **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 be 1.5 mm^2

(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 1.5mm^2 size per phase

(d) Separate control cables shall be used for current transformers

(e) Separate control cables shall be laid for EPB (Emergency/Local Push Button) status from EPB to Switchgear for the Switchgear and PLC/DCS.

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 / IEC: 61439-1/2	Low Voltage Switchgear & Control gear assemblies
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

3.01.00 **Power Supply**

3.01.01 AC SYSTEM

1)	Voltage	415 V ± 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) for 1 second

3.01.02 DC SYSTEM

1)	System Voltage	240 V DC 2-Wire, Unearthed
2)	Fault Level	20 kA for 1 second

3.01.03 CONTROL SUPPLY VOLTAGE

1)	Trip & closing coil of circuit breaker	240 V DC/120 V DC
2)	Spring charging motor	240 V DC/120 V DC
3)	MCC control supply	110 V AC Neutral solidly earthed
4)	Space heater & lighting	240 V AC Neutral solidly earthed

3.02.00 **CUBICLE DATA**

Busbar Rating

	1) Continuous Current rating	As per requirement
	2) Short time rating where	
	a) CB is used as incomer	50 kA(RMS) for one sec
	b) Fuse protection is used in Incomer	Prospective current of 50 kA(RMS) for the fuse clearing time
	3) Dynamic Rating where	
	a) CB is used as incomer	105 kA(PEAK)
	b) Fuse Protection is used in incomer	Prospective current of 105 kA (PEAK) as limited by fuse
	4) Busbar insulation	
	a) For switchgear	PVC Sleeve insulated
	b) For MCC	PVC Sleeve insulated
	c) ACDB	PVC Sleeve insulated
	d) DCDB	PVC Sleeve insulated
	e) For fuse boards	PVC Sleeve insulated/ epoxy coated
3.03.00	**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
3.04.00	**METERS**	

	1)	Accuracy class	2.0
	2)	One min. power frequency withstand test voltage	2.0 kV (rms)
3.05.00	**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 fuse protected feeders	Prospective current of 50 kA(RMS) for the Fuse clearing time
	8)	Dynamic withstand	
		a) For CTs Associated with circuit breaker	105 kA(PEAK)
		b) For CT Associated with fuse protected feeders	Prospective current of 105 kA(PEAK) as Limited by fuse
3.06.00	**BUSDUCT**		
	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)
	BUSDUCT (SANDWICH TYPE)		
	1)	Type	Bus Trunking
	2)	Rated Insulation voltage	1000V
	3)	One second short ckt withstand current	50KA(RMS)
	4)	Momentary dynamic current withstand	105KA(PEAK)
	5)	Power frequency withstand voltage	3.5kv
	6)	Impulse withstand voltage	8kV
	7)	Insulation	Class F
3.07.00	**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
3.08.00	**HRC FUSES**		
	1)	Voltage Class	650 Volts

	2)	Rupturing capacity	80 kA (rms) for AC ckt. 20 kA for DC ckt.
3.09.00	**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
3.10.00	**Relays**		
	1)	Power frequency withstand voltage	2.5 kV for 1 sec. or 2.0 kV for 1 min.
3.11.00	**CONTROL TRANSFORMERS**		
	1)	Type	Dry / Cast Resin
	2)	Voltage Ratio	415 / 110 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.
3.12.00	**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

3.13.00 **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	110 V / 415 V / 240 V, 50 Hz (for AC) / 220 V / 110 V DC (for DC)
b)	Output	4-20 mA (2 Nos. decoupled)
c)	Accuracy	1.0

3.14.00 **MCCB**

1)	Rated voltage	415V
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

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 Steel Reinforced EPDM /PU Foam 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 switchboards shall comply to the Internal arc fault containment tests of 50 kA for 0.3s.
4.08.00	The enclosure for outdoor 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.
4.09.00	All switchboards shall be of uniform height not exceeding 2450 mm. The height of the operating handle, push buttons etc shall be restricted between 300mm and 2000mm.
4.10.00	Switchboards shall be easily extendable on both sides by the addition of vertical sections after removing the end covers.
4.11.00	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.
4.12.00	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. No live parts shall be accessible with equipment drawn out and degree of protection within the compartment shall be IP2X. 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 adequate 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.

4.13.00 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. Steel Reinforced EPDM /PU Foam gasket shall be provided between the panel sections to avoid ingress of dust into panels.

4.14.00 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.

4.15.00 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.

4.16.00 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.

4.17.00 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.

4.18.00	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.
4.19.00	Individual opening in the vertical bus enclosure shall permit the entry of moving contacts from the draw-out modules into vertical droppers.
4.20.00	As indicated in schematic drawings of DDCMIS controlled modules, contractor shall supply & mount two (2) coupling relays in the corresponding modules.
4.21.00	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.
4.22.00	Employer reserves the right to alter the cable entries, if required during detailed engineering, without any additional commercial implication.
4.23.00	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.
4.24.00	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.
4.25.00	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 switch /

fuses 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 FUSE BOARDS

6.01.00 All fuse boards shall be metal enclosed, fixed type, non-compartmentalized construction, suitable for indoor/ outdoor mounting on wall or steel structure.

6.02.00 The fuse 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 fuse 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 Steel Reinforced EPDM /PU Foam gaskets shall be provided to make fuse boards completely dust and vermin-proof with a degree of protection of IP-52 for indoor and IP-54 for outdoor application, as per IS/IEC 60947.

6.05.00 Each DC fuse board shall comprise of the following :

(a.) 1 no. 63 A switch as incomer

(b.) 100 A fully insulated (PVC sleeved or epoxy coated) busbars.

(c.) 8 nos. 16A outgoing Fuse feeders.

(d.) 1 no. auxiliary contactor for supply monitoring.

(e.) 1 no. indicating lamp with resistor and blue coloured lens.

6.06.00 Each AC fuse board shall comprise of the following :

(a.) 1 no. 63A TPN switch as incomer.

(b.) 100 A, 3-phase, 4-wire, fully insulated (PVC sleeved or epoxy coated) busbars.

(c.) 9 nos. 16 A single phase switch fuse units and 3 nos. 16 A TPN switch fuse units as outgoing feeders or alternatively 16 amps MCCB can be provided.

(d.) 3 nos. indicating lamps with resistors and coloured lenses (R, Y, B) for incoming supply monitoring.

6.07.00 The fuses shall be mounted in an insulating fuse carrier and it shall be possible to replace the outgoing feeder fuses without disturbing the other feeders. The handle of incoming switch shall be mounted on the door of the fuse board, with padlocking facility in both 'ON' and 'OFF' positions. The outgoing feeder switches shall preferably be of rotary type.

6.08.00	Cable entry facilities shall be provided at bottom with removable gland plates of suitable thickness. However, top cable entry may be allowed in case of layout constraints. 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	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, switch-fuse etc. 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 shall be an independent circuit with switch and fuse 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 an isolating switch, HRC fuse and neutral link 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.

10.07.00 All circuit breakers shall be provided with the following interlocks :

10.07.01 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.

10.07.02 Closing of a circuit breaker shall not be possible unless it is in "SERVICE" position, "TEST" position or in "FULLY WITHDRAWN" position.

10.07.03 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.

10.07.04 A breaker of particular rating shall be prevented from insertion in a cubicle of a different rating.

10.07.05 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.

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 1 No. per switchgear room.

12.00.00 AIR BREAK SWITCHES

12.01.00 Air break switches shall be of heavy duty, single throw, group operated, load break, fault make type when associated with fuses. All switches for motor circuits shall be of utilization category AC-23A with 1NO +1NC auxiliary contact, which shall be wired to the control circuit as shown in the schematic drawings. All switches for other outgoing feeders shall be of utilization category AC-22A. All switches for DC circuits shall be suitable for 240 V DC and shall be of DC-22 utilization category.

12.02.00 Continuous current rating of the switches shall be selected from the 'Module Selection tables' for various feeders.

12.03.00 The combination of switch-fuse unit would be preferred. However, if separate switch and fuses are provided, switch shall be located before fuses.

12.04.00 The main switches shall be operable from outside the module door. The switch handle shall clearly indicate the position of switch. Switch operating handles shall be provided with padlocking facilities. However, incomer switches of switchboards shall be provided with padlocking facility in both 'ON' and 'OFF' positions.

12.05.00 Interlocks shall be provided such that the cubicle door will not open when the switch is in closed position and the switch will close only when the door is closed.

12.06.00 Switches and fuses for AC/DC control supply and heater supply wherever required, shall be mounted inside the cubicles. Toggle switch is not acceptable.

12.07.00 Even if a single phase feeder is required for certain applications, Contractor shall provide TPN switch, fuse-bases and cable/ link connections between switch/fuse and vertical busbars for all the three phases, so that changing from single phase feeder to three phase feeder is possible without any modification other than inserting fuses at site.

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 CHP conveyor motors, minimum rating of power contactors shall be 240% of full load current of the motors. For other CHP drives, minimum rating of power contactors shall be 160% of full load current of motor.

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 FUSES

16.01.00 All fuses shall be of HRC cartridge fuse link type. Screw type fuses shall not be accepted. Fuses for AC circuits shall be rated for 80kA rms (prospective) breaking capacity at 415V AC and for DC circuits, 20kA rms breaking capacity at 240V DC.

16.02.00 Fuse shall have visible operation indicators. Insulating barriers shall be provided between individual power fuses.

16.03.00 Fuse shall be mounted on insulated fuse carriers, which are mounted on fuse bases. Wherever it is not possible to mount fuses on carriers, fuses shall be directly mounted on plug-in type of bases. In such cases one set of insulated fuse pulling handles shall be supplied with each switchboard.

16.04.00 Fuse ratings shall be selected by the Contractor from the 'Module Selection Tables' for various feeder ratings. However, the fuse ratings for motor feeders given in the 'Motor Module Selection Table' are indicative only, and the same shall be coordinated by the Contractor to achieve class-II protection coordination and also to match the motor characteristics. Switch rating shall in no case be less than the fuse rating.

16.05.00 The Neutral links shall be mounted on fuse carriers which shall be mounted on fuse bases.

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 HRC current limiting fuses 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**
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. 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 PLC/DCS 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 PLC/DCS 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	The numerical relay shall be capable of measuring and storing values of a wide range of quantities, events, faults and disturbance .
18.04.00	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.
18.05.00	One minute power frequency withstand test voltage for all numerical relays shall at least be 2kV (rms).
18.06.00	Failure of a control supply and de-energization of a relay shall not initiate any circuit breaker operation.
18.07.00	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.
18.08.00	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.
18.09.00	All the numerical relays shall have communications on two ports, local front port for communication with laptop and one RJ45 port on IEC 61850. 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.
18.10.00	All Numerical relays shall have features for electrical measurements including voltage, current, power (active & reactive), frequency, power-factor and energy parameters.
18.11.00	Relays shall have event recording feature, recording of abnormalities and operating parameters with time stamping.
18.12.00	Master trip (86) and non-86 trips shall be software configurable to output contacts and no separate master trip relay shall be used.
18.13.00	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.
18.14.00	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.

18.15.00	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.
18.16.00	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.
18.17.00	Relays shall have at least two sets or groups of two different sets of adaptable settings. Relays shall have multiple IEC / ANSI programmable characteristics.
18.18.00	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.
18.19.00	All cards / hardware of numerical relays shall be suitable for operation in Harsh Environmental conditions with respect to high temperature, humidity & dust.
18.20.00	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.
18.21.00	All I/Os shall have galvanic isolation. Analog inputs shall be protected against switching surges, harmonics etc.
18.22.00	Numerical relays shall have two level password protections, one for read only and other for authorization for modifying the setting etc.
18.23.00	Numerical relays shall have feature for Time synchronization. The resolution of time synchronization shall be +/- 1.0 millisecond or better throughout the entire system.
18.24.00	Relays 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 PLC/DCS 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	Sequence of events shall have 1ms resolution at device level.
19.09.00	Measurement accuracy shall be 1 % for RMS Current and voltage. It shall be possible to carryout open / close operation of breakers from a laptop by interfacing from the relay front port during initial commissioning.
19.10.00	Circuit-breaker status, protection status, etc. required for control logics shall be hardwired to PLC/DCS. 4-20mA analog output (current signal) for use- in PLC/DCS shall be provided in all breakers. This may be provided as analog output from the Numerical relay or may be generated using a suitable CT & Current transducer. In case analog output is not available in the relay, the same may be achieved using external I/O device of same make complying with the requirement stated elsewhere in this specification. In addition, any other requirement of digital & analog signals for process controls shall be taken care of.
19.11.00	**TRAINING**
19.11.01	**Training workshop at site for Switchgear** Workshop Training at site shall aim for familiarization of Site Engineers for commissioning and day to day O & M of LT Switchgears. The scope shall include one number of LT Switchgear workshop and Training for a batch of 20 Engineers and a separate batch of 20 supervisors/technicians for two (2) days at Project site. One day shall be for class-room training & One day shall be for hands-on training on LT Switchgears. The workshop shall be organized before the commissioning of First LT Switchboard. Employer shall provide the required Infrastructure such as Training Conference room, Projection systems etc.
19.11.02	**Training workshop at site for Numerical Relay** 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. The scope shall include one number of Numerical Relay workshops and Training for a batch of 20 Engineers at Project Site for 2 days at project site. One day shall be for class-room training & One day shall be for hands-on training on Numerical Relays. The workshop shall be organized before the

commissioning of First LT Switchboard. Employer shall provide the required Infrastructure such as Training Conference room, Projection systems etc.

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 & < 100kW) shall have a compressed scale at the upper current region to cover the starting current up to 6.0 times the CT primary current.

20.05.00 All motor feeders of rating ≥ 30 kW and < 110 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 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 switches and fuses shall be provided.
23.03.00	The circuit for each panel and motor space heater should have an isolating switch, HRC fuse and isolating link. 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 and the cable shall have current rating to carry the let through energy of the corresponding fuses in case of a fault. 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.
24.10.00	Wiring Duct shall be Halogen Free complying to 1) VDE 0472/815 or equivalent standard 2) UL94 flammability rating of V-0 for continuous use upto 95 degree Celsius and 3)RoHS (lead Free) Compliant.
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. However for DDCMIS terminals shall be suitable for 1.5 mm^2 cable.
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.
25.08.00	DIN Rail shall conform to DIN EN 60715/ Equivalent Standard, with base metal of cold rolled low carbon steel according to DIN EN 10130/Equivalent Standard, surface coating /trivalent chromate passivation in accordance with EN 12329/ Equivalent Standard. Salt Spray Test withstand minimum 130hrs (while rust) and 300hrs (red rust). The DIN Rail shall be RoHS compliant.
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 push button stations 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, Fuse 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. Letter size shall be of at least 10mm height.

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 Steel Reinforced EPDM /PU Foam 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	**LIGHTING / WELDING TRANSFORMERS**
	Each AC Lighting Distribution Board (LDB) shall be fed from 415V / 415V, 50kVA(minimum) isolating transformer & Each Welding Distribution Board (LDB) 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.
32.00.00	**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.
33.00.00	**GASKETS**

The gaskets, wherever specified, shall be of good quality Steel Reinforced EPDM /PU Foam with good ageing, compression and oil resistance characteristics suitable for panel applications.

34.00.00 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.

35.00.00 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.

36.00.00 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 / fuses / 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.

37.00.00 TESTS AND TEST REPORTS

37.01.00 **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 ten 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 ten 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.

37.02.00 The following type test certificates of LT Switchgear and MCC panels shall be submitted.

1)	Circuit breaker of each rating	
	a)	Test sequence 1
	b)	Combined test sequence (With Circuit breakers mounted inside the Switchgear panel)
2)	Complete design verification of Switchgear/MCC Panels as per IEC 61439 Part-1, Annexure-D	
3)	Internal arc test for Personnel and Assembly Protection as per IEC/TR 61641	
4)	MCC modules of any three ratings, as selected by the Employer, for class - II protection Co-ordination.	
5)	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.	

37.03.00 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 ten 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 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 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

(d.) MCCB

37.04.00 Type test reports for the following tests on the model of the Numerical relays 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

37.05.00 All routine tests as per the specification and relevant standard IS 8623 shall be carried out.

37.06.00 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.

37.07.00 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.

37.08.00 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.

38.00.00 ERECTION / INSTALLATION OF SWITCHBOARDS AND OTHER EQUIPMENTS

38.01.00 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.

38.02.00 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.

38.03.00 Manufacturer's and Employer's instructions and recommendations shall be correctly followed in handling, setting, testing and commissioning of all equipment.

38.04.00 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.

38.05.00 All switchboards shall be installed in accordance with Indian Standard, IS: 3072, and Employer's instructions.

38.06.00 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.

38.07.00 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.

38.08.00	Equipment furnished with finished coats of paint shall be touched up by Contractor if their surface is spoiled or marred during erection / commissioning.
38.09.00	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.
39.00.00	**COMMISSIONING CHECKS / TESTS**
39.01.00	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.
39.02.00	The Contractor shall carry out the following commissioning checks, in addition to other checks and tests recommended by the manufacturers.
39.03.00	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.
39.04.00	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.

39.05.00	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
39.06.00	Voltage Transformers (a.) Visual inspection. (b.) IR Value (c.) Ratio check (d.) Magnetising current (e.) Line connection as per connection diagram
39.07.00	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.
39.08.00	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.

39.09.00 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.

40.00.00 AC MODULES DESCRIPTION

40.01.00 **Module type DAE (Circuit Breaker Module)**

(a.) One (1) Triple-pole circuit breaker, complete with all accessories and power operated mechanism, as specified.

(b.) Three (3) Current transformers for Protection and metering.

(c.) One (1) DC isolating Switch

(d.) Six (6) HRC Control fuses.

(e.) Numerical relay for the following:

- Short Circuit Protection
- Earth Fault Protection
- Over Load protection
- Energy Metering
- Current and Voltage metering
- Trip Circuit Supervision
- CB Monitoring
- Synchronizing Check feature

40.02.00 **Module Type DAET (Circuit Breaker Incomer From Transformer)**

Similar to module type DAE; but with additional PS Class Current transformers for Restricted Earth Fault Protection. The Numerical relay shall have provision for REF protection in addition to the features listed against module type DAE.

40.03.00 **Module Type CC (Contactor Changeover Between Two In Coming Supplies)**

(Note: Main and Reserve incomers shall be housed in separate draw-out modules, located in different panels.)

The draw-out modules shall be provided with service position limit switch having 2 NO+2NC contacts.

Main Incomer

One (1) Triple pole load break isolating switch .

One (1) Triple pole contactor with coil suitable for 415 V AC.

Two (2) Auxiliary contactors with coil suitable for 415 V AC.

One (1) Indicating lamp with resistor and coloured lens suitable for 415 V AC.

Three (3) HRC control fuses.

Reserve Incomer

One (1) Triple pole load break isolating switch

One (1) Triple pole contactor with coil suitable for 415 V AC.

One (1) Indicating lamp with resistor and coloured lens suitable for 415 V AC.

Two (2) HRC control fuses.

40.04.00 **Module Type CS (AC Control Supply Module)**

(Note: Module type CS will be of non-draw-out type)

Two (2)	415/110 V control transformers.
Four (4)	110V auxiliary relays.
Two (2)	Earth links.
Eight (8)	HRC Control fuses.
Two (2)	Selector switches

40.05.00 **Module Type DG (Circuit Breaker Incomer From DG Set)**

(a.)	One (1)	Triple-pole circuit breaker, complete with all accessories and power operated mechanism, as specified.
(b.)	Three (3)	Current transformers for protection & metering.
(c.)	One (1)	DC isolating Switch
(d.)	Six (6)	HRC control fuses

(e.) Numerical relay for the following:

- Differential protection
- Over Load protection
- Reverse Power Protection
- DG Neutral displacement
- Energy Metering
- Current and Voltage metering
- DG Monitoring

40.06.00 **Module Type E/E1/E2 (Switch Fuse Module/MCCB)**

(a) One (1) Triple pole switch-fuse unit with three pole isolating switch and three / one / two HRC fuses for E/E1/E2 modules, respectively.

(b) One (1) Neutral link.
(c) One (1) 3 pole MCCB (for rating 100A and above)

40.07.00 **Module Type G1 (VT Module with Under Voltage / No Volt Relay)**

(a.) Three (3) 415/√3 / 110/√3 V single phase voltage transformers, mounted on a common draw-out chassis

(b.) Three (3) HRC fuses for VT primary.

(c.) Three (3) HRC control fuses.

40.08.00 **Module Type H (Isolating Switch Module)**

(a) One (1) Triple pole load break isolating switch

(b) One (1) Neutral link

40.09.00 **Module type K1 (Non Reversible Motor Rated Below 30 kW Controlled from MCC)**

(a) One (1) Triple pole fuse switch unit with three pole load break isolating switch and three HRC fuses.

(b) One (1) Triple pole contactor.

(c) One (1) Bimetallic thermal overload relay with single phasing preventer. For motor with high starting time, heavy duty overload relay shall be provided.

(d) Two (2) Push buttons.

(e) Three (3) Indicating lamps with resistors and coloured lenses.

(f) One (1) HRC control fuse.

(g) One (1) Control link.

40.10.00 **Module Type K11 (Non reversible Motor Rated 30kW to 200kW Controlled from MCC)**

Similar to module type K1 but with the following additions:

One (1) Current transformer for metering.

One (1) Ammeter

One (1) Single-pole switch and fuse for motor space heater.

40.11.00 **Module type DK2 (Non Reversible Motor rated below 30kW Controlled from DDCMIS)**

(a) One (1) Triple pole switch fuse unit with three pole load break Isolating switch and three HRC fuses.

(b) One (1) Triple pole contactor.

(c) One (1) Bimetallic thermal overload relay with single phasing preventor. Modules marked with * (DK2* / PK2*) shall not have this relay. For motor with high starting time, heavy duty overload relay shall be provided.

(d) Three (3) Indicating lamps with resistors and coloured lenses.

(e) One (1) HRC control fuse.

(f) One (1) Control link

(g) One (1) Auxiliary contactor

(h) Two (2) Coupling relays suitable for 24V DC.

(i) One (1) digital energy meter with analog output of current (4-20 mA) for CHP dust suppression motors.

40.12.00 **Module Type DK21 (Non Reversible Motor rated 30kW to up to 110KW (* See Remark) controlled from DDCMIS).**
(*) Remark : For CHP Motors –upto 160 KW

(a) Similar to module type DK2 but with the following additions :

(b) Three (3) Current transformers for metering.

(c) One (1) Ammeter (for motors of rating ≥ 30kW & < 110kW)

(d) One (1) Single-pole switch and fuse for motor space heater.

(e) One (1) Digital Energy Meter with Analog output of Current (4-20 mA) (for motors of rating ≥ 30kW & < 110kW)

40.13.00 **Module Type DN1 (Reversible Motor Controlled from DDCMIS)**

(a.) One (1) Triple pole fuse switch unit with three pole load break solating switch and three HRC fuses.

(b.) Two (2) Triple pole mechanically interlocked, forward / reverse contactors.

(c.) One (1) Bimetallic thermal overload relay with single phasing preventor.

(d.) One (1) Indicating lamp with resistor and coloured lens.

(e.) One (1) HRC control fuse

(f.) One (1) Control link

(g.) One (1) Auxiliary contactor

(h.) Two (2) Coupling relays suitable for 24V DC.

40.14.00 **Module Type VM (Voltmeter Module)**

(a.) Three (3) HRC fuses.

(b.) One (1) Voltmeter (0-500 V.)

(c.) One (1) Four position voltmeter selector switch

(d.) One (1) 415 V auxiliary contactor with 2 NO + 2 NC contacts.

(e.) One (1) Voltage transducer with output of 4-20mA between R & Y phases

40.15.00 **Module Type DM (Circuit Breaker (DDC /PLC Controlled) Motor Feeder for motor rated 110 KW & above (except for CHP motors).**

(a.) One (1) Triple-pole circuit breaker, complete with all accessories and power operated mechanism, as specified.

(b.) Three (3) Current transformers for Protection and metering.

(c.) One (1) DC isolating Switch

(d.) Six (6) HRC Control fuses.

(e.) One (1) Single-pole switch and fuse for motor space heater

(f.) Numerical relay for the following:

Short Circuit Protection (50)

Thermal Over Load protection (51I)

Earth fault Protection (50N)

Negative sequence Protection (46)

Restart inhibit protection (49)

Locked Rotor Protection

Energy Metering

Current and Voltage metering

Trip Circuit Supervision

CB Monitoring

41.00.00 DC MODULES DESCRIPTION

41.01.00 **Module Type -CH (Incomer)**

(a) One (1) Double pole, 250 V DC fuse -switch unit

41.02.00 **Module Type - DC**

(a.) One (1) Double pole 250V DC switch / circuit breaker with 2NO+2NC auxiliary contacts.

41.03.00 **Module Type - HD (DC Isolating Switch / Circuit - Breaker Module)**

(a.) One (1) Double pole , 250 V DC switch isolator / circuit breaker

41.04.00 **Module Type-S (DC Metering and Protection Module)**

(b.) One (1) Voltmeter, 0-300V DC

(c.) One (1) Three position voltmeter selector switch

(d.) One (1) Instantaneous under voltage relay (27) with a setting of 95% of 240V DC. The resetting ratio of relay should not be more than 1.05.

(e.) One (1) Instantaneous over voltage relay (59) which shall operate at 110% of 240 V DC. The resetting ratio of relay should not be less than 0.95.

(f.) One (1) Earth leakage relay having adjustable pick up range between 3 to 7mA. The relay shall be suitable for 240V / 50V DC and 240V AC auxiliary supply.

(g.) Two (2) Indicating lamps with resistors & coloured lenses, one each for 'Earth fault' and 'DC supply failure ' indications.

(h.) Three (3) HRC control fuses.

(i.) One (1) Neutral link

41.05.00 **Module Type -X (DC Isolating Switch Fuse Module)**

(j.) One (1) Double pole, 250 V DC fuse switch unit with two HRC fuses.

42.00.00 SELECTION TABLES

42.01.00 **Feeder Module, Other than Motor Selection Table (415 V AC)**

Sl. No.	Feeder Rating (Amp.)	Switch/MCCB Rating (Amp.)	Fuse Rating (Amp.)
1.	0-16	16	16
2.	17-32	32	32
3.	33-45	63	63
4.	46-63	63	63
5.	64-99	100	100
6.	100	100A MCCB	
7.	101-160	160A MCCB	
8.	161-250	250A MCCB	
9.	251-400	400A MCCB	
10.	401-1120 (Breaker)		
11.	1121-1680 (Breaker)		

42.02.00 **Motor Module Selection table**

Sl. No.	Motor rating kW	Max. Motor Amp.	Switch rating Amp.	Fuse rating Amp.	Contactor rating Amp.
1.	1.1-1.5	3.5	16	6/16	16
2.	1.6.3.0	7	32	20	16
3.	3.1-5.5	11	32	32	16
4.	5.6-7.0	14.4	63	50	32
5.	7.1-13.0	27.3	63	63	32
6.	13.1-24.0	45	125	80/100	63
7.	24.1-37.0	70	125	125	70 (upto 30kW) 100 (above 30kW)

8.	37.1-55.0	100	250	160	100 (upto 40kW) 160 (upto 55kW)
9.	55.1-80.0	150	250	200	200
10.	80.1-200	CIRCUIT BREAKER			

42.03.00 **Switch Fuse Module Selection Table (220 V DC)**

For all 220 V DC modules other than for motors, the ratings of switches fuses and cable termination shall be selected from the following table

Sl. No.	Feeder rating Amp.	Switch rating Amp.	Fuse rating Amp.
1.	0-6	10	6
2.	6-10	16	10
3.	10-14	16	16
4.	14-19	32	32
5.	19-32	32	32
6.	32-53	63	63
7.	53-81	100	100
8.	81-114	125	125
9.	114-125	250	250
10.	215-340	400	400
11.	340-560	600	600
12.	560-1000	Circuit Breaker	
13.	1000-1400	Circuit Breaker	

43.00.00 COMMISSIONING OF LT SWITCHGEARS

Commissioning of LT switchgears at site shall only be carried out either by the switchgear manufacturer himself or under the supervision of the switchgear manufacturer.

44.00.00 RESPONSIBILITY OF THE ASSOCIATE/COLLABORATOR (APPLICABLE IF LT SWITCHGEAR IS SUPPLIED THROUGH PROVENNESS CRITERIA: ROUTE-2):

The Associate/Collaborator (as applicable) for sourcing of LT Air Circuit Breaker shall be fully responsible and accountable for the item supplied and its compliance to the specification requirements.

The Associate/Collaborator (with respect to his manufactured and supplied LT Air Circuit Breaker) shall:

i) Participate in the Inspection of the LT Switchgears at Switchgear Supplier's Works, if required by Employer.

(ii) Participate in Technical Co-ordination Meetings (TCMs) from time to time during detailed engineering, if required.

(iii) Participate in Site Testing and Commissioning of LT Switchgears, if required.

(iv) Participate/address/resolve the issues raised during Contract Execution Period.

44.00.00 **Insulating Mat**

Insulating mat supplied for laying in front of LT Switchgears in switchgear rooms shall be as per IS:15652.

LEGEND	DESCRIPTION	LEGEND	DESCRIPTION
52	CIRCUIT BREAKER	64R	RESTRICTED EARTH FAULT PROTECTION
42	CONTACTOR	51G	STAND BY EARTH FAULT PROTECTION
S.A.	SURGE ARRESTOR	87T	3 PHASE BIASED TRANSFORMER DIFFERENTIAL PROTECTION
	CURRENT TRANSFORMER	27M	3 PHASE UNDER VOLTAGE PROTECTION FOR MOTOR TRIPPING
	CORE BALANCE CURRENT TRANSFORMER	27U	3 PHASE BUS UNDER VOLTAGE
	VOLTAGE TRANSFORMER	27N	NO VOLT PROTECTION FOR BUS
50	TRIPLE POLE IDMTL/DMT O/C PROTECTION	50BF	CIRCUIT BREAKER FAILURE PROTECTION
51	TRIPLE POLE INSTANTENIOUS O/C PROTN.	86	LOCKOUT FUNCTION
50N	IDMTL / DMT SENSITIVE E/F PROTECTION	3I	3 PHASE CURRENT MEASUREMENT
51N	INSTANTENIOUS E/F PROTECTION	Io	NEUTRAL CURRENT MEASUREMENT
49	THREE PHASE THERMAL O/L PROTN. WITH O/L ALARM & RESTART INHIBITE FUNCTION	3U	3 PHASE VOLTAGE MEASUREMENT
50L/R	STALLING / LOCKED ROTOR PROTECTION	Uo	RESIDUAL VOLTAGE MEASUREMENT
46	THREE PHASE NEGATIVE PHASE SEQUENCE PROTECTION	P	ACTIVE POWER MEASUREMENT
66	NUMBER OF START LIMITATION/REPATETIVE START PROTECTION	Q	REACTIVE POWER MEASUREMENT
2	TIME DELAY RELAY	E	ENERGY MEASUREMENT
60	FUSE FAILURE PROTECTION	PF	POWER FACTOR MEASUREMENT
		HZ	FREQUENCY MEASUREMENT
87M	3 PHASE MOTOR DIFFERENTIAL PROTECTION	HM	HOUR RUN METER

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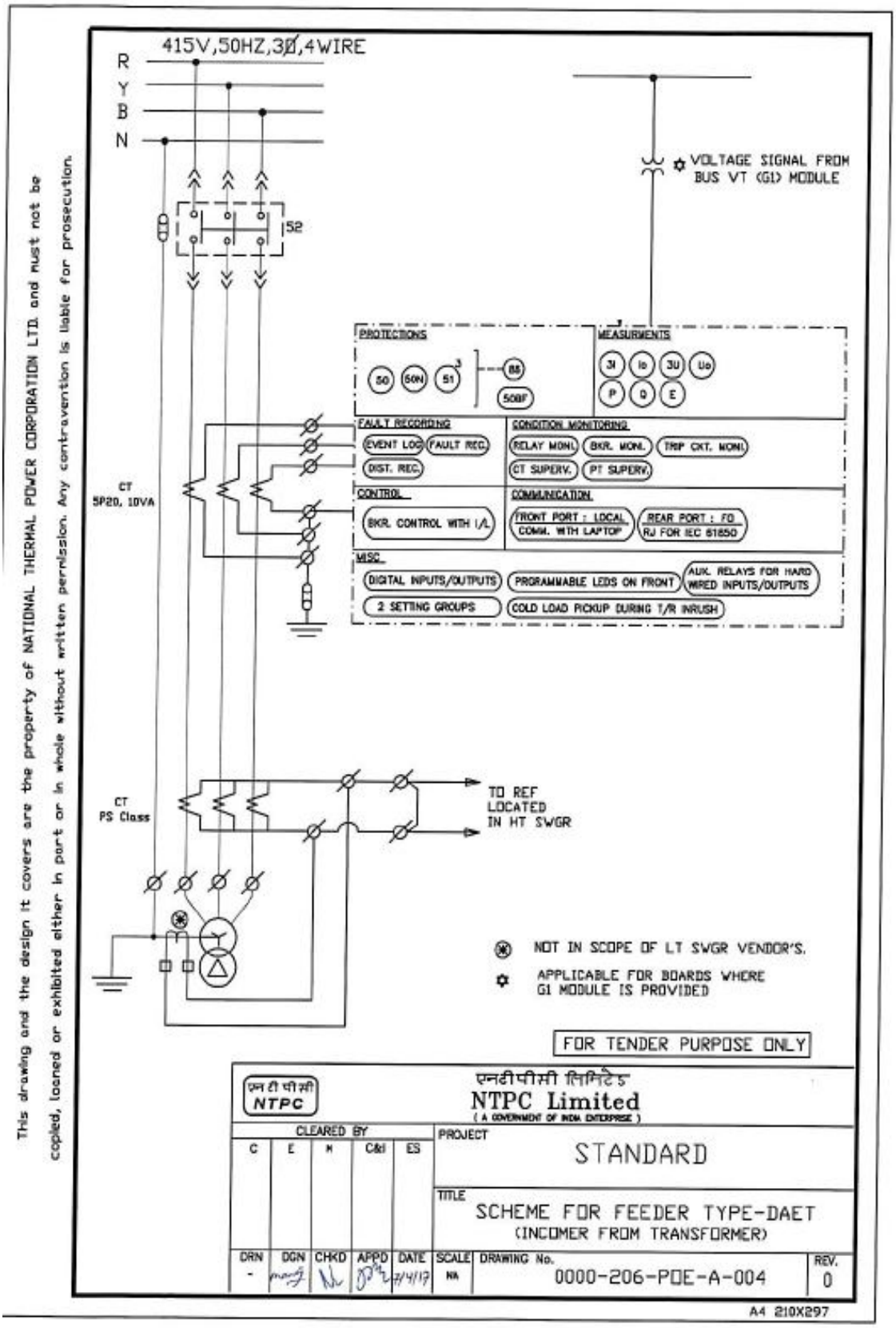
					LEGEND DETAILS	

DRN	DGN	CHKD	APPD	DATE	SCALE	DRAWING No.	REV.
-				10/01/07	NA	0000-206-POE-A-003	0

LEGEND.DWG A4 210X297


415V,50HZ,3Ø,4WIRE
R
Y
B
N
52
VOLTAGE SIGNAL FROM BUS VT (G1) MODULE
PROTECTIONS
50
50N
51
86
50BF
MEASURMENTS
3I
Io
3U
Uo
P
Q
E
FAULT RECORDING
EVENT LOG
FAULT REC.
DIST. REC.
CONDITION MONITORING
RELAY MONI.
BKR. MONI.
TRIP CKT. MONI.
CT SUPERV.
PT SUPERV.
CONTROL
BKR. CONTROL WITH I/L
COMMUNICATION
FRONT PORT : LOCAL COMM. WITH LAPTOP
REAR PORT : FO RJ FOR IEC 61850
MISC.
DIGITAL INPUTS/OUTPUTS
PROGRAMMABLE LEDS ON FRONT
AUX. RELAYS FOR HARD WIRED INPUTS/OUTPUTS
2 SETTING GROUPS
COLD LOAD PICKUP DURING T/R INRUSH
CT
5P20, 10VA
CT
PS Class
TO REF LOCATED IN HT SWGR
NOT IN SCOPE OF LT SWGR VENDOR'S.
APPLICABLE FOR BOARDS WHERE G1 MODULE IS PROVIDED
FOR TENDER PURPOSE ONLY
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CLEARED BY
C
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PROJECT
STANDARD
TITLE
SCHEME FOR FEEDER TYPE-DAET
(INCOMER FROM TRANSFORMER)
DRN
DGN
CHKD
APPD
DATE
SCALE
DRAWING No.
0000-206-POE-A-004
REV.
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A4 210X297
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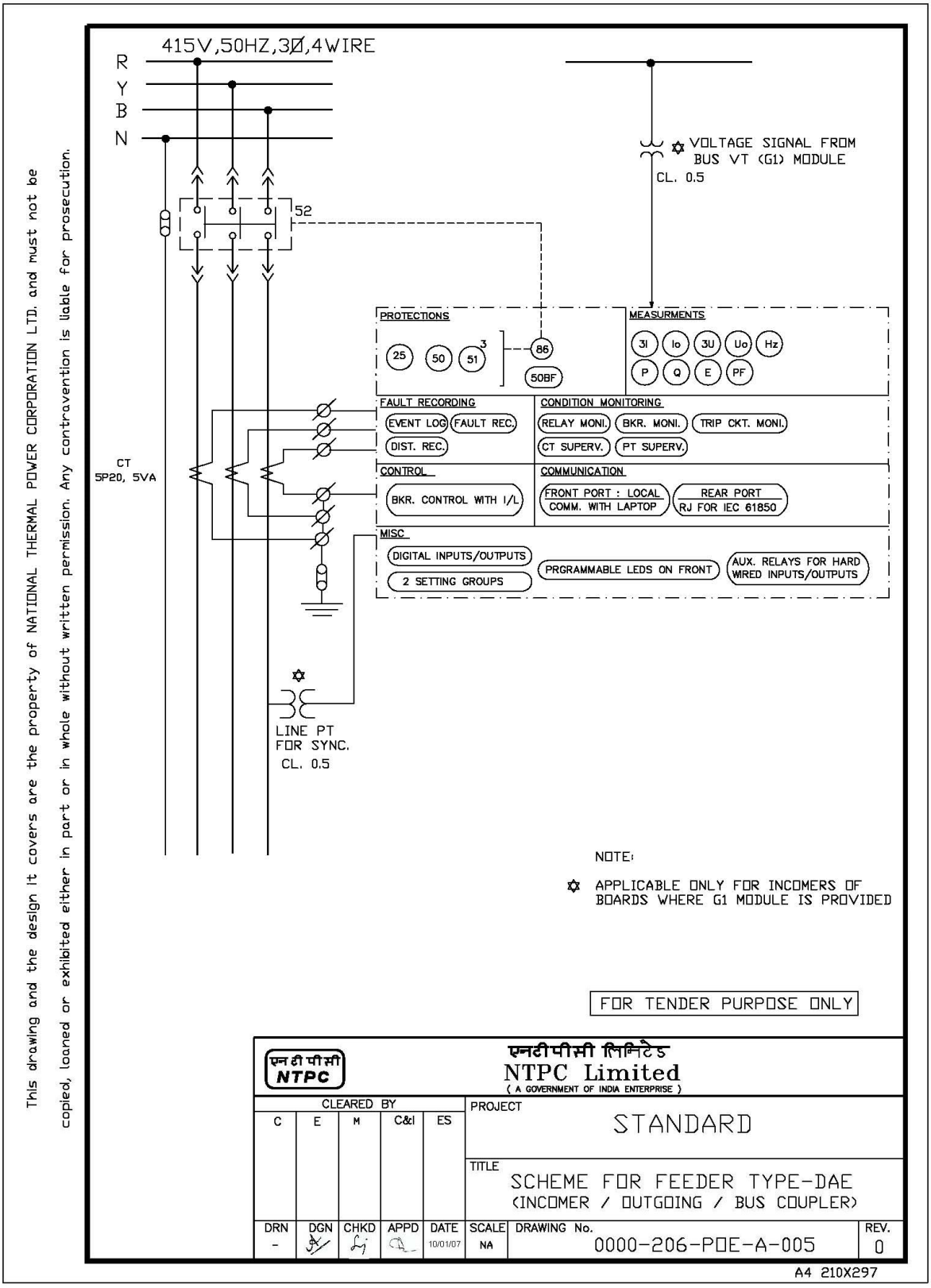

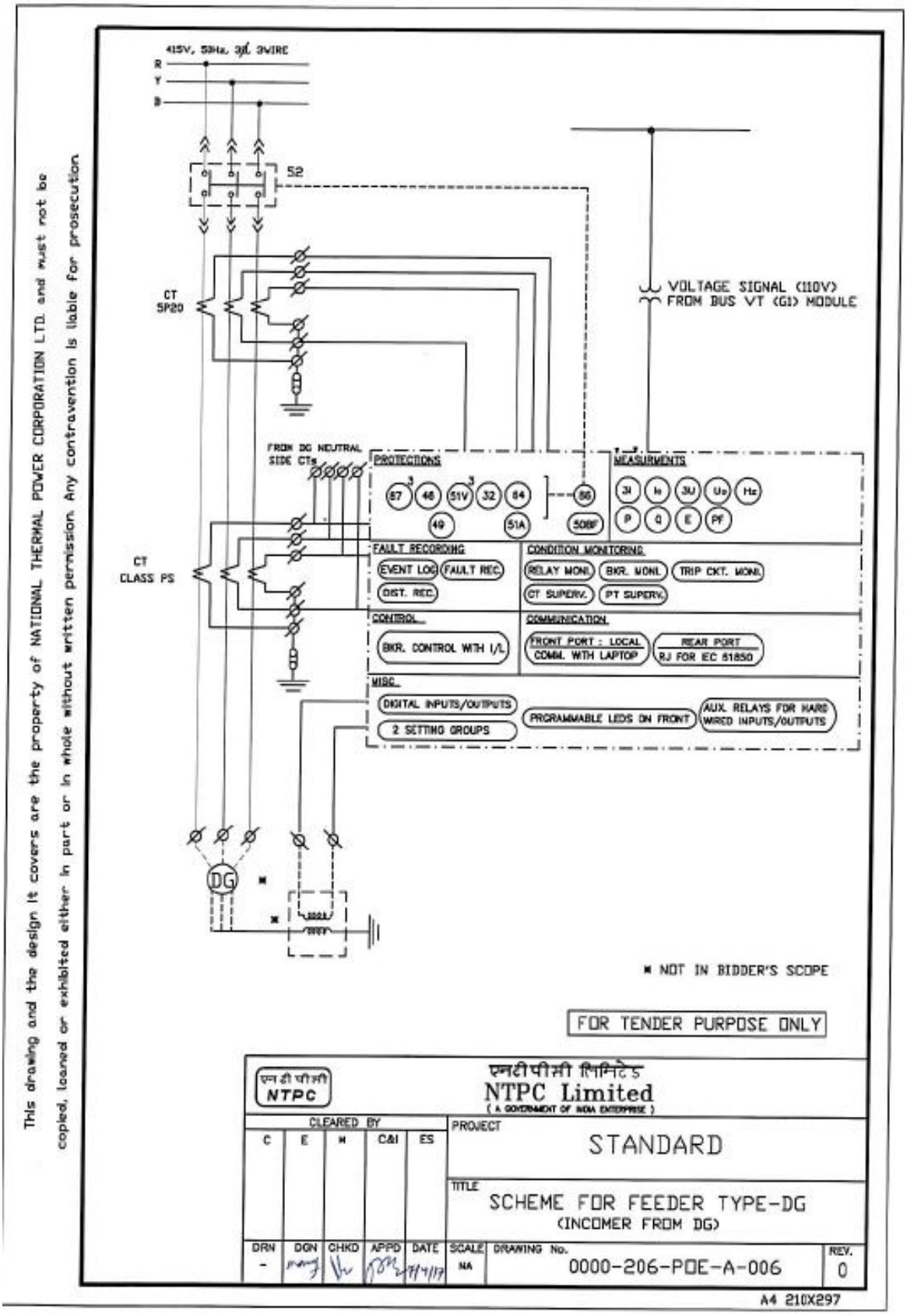
415V, 50Hz, 3Ø, 3WIRE
R
Y
B
52
CT
5P20
VOLTAGE SIGNAL (110V)
FROM BUS VT (G1) MODULE
FROM DG NEUTRAL
SIDE CTs
CT
CLASS PS
PROTECTIONS
87
46
51V
32
64
49
51A
86
50BF
MEASURMENTS
3I
Ia
3U
Ua
Hz
P
Q
E
PF
FAULT RECORDING
EVENT LOG
FAULT REC.
DIST. REC.
CONDITION MONITORING
RELAY MONI.
BKR. MONI.
TRIP CKT. MONI.
CT SUPERV.
PT SUPERV.
CONTROL
BKR. CONTROL WITH I/L
COMMUNICATION
FRONT PORT : LOCAL
COMM. WITH LAPTOP
REAR PORT
RJ FOR IEC 61850
MISC.
DIGITAL INPUTS/OUTPUTS
2 SETTING GROUPS
PROGRAMMABLE LEDS ON FRONT
AUX. RELAYS FOR HARD WIRED INPUTS/OUTPUTS
DG
* NOT IN BIDDER'S SCOPE
FOR TENDER PURPOSE ONLY
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NTPC Limited
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C
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PROJECT
STANDARD
TITLE
SCHEME FOR FEEDER TYPE-DG
(INCOMER FROM DG)
DRN
DGN
CHKD
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DRAWING No.
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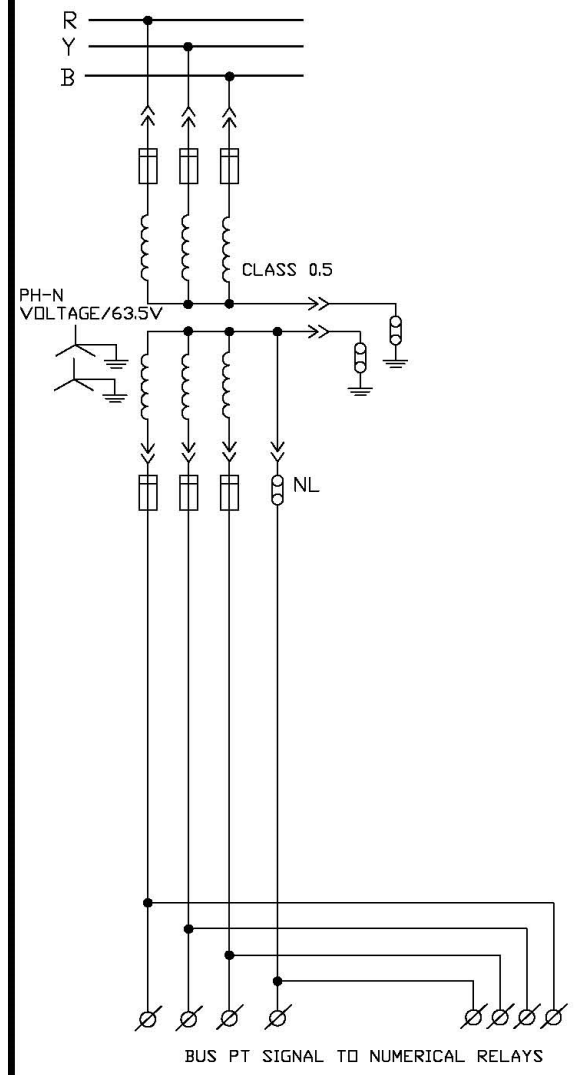

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C	E	M	C&I	ES	STANDARD		
					TITLE: SCHEME FOR MODULE TYPE - G1 (BUS PT)		
DRN	DGN	CHKD	APPD	DATE	SCALE	DRAWING No.	REV.
-				10/01/07	NA	0000-206-POE-A-007	0

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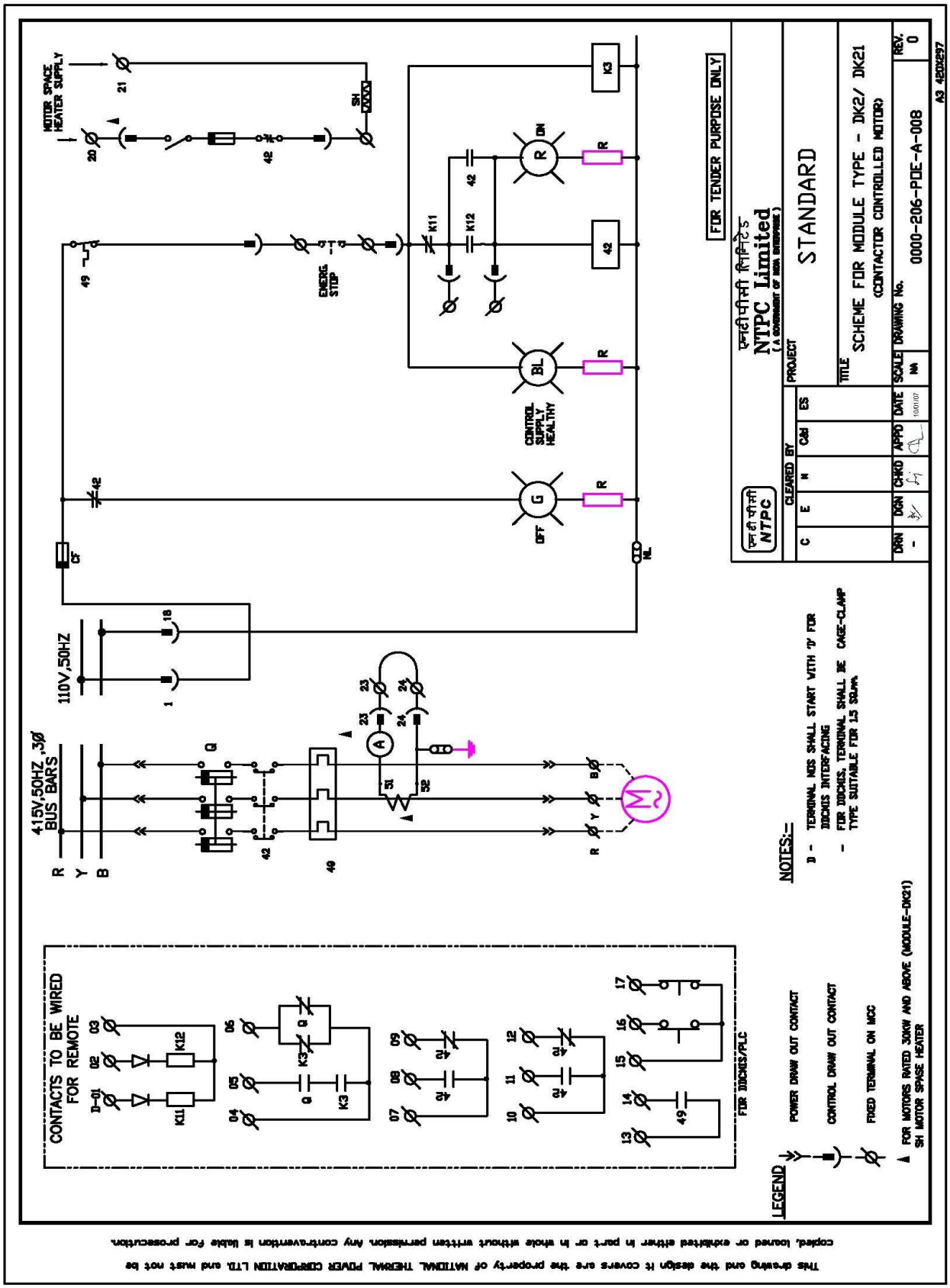

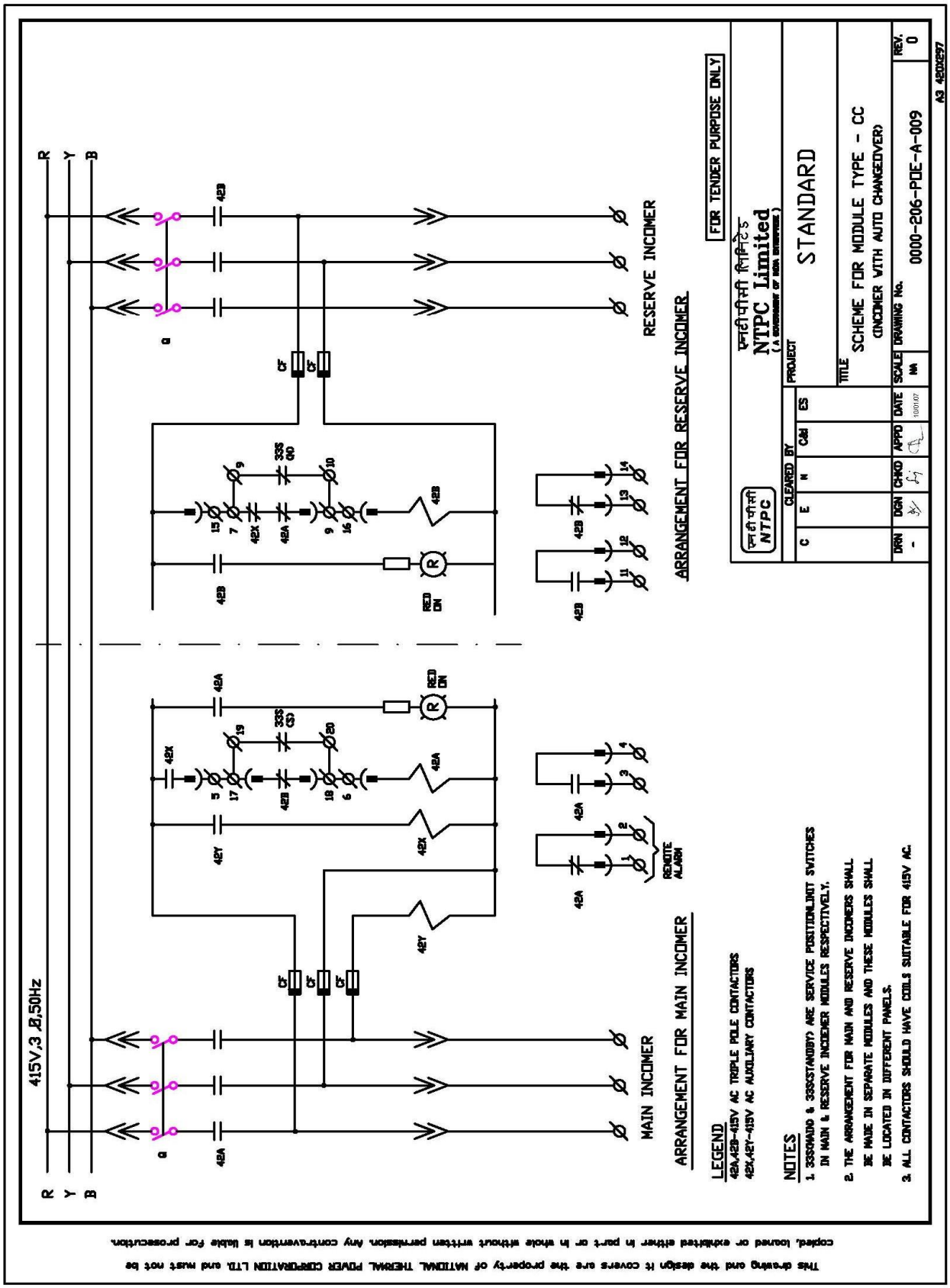
R Y B
415V,3 Ø,50Hz
MAIN INCOMER
RESERVE INCOMER
ARRANGEMENT FOR MAIN INCOMER
ARRANGEMENT FOR RESERVE INCOMER
LEGEND
42A,42B-415V AC TRIPLE POLE CONTACTORS
42X,42Y-415V AC AUXILIARY CONTACTORS
NOTES
1. 33SOA&B & 33SOSTANDBY) ARE SERVICE POSITION LIMIT SWITCHES IN MAIN & RESERVE INCOMER MODULES RESPECTIVELY.
2. THE ARRANGEMENT FOR MAIN AND RESERVE INCOMERS SHALL BE MADE IN SEPARATE MODULES AND THESE MODULES SHALL BE LOCATED IN DIFFERENT PANELS.
3. ALL CONTACTORS SHOULD HAVE COILS SUITABLE FOR 415V AC.
FOR TENDER PURPOSE ONLY
NTPC Limited
PROJECT
STANDARD
TITLE
SCHEME FOR MODULE TYPE - CC
(INCOMER WITH AUTO CHANGEOVER)
DRAWING No.
0000-206-PDE-A-009
REV. 0
SCALE NA
DATE 10.01.07
CLEARED BY
DRN -
DGN
CHKD
APPD
A3 420x297
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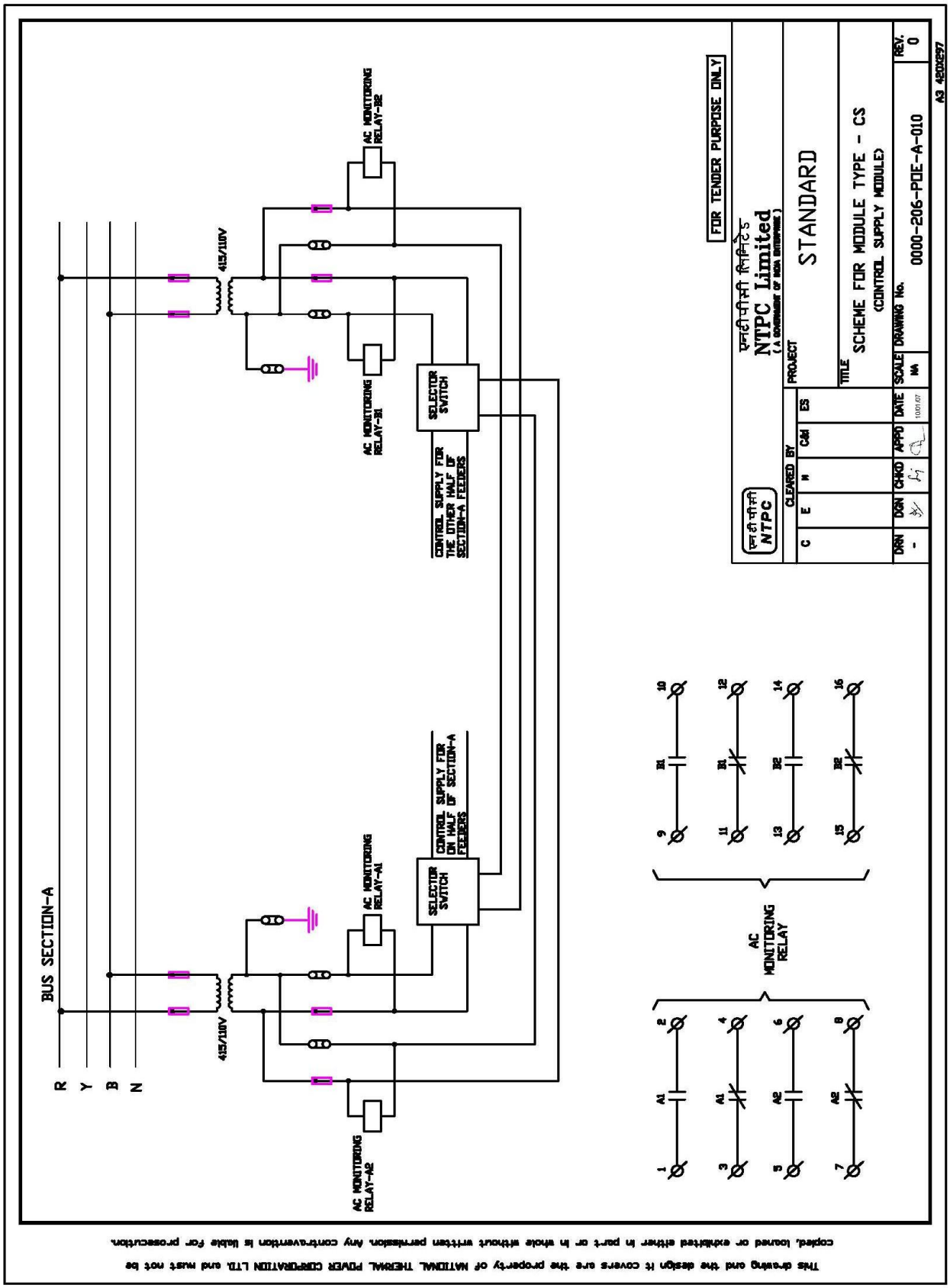

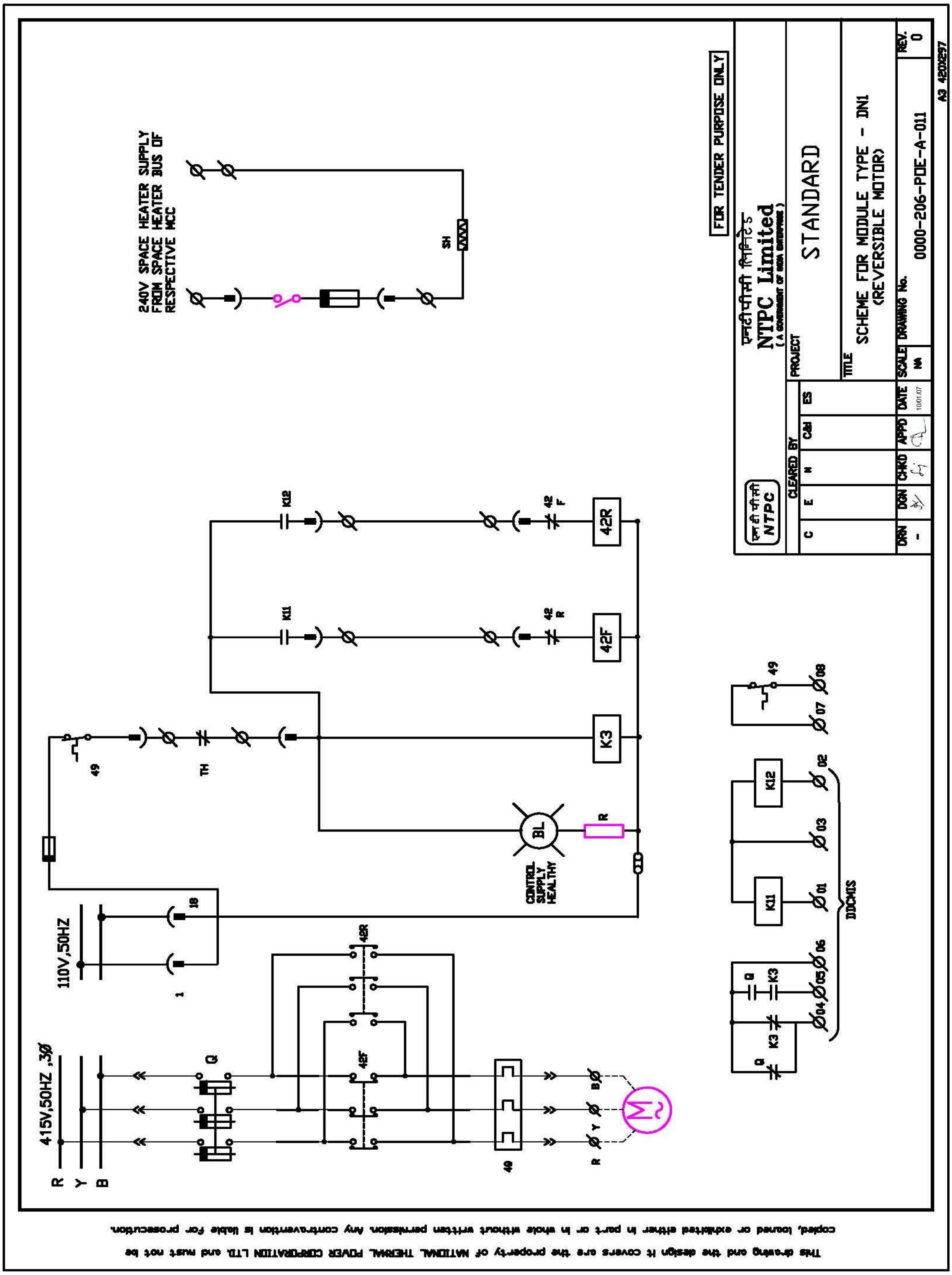
FOR TENDER PURPOSE ONLY
NTPC Limited
STANDARD
SCHEME FOR MODULE TYPE - DN1
(REVERSIBLE MOTOR)
0000-206-POE-A-011
240V SPACE HEATER SUPPLY FROM SPACE HEATER BUS OF RESPECTIVE MCC
415V,50HZ ,3Ø
110V,50HZ
CONTROL SUPPLY HEALTHY
DDCMIS
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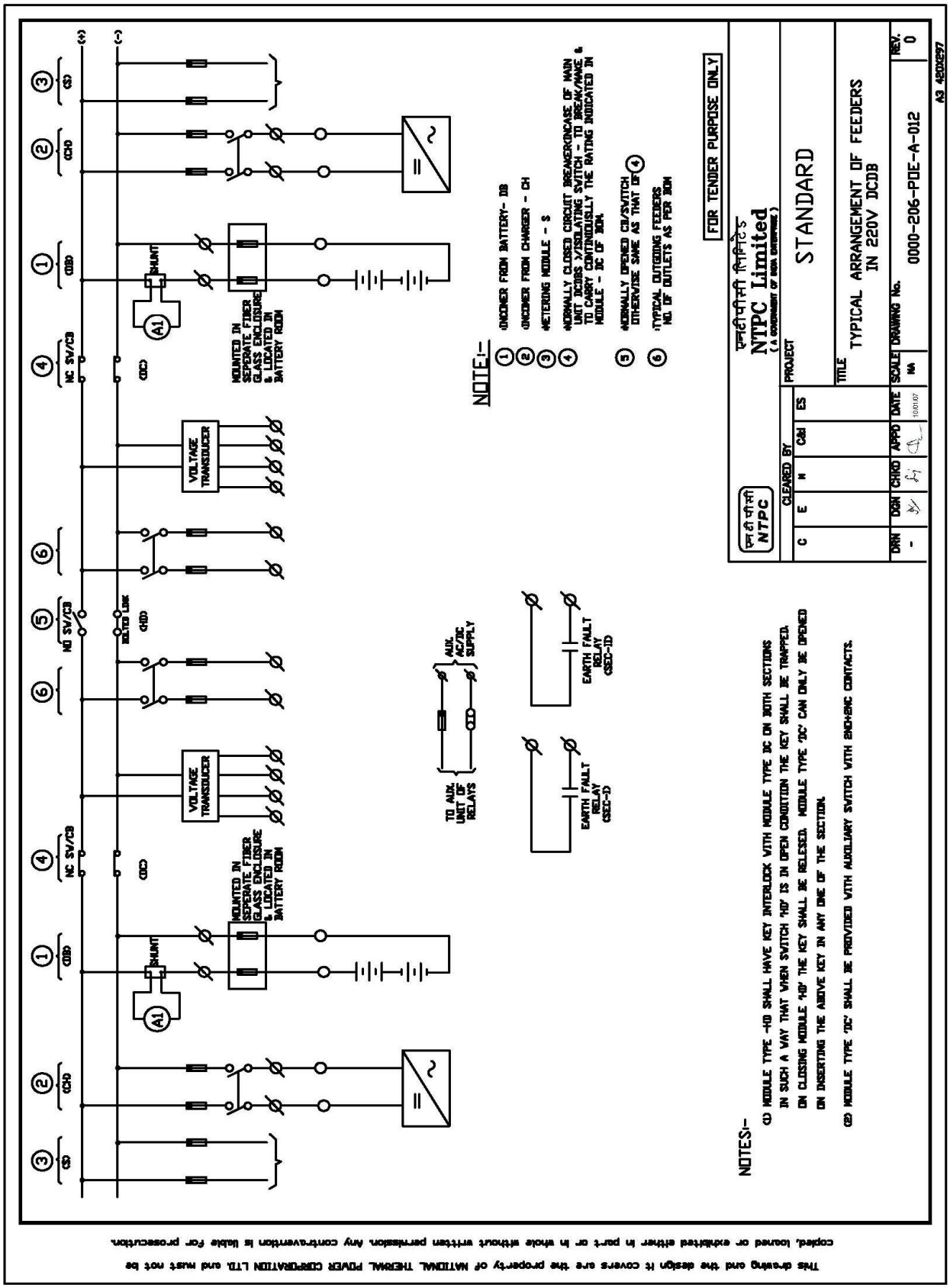
NOTE:-
1. ENCOMER FROM BATTERY- DB
2. ENCOMER FROM CHARGER - CH
3. METERING MODULE - S
4. NORMALLY CLOSED CIRCUIT BREAKER/CASE OF MAIN UNIT DC/DC I/SOLATING SWITCH - TO BREAK/MAKE & TO CARRY CONTINOUSLLY THE RATING INDICATED IN MODULE - DC OF 3DM.
5. NORMALLY OPENED CB/SWITCH OTHERWISE SAME AS THAT OF 4
6. TYPICAL OUTGOING FEEDERS NO. OF OUTLETS AS PER 3DM
FOR TENDER PURPOSE ONLY
NTPC Limited
(A GOVERNMENT OF INDIA ENTERPRISE)
PROJECT
STANDARD
TITLE
TYPICAL ARRANGEMENT OF FEEDERS IN 220V DCDB
DRAWING No.
0000-206-POE-A-012
REV.
0
SCALE
NA
DRN
DGN
CHKD
APPD
DATE
CLEARED BY
C&I
ES
NOTES:-
1. MODULE TYPE -HD SHALL HAVE KEY INTERLOCK WITH MODULE TYPE DC ON BOTH SECTIONS IN SUCH A WAY THAT WHEN SWITCH 'HD' IS IN OPEN CONDITION THE KEY SHALL BE TRAPPED. ON CLOSING MODULE 'HD' THE KEY SHALL BE RELEASED. MODULE TYPE 'DC' CAN ONLY BE OPENED ON INSERTING THE ABOVE KEY IN ANY ONE OF THE SECTION.
2. MODULE TYPE 'DC' SHALL BE PROVIDED WITH AUXILIARY SWITCH WITH 8NO+8NC CONTACTS.
SHUNT
A1
MOUNTED IN SEPERATE FIBER GLASS ENCLOSURE & LOCATED IN BATTERY ROOM
VOLTAGE TRANSDUCER
NC SV/CB
NO SV/CB
MCCB LINK
AUX. AC/DC SUPPLY
TO AUX. UNIT OF RELAYS
EARTH FAULT RELAY (SEF-1D)
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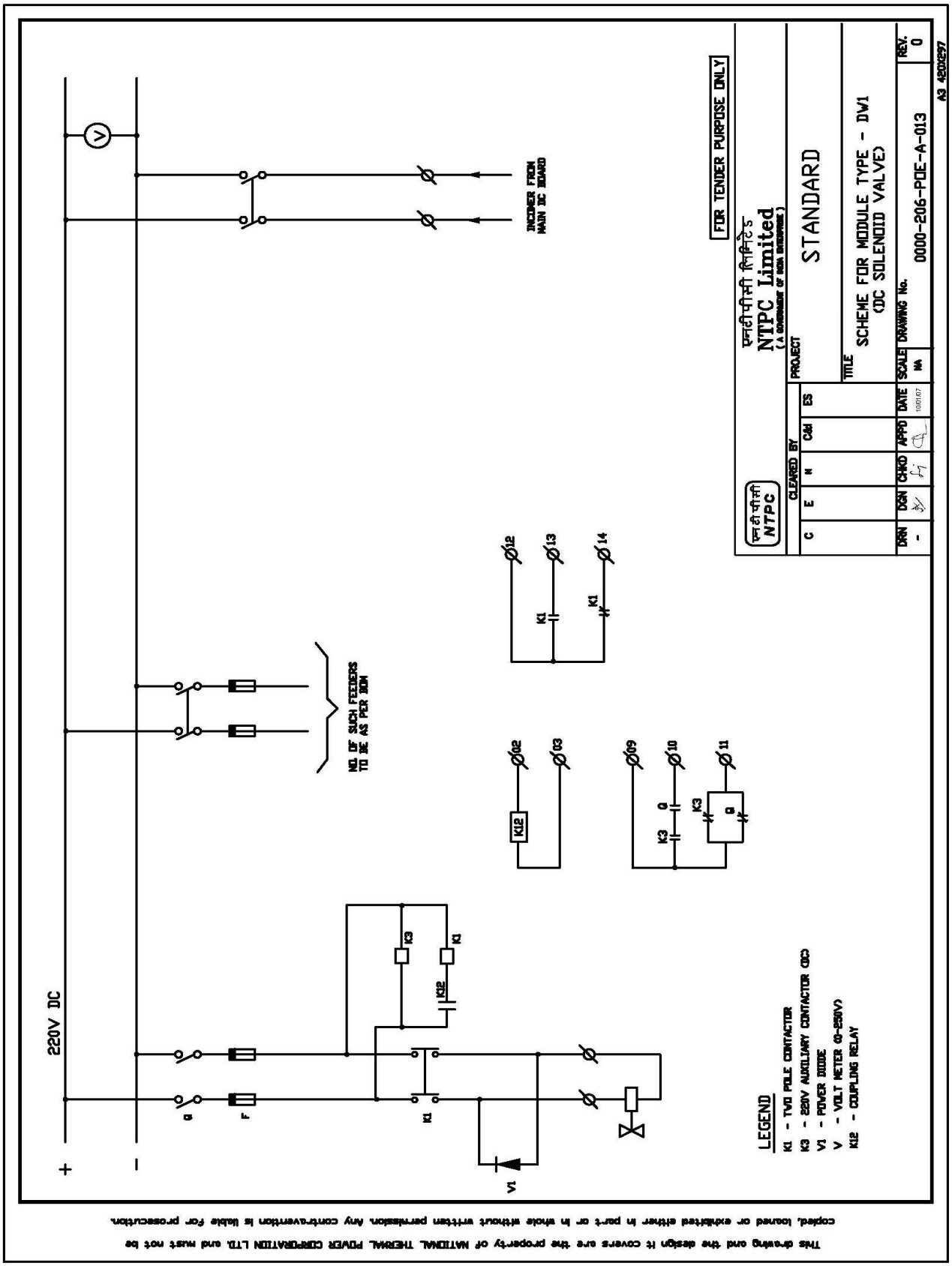
A3 420x297


FOR TENDER PURPOSE ONLY
एनटीपीसी लिमिटेड
NTPC Limited
(A GOVERNMENT OF INDIA UNDERTAKING)
NTPC
CLEARED BY
C
E
N
C&I
ES
DRN
DGN
CHKD
APPD
DATE
10.01.07
PROJECT
STANDARD
TITLE
SCHEME FOR MODULE TYPE - DV1
(DC SOLENOID VALVE)
SCALE
NA
DRAWING No.
0000-206-PDE-A-013
REV.
0
A3 4202297
INCOMER FROM
MAIN DC BOARD
NO. OF SUCH FEEDERS
TO BE AS PER BOM
220V DC
+
-
V1
K1
K3
K12
LEGEND
K1 - TWO POLE CONTACTOR
K3 - 220V AUXILIARY CONTACTOR (DC)
V1 - POWER DIODE
V - VOLT METER (0-250V)
K12 - COUPLING RELAY
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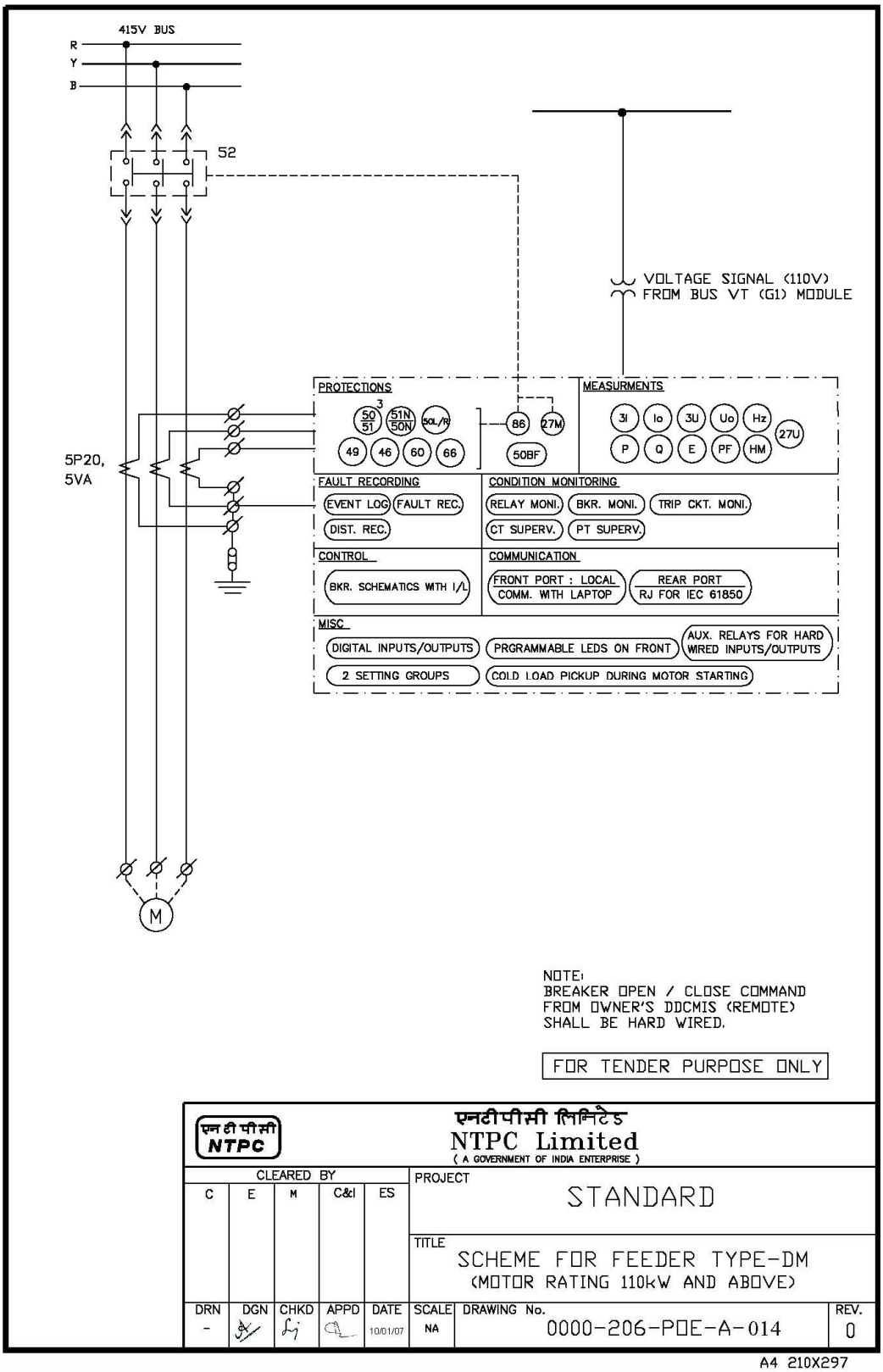

NOTE:
BREAKER OPEN / CLOSE COMMAND
FROM OWNER'S DDCMIS (REMOTE)
SHALL BE HARD WIRED.

FOR TENDER PURPOSE ONLY

एनटीपीसी लिमिटेड
NTPC Limited
(A GOVERNMENT OF INDIA ENTERPRISE)

CLEARED BY					PROJECT			
C	E	M	C&I	ES	STANDARD			
					TITLE: SCHEME FOR FEEDER TYPE-DM (MOTOR RATING 110kW AND ABOVE)			
DRN	DGN	CHKD	APPD	DATE	SCALE	DRAWING No.		REV.
-				10/01/07	NA	0000-206-POE-A-014		0

A4 210X297

SUB-SECTION-II-E10

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 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 luminairies.
IS:2148	Flame proof enclosures of electrical apparatus.
IS:418	Tungsten filament general service electric lamps.
IS:1258	Bayonet lamp holders.
IS:1534	Ballast for fluorescent lamps.
IS:1569	Capacitors for use in tubular fluorescent, high pressure mercury vapour and low pressure sodium vapour discharge lamp circuit.
IS:1777	Industrial luminaire with metal reflectors.
IS:2215	Starters for fluorescent lamps.
IS:2418	Tubular fluorescent lamps for general lighting services.
IS:3323	Bi-pin lamp holders for tubular fluorescent lamps.
IS:3324	Holders for starters for tubular fluorescent lamps.
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.

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 controlgear
	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 upto 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	Photobiological 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)	Electro magnetic 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) Emergency AC Lighting System

(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 **Emergency AC Lighting System**

This system shall be provided for certain important areas in the main plant. The lighting fixtures connected to this system shall be normally "ON" along with the normal AC system. These will be fed from emergency lighting panels (ELPs) which in turn will be fed 3-phase, 4-wire supply from the emergency lighting distribution boards (ELDB'S). These lights will go off for a few seconds in case of AC supply failure at Emergency Switchgear, but shall be automatically restored when Emergency Switchgear is energised by Diesel generator set.

3.03.00 **DC Lighting System**

3.03.01 At strategic locations in the main 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 and Emergency 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 at station service switchgear as well as Emergency switch-gear. The DC supply will be automatically switched OFF after about 3 minutes following the restoration of supply to normal AC or emergency 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 LED 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 areas.

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 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 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 equipments 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, DC lighting including that of hazardous areas. 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 80 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 LED luminaires shall have minimum life of 25,000 burning hours with 80% of lumen maintenance at the end of the life.

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 water proof 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
- Overload 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

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 polyamide 6.6 or better suitable for terminating multicore 35 or 70 Sq. mm. stranded aluminium conductor incoming cable and 10 Sq. mm. stranded aluminium conductor for each outgoing circuits voltage. All terminals shall be shrouded, numbered and provided with identification strip for the feeders.

(d) MCB's shall be current limiting type with magnetic and thermal release suitable for manual closing and automatic tripping under fault condition. MCB's shall have short circuit interrupting capacity of 9 KA rms. MCB 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 terminal shall be shrouded to avoid accidental contact.

(e) Contactors of AC lighting panels shall be 3 no's, 32 A, 3 pole continuous duty MCB, load make-break type suitable for 415 V, 3 phase 4 wire system. HRC fuses with suitable mounting base of 125A shall be provided in the incomer of Contactors in the LP.

(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 Almanac Time switch with battery back up of min. TEN years, 4 Digit LED display, 24 hours range, manual override facility, 10 Amp 3 relay output, with NO/NC Contacts suitable for operation on 240V single phase AC supply.

(h) Each lighting panel (LP-3) shall be fed from a 415V/42V, 3 phase-4 wire, 3 KVA transformer. The transformer shall be located inside the lighting panel itself. Transformers shall be dry type, natural air cooled with class F insulation or better. Impedance of transformer shall be 5%. Transformers shall be tested as per IS:11171. Off-circuit tap changer with +/- 5% in steps of +/- 1.25% tapping shall be provided. One minute power frequency withstands voltage for lighting transformer shall be 2.5 KV.

(i) Lighting Panels shall be of following types:

TYPE	INCOMER FEEDER	OUTGOING FEEDERS	DETAILOFCONTENTS
LP-1	3No. 415V, 32 A, TP MCB (31/2Cx70sq.mm cable)	18Nos.,20A, 240V MCB	415V, 63A(min.), AC2 duty contactor and Programmable Digital Timer of 24 hour range 10A, 240V selector switch, fuse, etc. outdoor type and IP:55 degree of protection
LP-2	3No. 415V, 32 A, TP MCB (31/2Cx35sq.mm cable)	9 Nos.,20A, 240V MCB	415V, 63A(min.), AC2 duty contactor and Programmable Digital Timer of 24 hour range 10A, 240V selector switch, fuse, etc. outdoor type and IP:55 degree of protection
LP-3	1 No., 4A fuse 3 KVA transformer,40A TPN MCB	24 Nos., 16A, 45V MCB	IP 55 degree of protection. Incomer shall be suitable for receiving 4Cx16 sq. mm cable and outgoing circuit shall be suitable for 2Cx16 sq. mm cable.
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.

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11. Wires of different phase shall normally run in separate conduit.

12. Power supply shall be fed from 415 / 240 V normal AC supply, emergency 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 100KVA 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.

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 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	HPGCL 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	HPGCL 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	HPGCL appd. make	1-4 way, suitable for loop-in loop- out of 2 core -16 sq.mm. Al. Cable.

14. In the hazardous areas 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 fluorescent lamps shall be have "Cool day light" colour designation. The mirror optics type fluorescent fixtures shall have no iridescence effect. Fixtures with better efficiency and upgraded proven system may also be considered

In candescent lamps may be used only with DC Lighting.

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.

4.01.00 **Ballasts (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.

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 and rust proof made of heat resistant TERNE coated steel.

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, stranded copper/aluminium 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. for copper and 4 sq.mm. for aluminium.

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 **Occupancy based Passive Infra-red sensors**

The sensors shall be recess mounted, programmable type suitable for lighting load of 6A with variable off delay settings. The detection area shall be minimum 5 metres for standard room height of 3mt. All the calibrated settings shall be stored in non-volatile memory of PIR sensor which shall be unaffected by power supply fluctuations. Necessary 16A contactor shall be supplied alongwith each sensor & shall be located inside the switch box

5.00.00 TESTS

5.01.00 For LED Fixture

a) All equipments to be supplied shall be of type tested design. During detailed engineering, the contractor shall submit for Employer'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 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.

b) However if 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 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 Employer either at third party lab or in presence of client /Employers representative and submit the reports for approval.

c) 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.

LED fixtures Type test reports to be submitted for one rating each of following type of LED fixtures.

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 lighting equipment:**

a) 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 ten 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.

b) However if 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 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.

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 IS

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. Proof of procurement of LEDs
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
(a)	Switchgear rooms, Charger, Rectifier room	200	Industrial type LED Luminaire
(b)	Control room, computer room, control equipment room	350	LED luminaire equivalent to Mirror optics with anti-glare features or downlighter.
(c)	Offices, conference rooms, etc.	300	Decorative mirror optics Type LED luminaire or LED downlighter
(d)	Battery rooms	100	totally enclosed corrosion Proof LED Luminaire
(e)	Transformer Area	20 (general) 50 (on equipment)	LED Luminaire
(f)	Diesel generating room /enclosure, pump house etc.	150	LED medium bay/ Industrial type LED Luminaire
(g)	Cable galleries/vault	50	Industrial type LED Luminaire
(h)	Street lighting- primary roads secondary roads	 20 10	LED street lights
(i)	Outdoor storage handling and unloading area	20	LED Luminaire
(j)	Stores	150	Industrial dust proof type LED Luminaire
(k)	Chemical stores/House	150	Corrosion proof LED Luminaire
(l)	Permanent stores	150	LED high/medium bay / Industrial trough LED Luminaire
(m)	Workshop, Buildings	150	LED high/medium bay / Industrial trough LED Luminaire
(n)	Laboratory General Analysis area	 150 300	 Corrosion proof LED Luminaire
(o)	Garage/Car Parking	50	Industrial type LED Luminaire

(p)	Transfer points, Sheds, tunnels, bunker house, Conveyor Gallery etc. in bidders scope	100	LED Dust tight/Well glass type Luminaire
(q)	Facility building, canteen etc.	150	Industrial type LED Luminaire
(r)	Corridors, Walkways	50	LED Luminaire
(s)	Building Periphery Lighting	10	LED Street Light fixture

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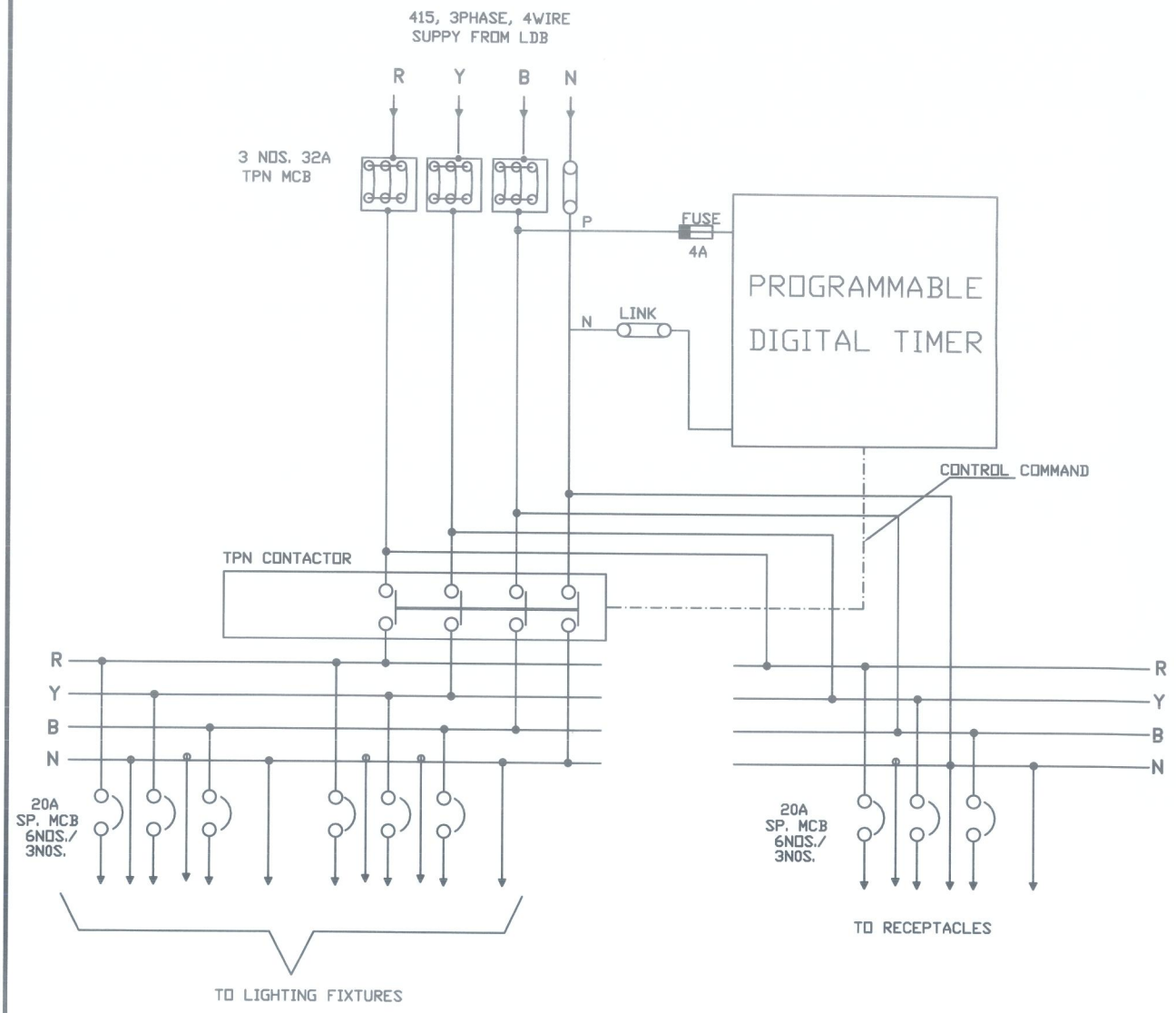
ANNEXURE-B

Sl.	Plant Areas	Normal AC Lighting System	Emergency AC Lighting System	220 V DC Lighting System	Portable DC Fixtures
1	DG Area/ Room	80%	20%		
2	FGD Control Room	80%	20%		√
3	Battery Room	80%	20%		
4	Cable Spreader Room/ Vault	80%	20%	√	
5	Pump House	100%			√
6	Switchgear Room	100%			√
7	Service Building	100%			
8	Area Lighting	100%			
9	Street Lighting	100%			
10	Transformer Yard and Storage Yard	100%			
11	FGD Plant	100%		√	

DC Emergency Lighting:

Sl.	Area	Average Lux Level
2	Control Equipment Room	100
3	Switchyard Control Room	20
4	Strategic Control Points (Switchgear room, Battery Room, UPS Area, Lube oil Room etc.	20
5	Cable Vault & Galleries	1 fixture at every 20 metres spacing along walkways
6	Stair Case	1 fixture at every 20 metres spacing along walkways
7	Exit/ Entry of Plant Building	1 fixture
8	Fire Exit Sign	1 fixture

.



S.NO.	LP TYPE	INCOM ISOLATER	OUTGOING 20A MCB'
1	LP-1	3 NOS 32A TPN MCB + 63A CONT + SYNC. TIMER + INDICATING LAMPS	12 NOS. SP+ 6NO. SP
2	LP-2	3 NOS 32A TPN MCB + 63A CONT + SYNC. TIMER + INDICATING LAMPS	6 NOS. SP+ 3NOS. SP

REV. NO.	DESCRIPTION	DRAWN	DESIGN	CHKD	M	E	C	C&I	ARCH	APPD	DATE
					CLEARED BY						
RC	FOR TENDER PURPOSE	√C	√C	RVP	–	√√	–	–	–		
RB	FOR TENDER PURPOSE	–	–	–	–	–	–	–	–	–	27.04.2000
RA	FOR TENDER PURPOSE	–	–	–	–	–	–	–	–	–	17.01.2000

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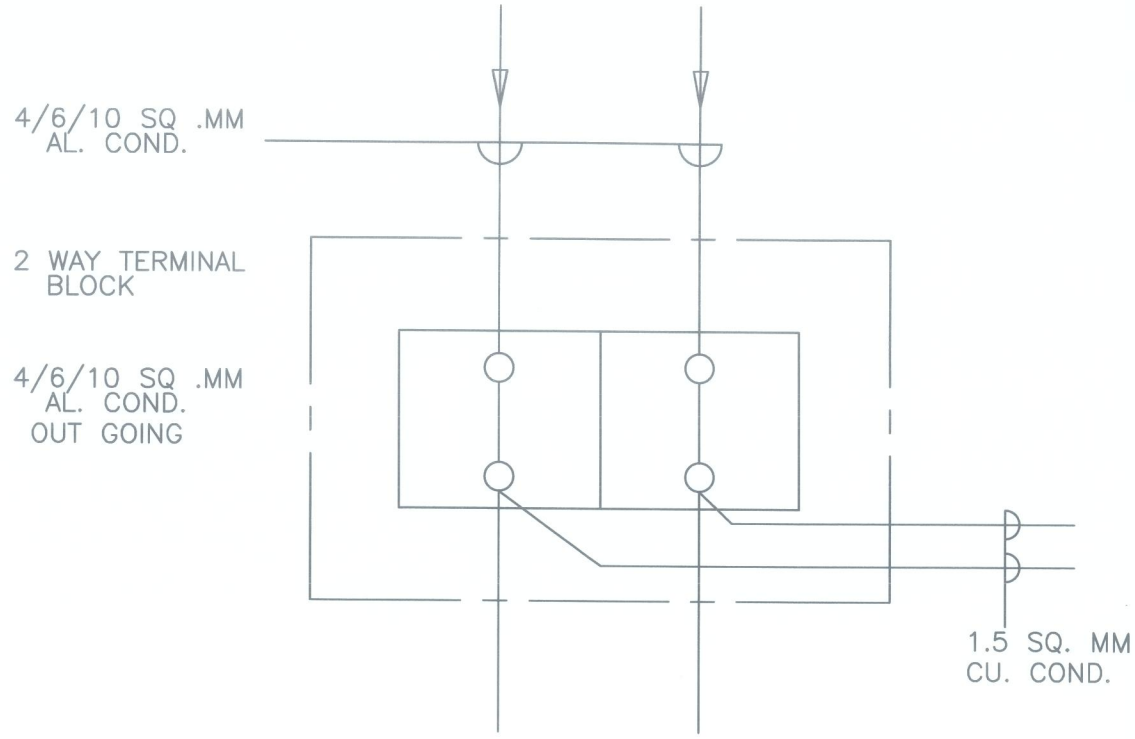
ENGINEERING DIVISION

PROJECT: STANDARD

TITLE: SCHEMATIC DIAGRAM FOR LIGHTING PANELS

SIZE	SCALE	DRG. NO.	REV. NO.
A4	NTS	0000-217-POE-A-001 SH 1 OF 20	RC



JUNCTION BOX TYPE – F

REV. NO.	DESCRIPTION	DRAWN	DESIGN	CHKD	M	E	C	C&I	ARCH	APPD	DATE
					CLEARED BY						
RC	FOR TENDER PURPOSE	VC	VC	RM	-	VV	-	-	-		15.02.05
RB	FOR TENDER PURPOSE	-	-	-	-	-	-	-	-	-	27.04.2005
RA	FOR TENDER PURPOSE	-	-	-	-	-	-	-	-	-	17.01.2000

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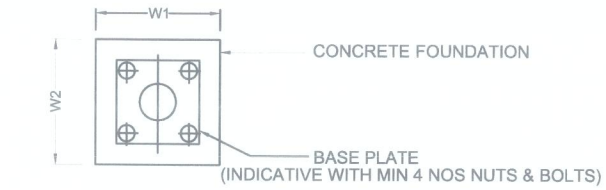
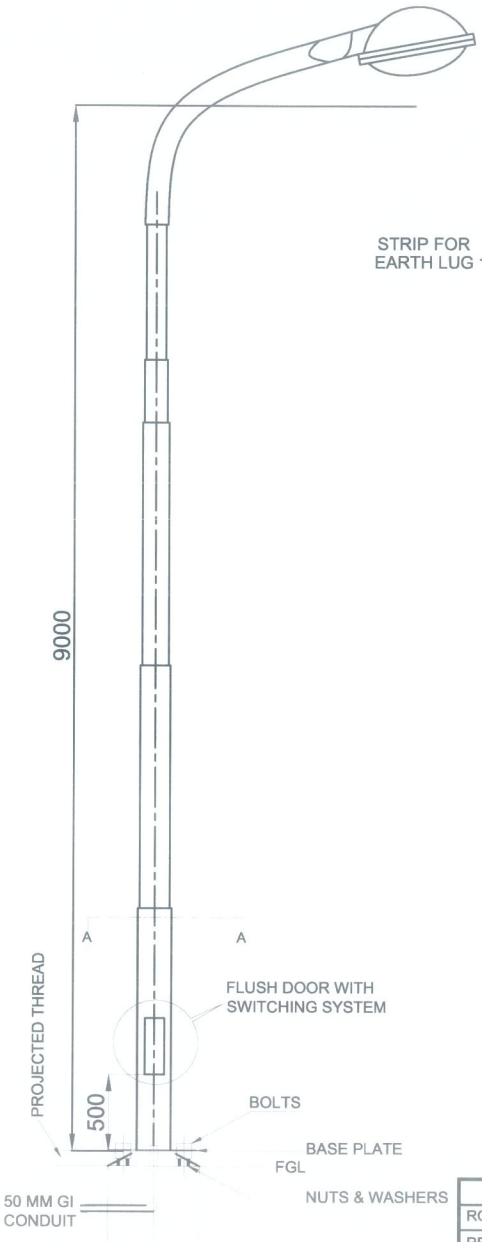
PROJECT: STANDARD

TITLE: SCHEMATIC DIAGRAM OF JUNCTION BOX WIRING

SIZE	SCALE	DRG. NO.	REV. NO.
A4	NTS	0000-217-POE-A-001 SH 3 OF 20	RC



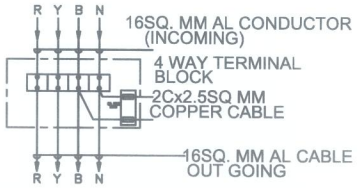
SECTION A–A



TYPE–A1

NOTE:–

1. ALL DIMENSIONS IN MM.
2. APPLICABLE STANDARD IS: 2713.
3. POLES SHALL BE OF MATERIAL MS & GALVANISED.
4. ALL HARDWARE SHALL BE GALVANISED/ZINC PASSIVATED.



SWITCHING ARRANGEMENT

REV. NO.	DESCRIPTION	DRAWN	DESIGN	CHKD	M	E	C	C&I	ARCH	APPD	DATE
		CLEARED BY									
RC	FOR TENDER PURPOSE	VC	VC	RVR	-	VV	-	-	-		15.04.2005
RB	FOR TENDER PURPOSE	-	-	-	-	-	-	-	-	-	27.04.2005
RA	FOR TENDER PURPOSE	-	-	-	-	-	-	-	-	-	17.01.2000

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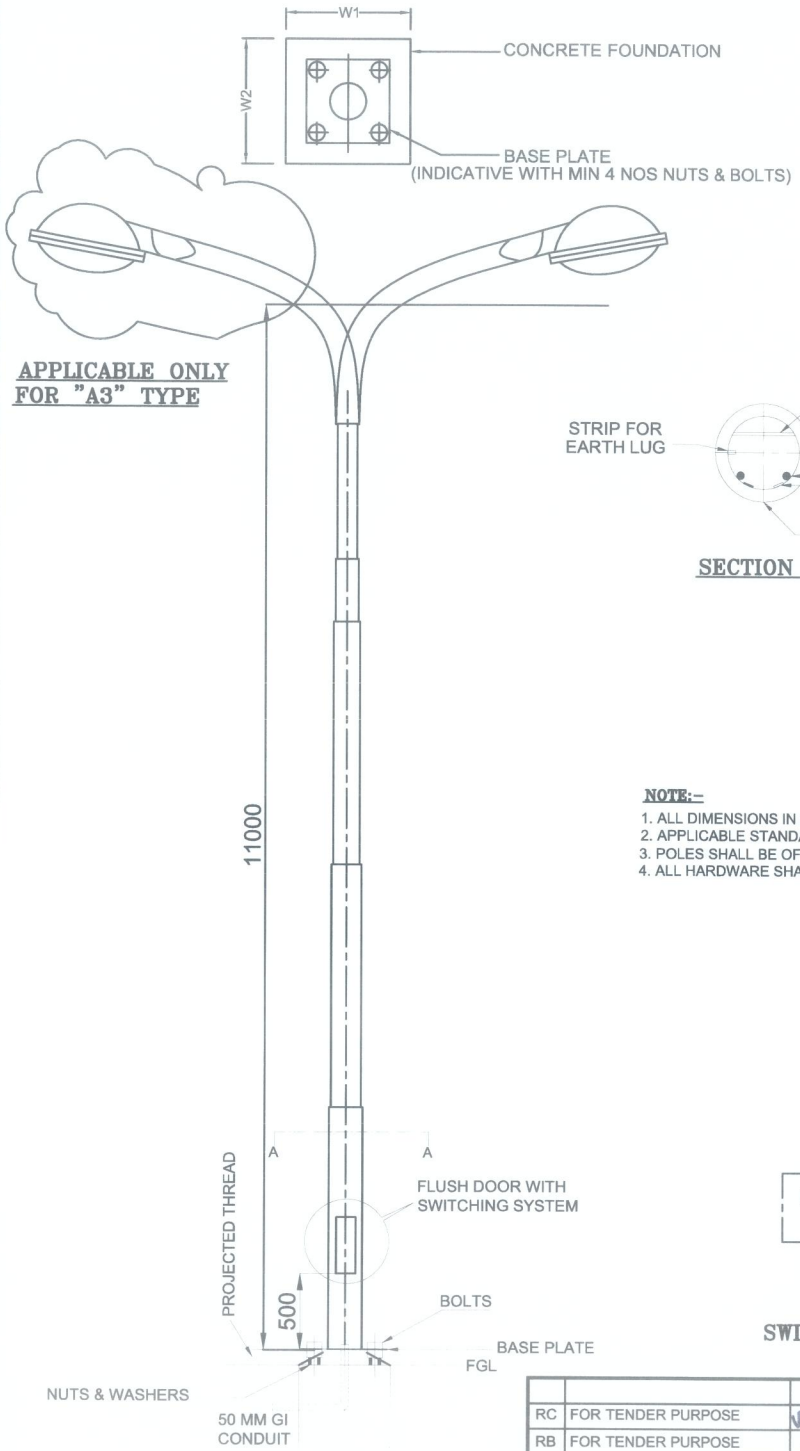
PROJECT: STANDARD

TITLE: GENERAL ARRANGEMENT FOR STREET LIGHTING POLES

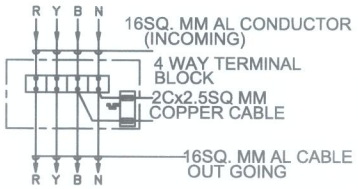
SIZE	SCALE	DRG. NO.	REV. NO.
A4	NTS	0000-217-POE-A-001 SH. 4 OF 20	RC



SECTION A–A

NOTE:–

1. ALL DIMENSIONS IN MM.
2. APPLICABLE STANDARD IS: 2713.
3. POLES SHALL BE OF MATERIAL MS & GALVANISED.
4. ALL HARDWARE SHALL BE GALVANISED/ZINC PASSIVATED.



SWITCHING ARRANGEMENT

TYPE–A2/A3

REV. NO.	DESCRIPTION	DRAWN	DESIGN	CHKD	M	E	C	C&I	ARCH	APPD	DATE
		CLEARED BY									
RC	FOR TENDER PURPOSE	VC	VL	KP	-	VV	-	-	-		27.04.2005
RB	FOR TENDER PURPOSE	-	-	-	-	-	-	-	-	-	17.01.2000
RA	FOR TENDER PURPOSE	-	-	-	-	-	-	-	-	-	

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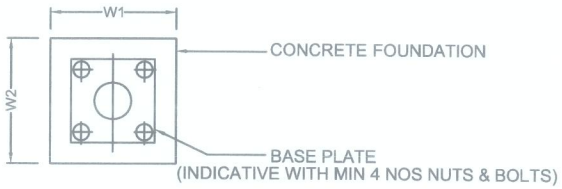
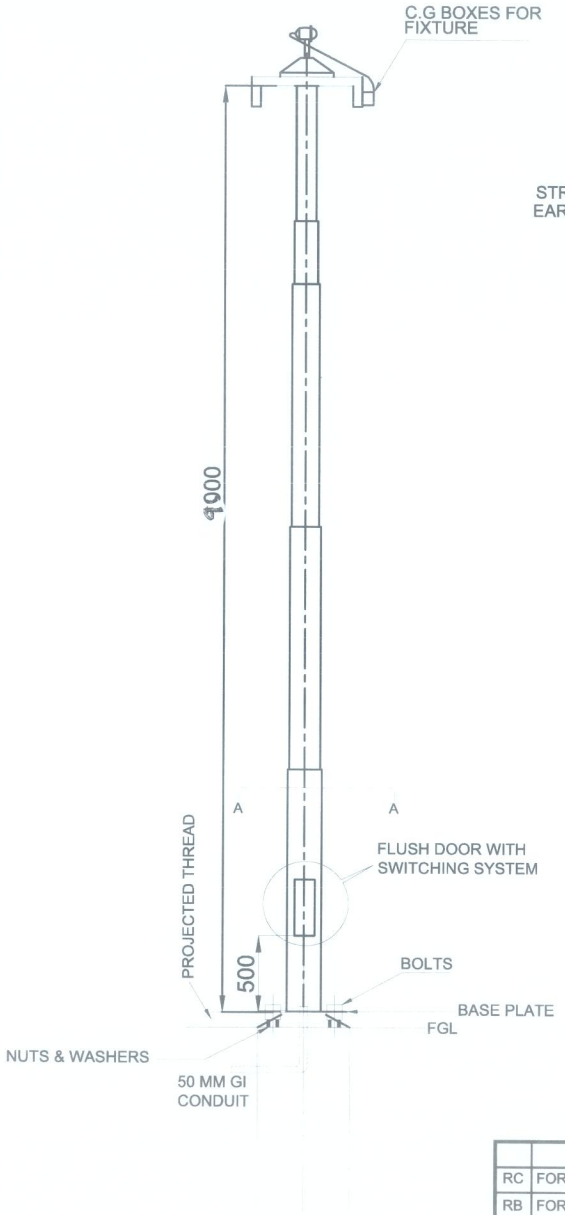
PROJECT: STANDARD

TITLE: GA OF STREET LIGHTING POLE TYPE A2 & A3.

SIZE	SCALE	DRG. NO.	REV. NO.
A4	NTS	0000-217-POE-A-002	RC



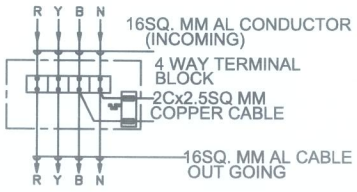


TYPE–C1

SECTION A–A

NOTE:–

1. ALL DIMENSIONS IN MM.
2. APPLICABLE STANDARD IS: 2713.
3. POLES SHALL BE OF MATERIAL MS & GALVANISED.
4. ALL HARDWARE SHALL BE GALVANISED/ZINC PASSIVATED.



SWITCHING ARRANGEMENT

REV. NO.	DESCRIPTION	DRAWN	DESIGN	CHKD	M	E	C	C&I	ARCH	APPD	DATE
		CLEARED BY									
RC	FOR TENDER PURPOSE	VC	VC	[illegible]	-	W	-	-	-	[illegible]	15/04
RB	FOR TENDER PURPOSE	-	-	-	-	-	-	-	-	-	27.04.2005
RA	FOR TENDER PURPOSE	-	-	-	-	-	-	-	-	-	17.01.2005

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NTPC LTD.
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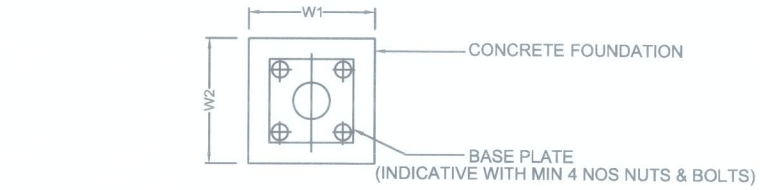
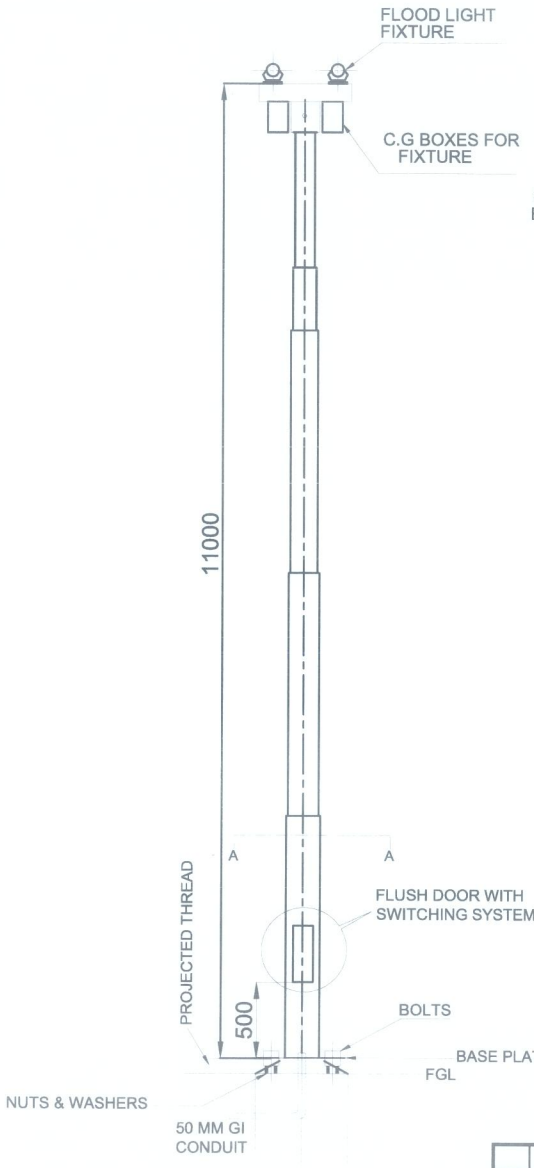
ENGINEERING DIVISION

PROJECT: STANDARD

TITLE: GENERAL ARRANGEMENT FOR FLOOD LIGHTING POLE

SIZE	SCALE	DRG. NO.	REV. NO.
A4	NTS	0000-217-POE-A-001 SH. 5 OF 20	RC



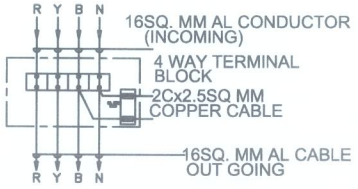


TYPE–C2

SECTION A–A

NOTE:–

1. ALL DIMENSIONS IN MM.
2. APPLICABLE STANDARD IS: 2713.
3. POLES SHALL BE OF MATERIAL MS & GALVANISED.
4. ALL HARDWARE SHALL BE GALVANISED/ZINC PASSIVATED.



SWITCHING ARRANGEMENT

REV. NO.	DESCRIPTION	DRAWN	DESIGN	CHKD	M	E	C	C&I	ARCH	APPD	DATE
					CLEARED BY						
RC	FOR TENDER PURPOSE	VC	VC		-		-	-	-		15.5
RB	FOR TENDER PURPOSE	-	-	-	-	-	-	-	-	-	27.04.2000
RA	FOR TENDER PURPOSE	-	-	-	-	-	-	-	-	-	17.01.2000

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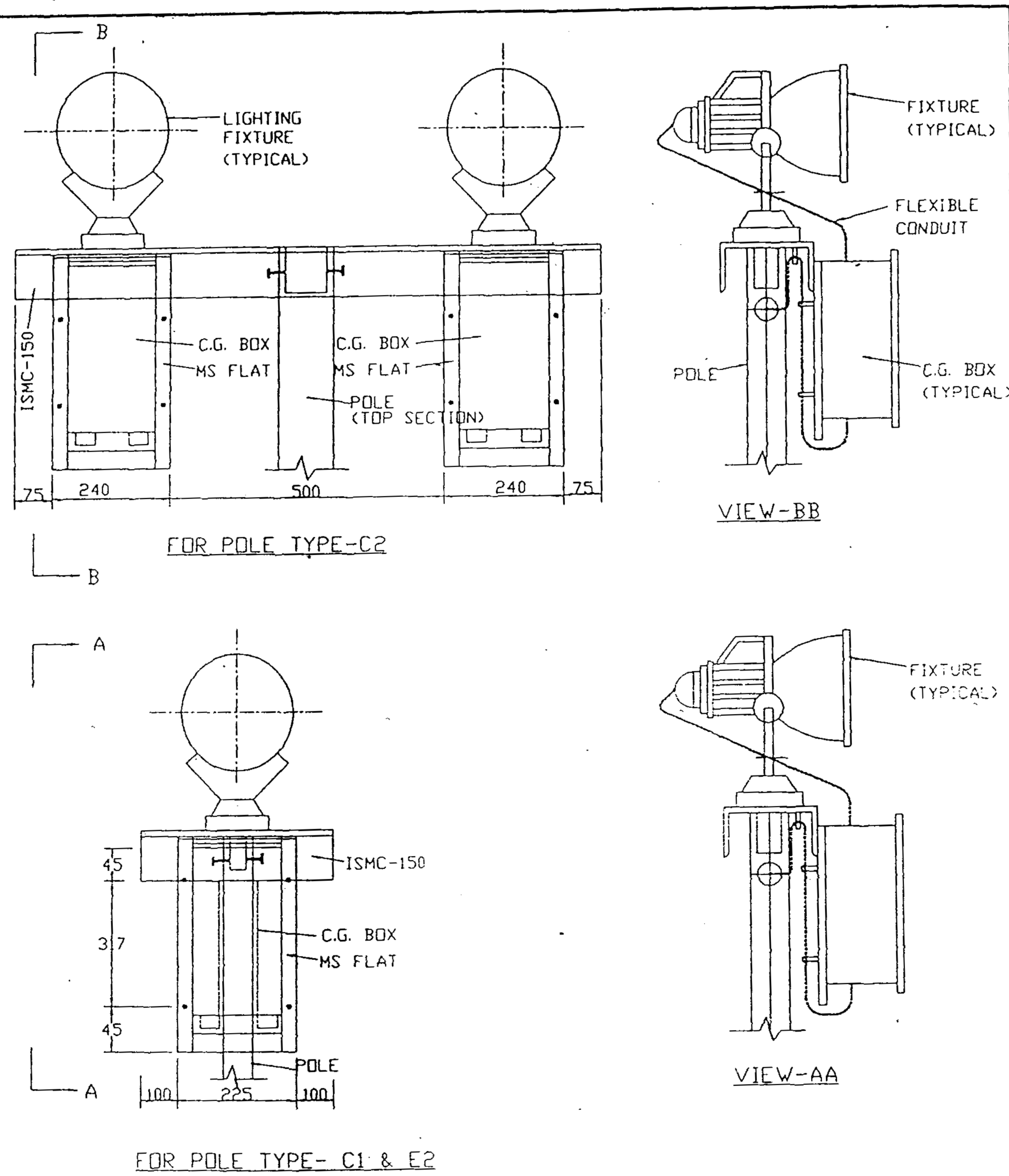
ENGINEERING DIVISION

PROJECT: STANDARD

TITLE: GENERAL ARRANGEMENT FOR FLOOD LIGHTING POLE

SIZE	SCALE	DRG. NO.	REV. NO.
A4	NTS	0000-217-POE-A-001 SH. 6 OF 20	RC



NOTES:

ALL DIMENSIONS ARE IN MM.

REV. NO.	DESCRIPTION	DRAWN	DESIGN	CHKD	M	E	C	C&I	ARCH	APPD	DATE
RB	FOR TENDER PURPOSE				-		-	-	-		
RA	FOR TENDER PURPOSE				-		-	-	-		
					CLEARED BY						

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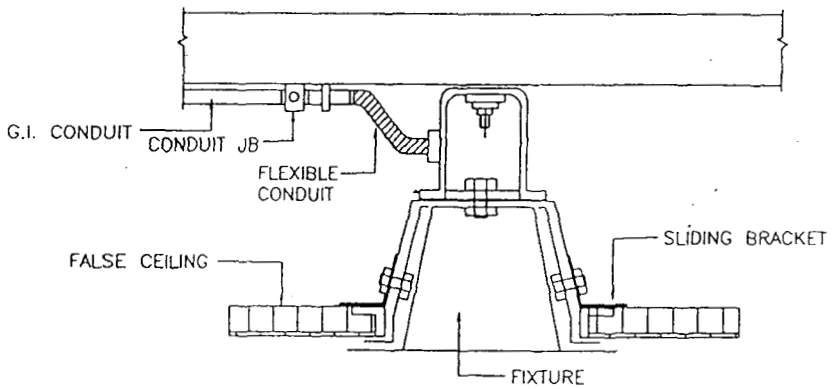
PROJECT	STANDARD
TITLE	MOUNTING DETAIL OF FLOOD LIGHT FIXTURE & CONTROL GEAR BOX ON POLES.

SIZE	SCALE	DRG. NO.	REV. NO.
A4	NTS	0000-217-POE-A-001 SH. 8 OF 20	RB

L8.DWG



TYPICAL FIXING DETAIL OF RECESSED LIGHTING FIXTURE IN FALSE CEILING AREA (TYPE-B)

NOTE:

ALL DIMENSIONS ARE IN MM.

REV. NO.	DESCRIPTION	DRAWN	DESIGN	CHKD	M	E	C	C&I	ARCH	APPD	DATE
					CLEARED BY						
RB	FOR TENDER PURPOSE				-		-	-	-		20.11.06
RA	FOR TENDER PURPOSE				-		-	-	-		

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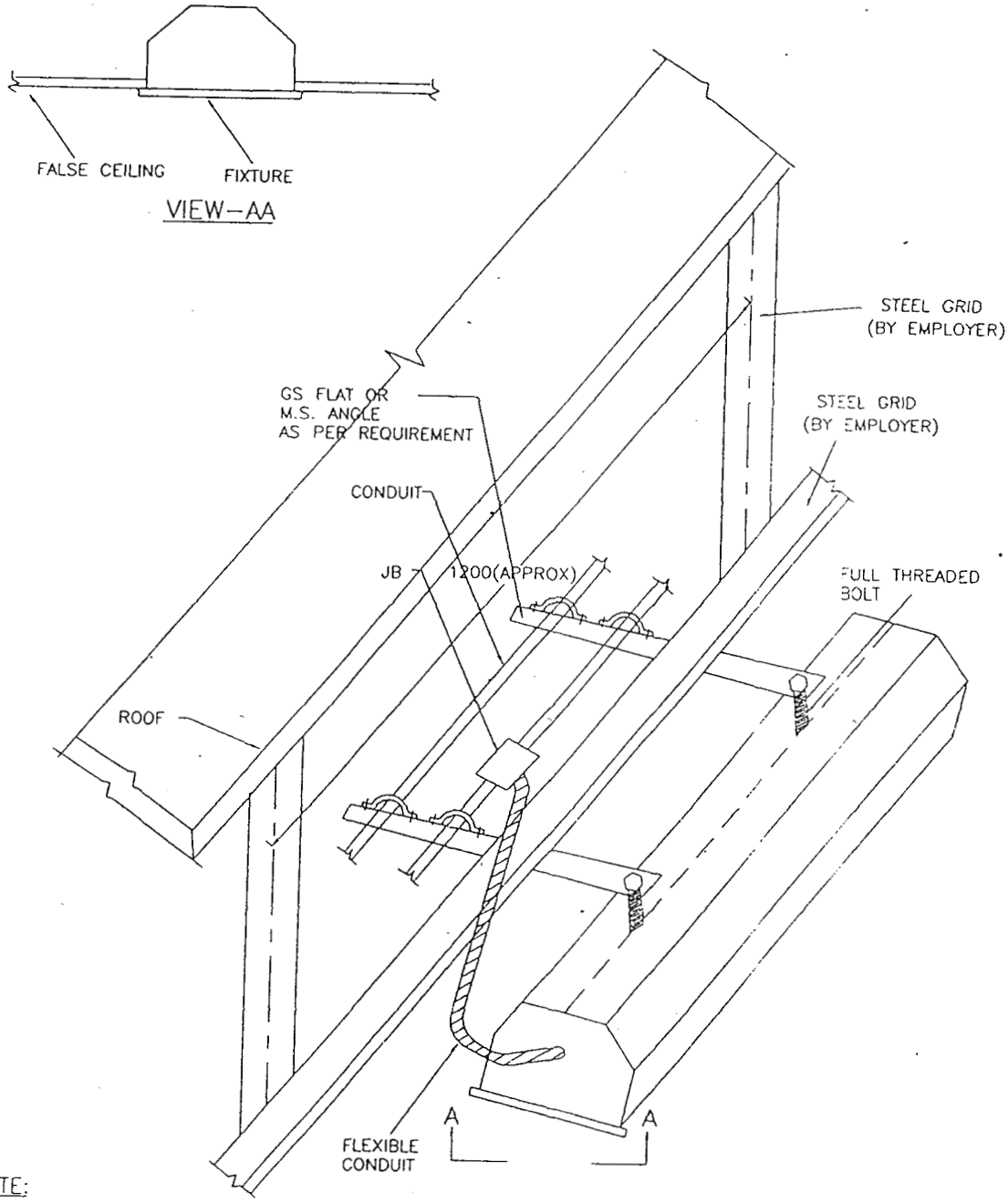
PROJECT	STANDARD		
TITLE	TYPICAL MOUNTING DETAIL OF FIXTURES IN FALSE CEILING AREA		
SIZE A4	SCALE NTS	DRG. NO. 0000-217-POE-A-001 SH. 10 OF 20	REV. NO. RB

L10.DWG



NOTE:

1. ALL DIMENSIONS ARE IN MM.
2. MINIMUM CLEAR DISTANCE BETWEEN FALSE CEILING AND STRUCTURE SHALL BE 300MM (APPROX.)

REV. NO.	DESCRIPTION	DRAWN	DESIGN	CHKD	M	E	C	C&I	ARCH	APPD	DATE
					CLEARED BY						
RB	FOR TENDER PURPOSE				–		–	–	–		20.11.16
RA	FOR TENDER PURPOSE	NS			–		–	–	–		

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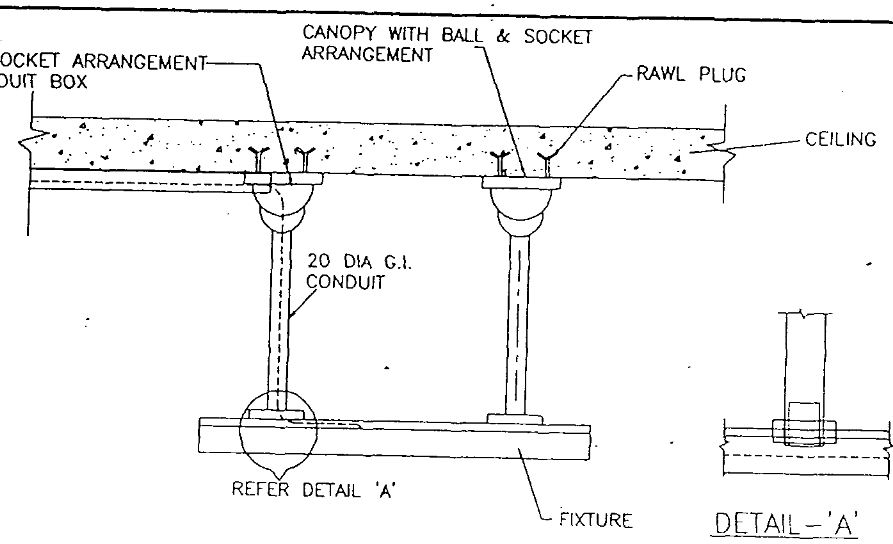
ENGINEERING DIVISION

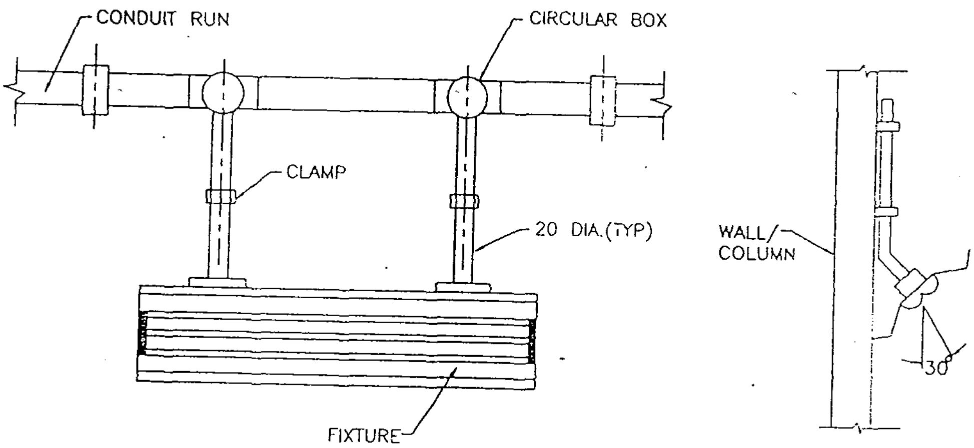
PROJECT	STANDARD		
TITLE	TYPICAL MOUNTING DETAIL OF FIXTURES IN FALSE CEILING AREA		
SIZE A4	SCALE NTS	DRG. NO. 0000–217–POE–A–001 SH. 11 OF 20	REV. NO. RB

L21.DWG



TYPE-C

DETAIL-'A'



TYPE-D

END VIEW

REV. NO.	DESCRIPTION	DRAWN	DESIGN	CHKD	M	E	C	C&I	ARCH	APPD	DATE
RB	FOR TENDER PURPOSE				-		-	-	-		
RA	FOR TENDER PURPOSE	NS					-	-	-		4.1.2000
					CLEARED BY						

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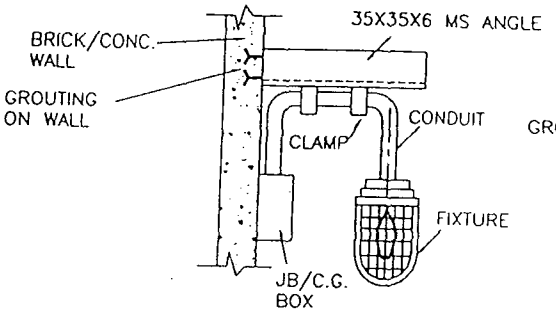
ENGINEERING DIVISION

PROJECT: STANDARD

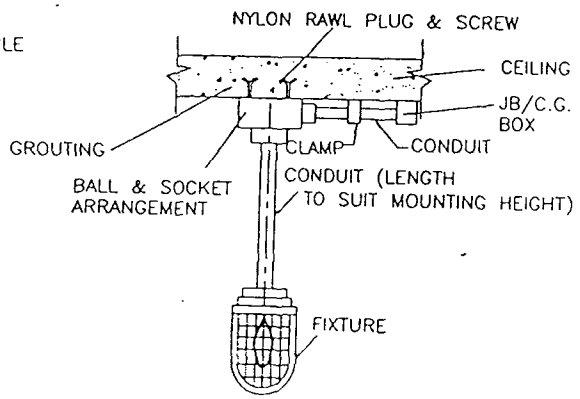
TITLE: TYPICAL MOUNTING DETAIL OF FLUORESCENT FIXTURE

SIZE	SCALE	DRG. NO.	REV. NO.
A4	NTS	0000-217-POE-A-001 SH. 12 OF 20	RB

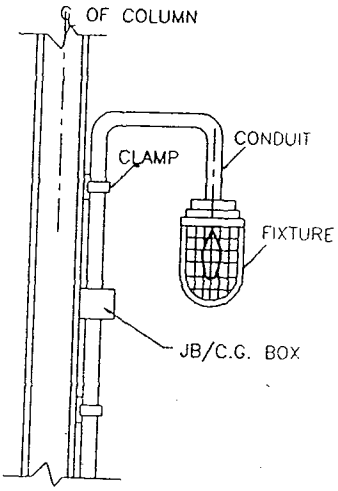
L11.DWG



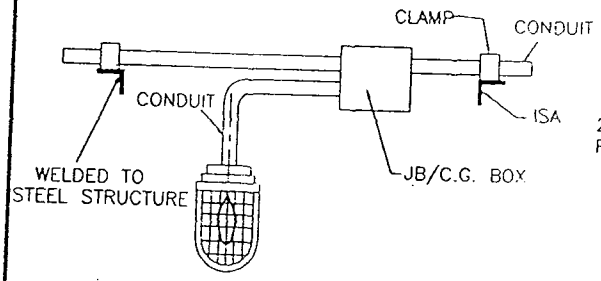
WALL MOUNTING (TYPE-E)



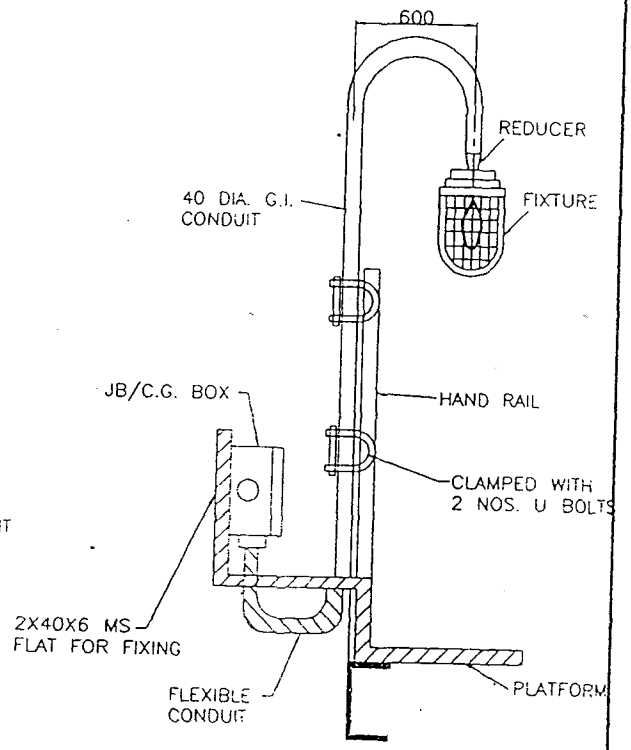
CEILING MOUNTING (TYPE-F)



COLUMN MOUNTING (TYPE-G)



STRUCTURE MOUNTING (TYPE-H)



HAND RAIL MOUNTING (TYPE-I)

NOTES:

ALL DIMENSIONS ARE IN MM.

REV. NO.	DESCRIPTION	DRAWN	DESIGN	CHKD	M	E	C	C&I	ARCH	APPD	DATE
RB	FOR TENDER PURPOSE			-		-	-	-			
RA	FOR TENDER PURPOSE	NS			-		-	-	-		

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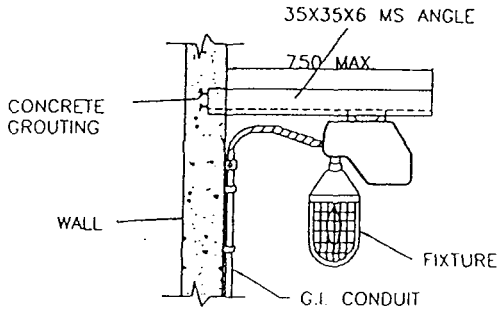
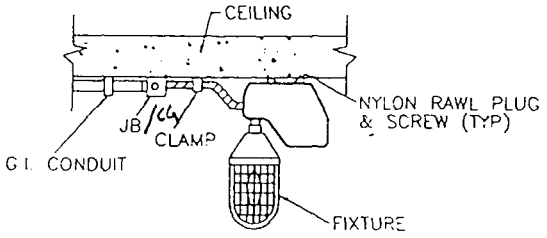
PROJECT	STANDARD		
TITLE	TYPICAL MOUNTING DETAIL OF WELL GLASS FIXTURE		
SIZE A4	SCALE NTS	DRG. NO. 0000-217-POE-A-001 SH. 13 OF 20	REV. NO. RB

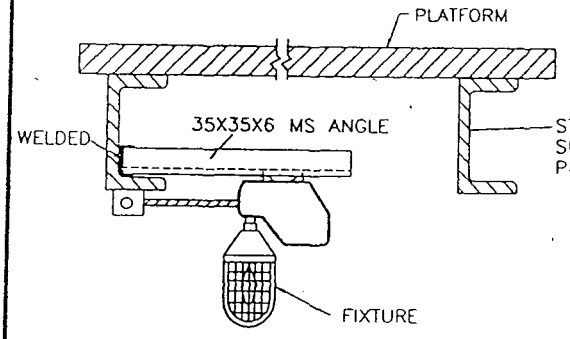
L12.DWG



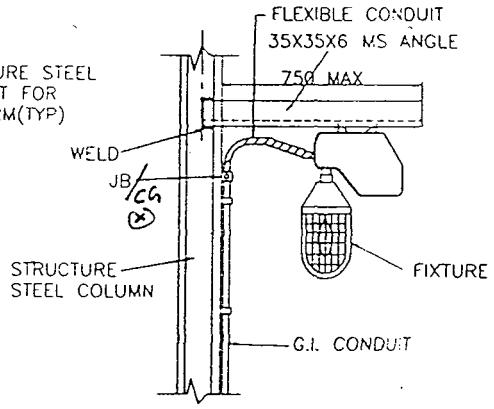
WALL MOUNTING (TYPE-J)



CEILING MOUNTING (TYPE-K)



STRUCTURE MOUNTING (TYPE-L)



COLUMN MOUNTING (TYPE-M)

NOTES:

ALL DIMENSIONS ARE IN MM.

@ In case of non-integral CG box

REV. NO.	DESCRIPTION	DRAWN	DESIGN	CHKD	M	E	C	C&I	ARCH	APPD	DATE
					CLEARED BY						
RB	FOR TENDER PURPOSE				-		-	-	-		20.11.06
RA	FOR TENDER PURPOSE	NS			-		-	-	-		6.12.2005

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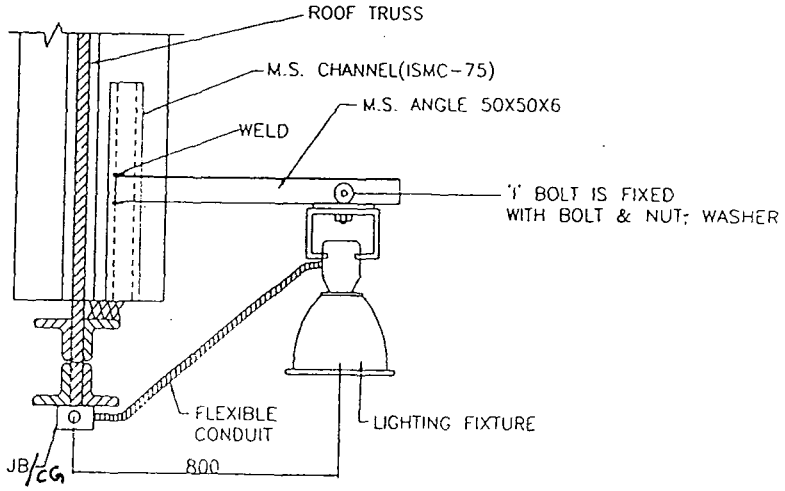
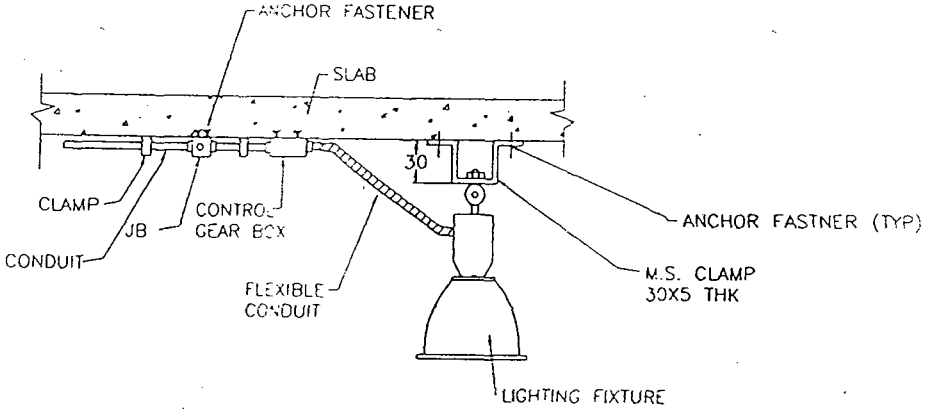
PROJECT	STANDARD		
TITLE	TYPICAL MOUNTING DETAIL OF INTEGRAL TYPE WELL GLASS FIXTURE		
SIZE A4	SCALE NTS	DRG. NO. 0000-217-POE-A-001 SH. 14 OF 20	REV. NO. RB

L13.DWG



STRUCTURE MOUNTING (TYPE-N)



CEILING MOUNTING (TYPE-O)

NOTES:

ALL DIMENSIONS ARE IN MM.

REV. NO.	DESCRIPTION	DRAWN	DESIGN	CHKD	M	E	C	C&I	ARCH	APPD	DATE
RB	FOR TENDER PURPOSE				-		-	-	-		
RA	FOR TENDER PURPOSE	NS			-		-	-	-		

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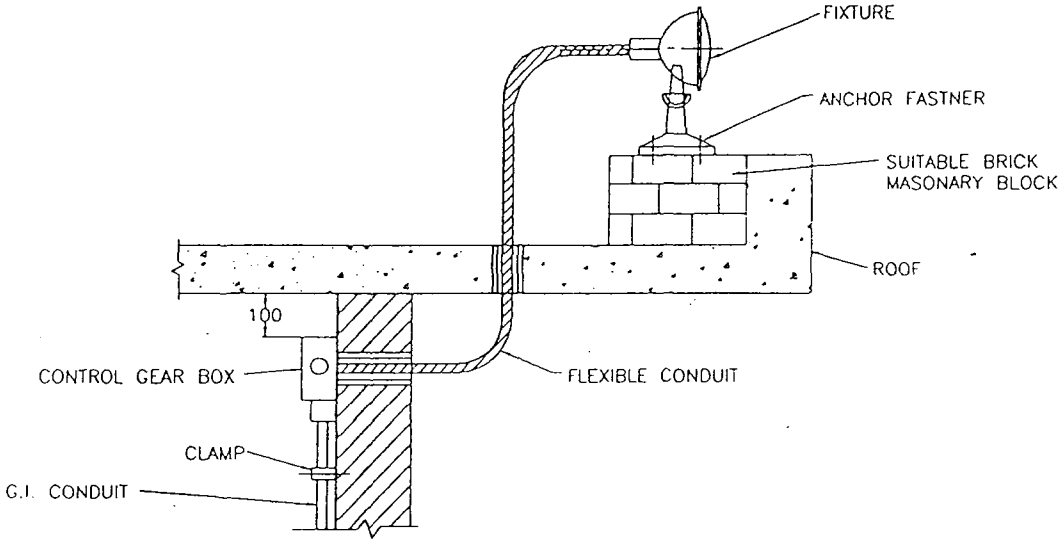
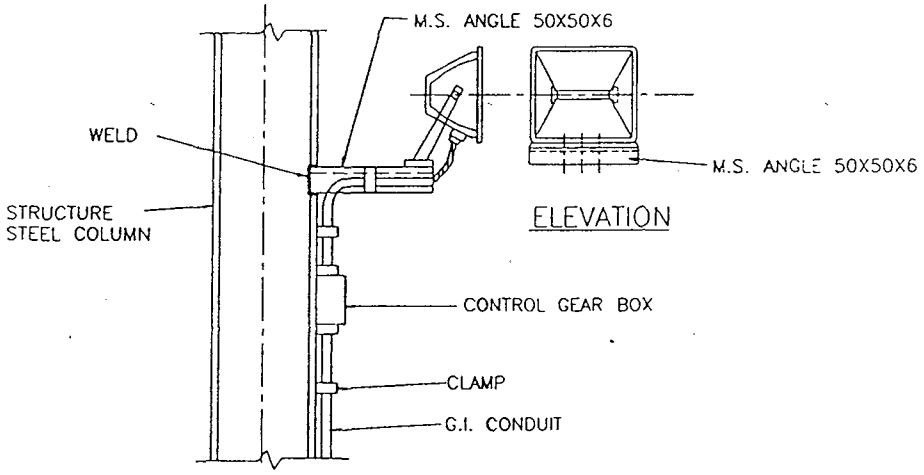
PROJECT	STANDARD		
TITLE	TYPICAL MOUNTING DETAIL OF HIGHBAY FIXTURES		
SIZE A4	SCALE NTS	DRG. NO. 0000-217-POE-A-001 SH. 15 OF 20	REV. NO. RB

L14.DWG



ROOF MOUNTING (TYPE-P)



COLUMN MOUNTING (TYPE-Q)

NOTES:

ALL DIMENSIONS ARE IN MM.

REV. NO.	DESCRIPTION	DRAWN	DESIGN	CHKD	M	E	C	C&I	ARCH	APPD	DATE
					CLEARED BY						
RB	FOR TENDER PURPOSE			KR	-		-	-	-		20.11.06
RA	FOR TENDER PURPOSE	NS			-		-	-	-		16.1.2006

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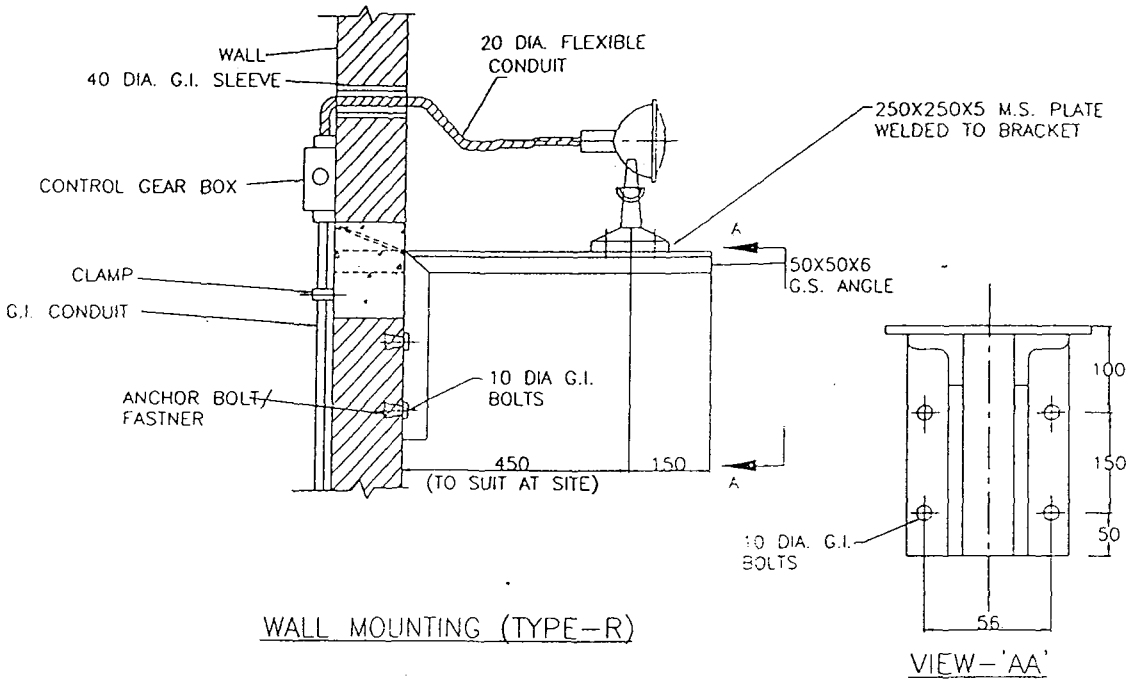
PROJECT: STANDARD

TITLE: TYPICAL MOUNTING DETAIL OF AREA LIGHTING FIXTURES

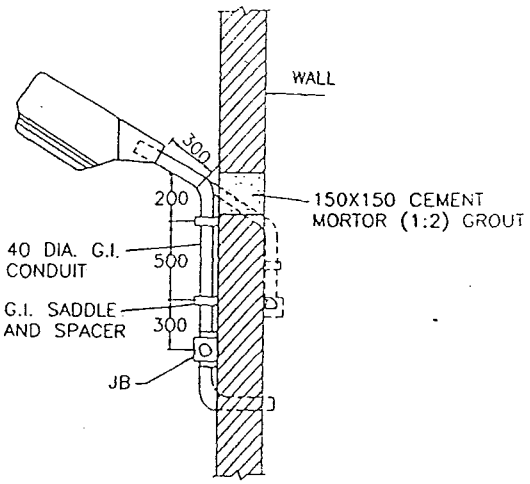
SIZE	SCALE	DRG. NO.	REV. NO.
A4	NTS	0000-217-POE-A-001 SH. 16 OF 20	RB

L15.DWG



WALL MOUNTING (TYPE–R)

VIEW–'AA'



WALL MOUNTING (TYPE–S)

NOTES:

ALL DIMENSIONS ARE IN MM.

REV. NO.	DESCRIPTION	DRAWN	DESIGN	CHKD	M	E	C	C&I	ARCH	APPD	DATE
RB	FOR TENDER PURPOSE				–		–	–	–		20-11-06
RA	FOR TENDER PURPOSE				–		–	–	–		

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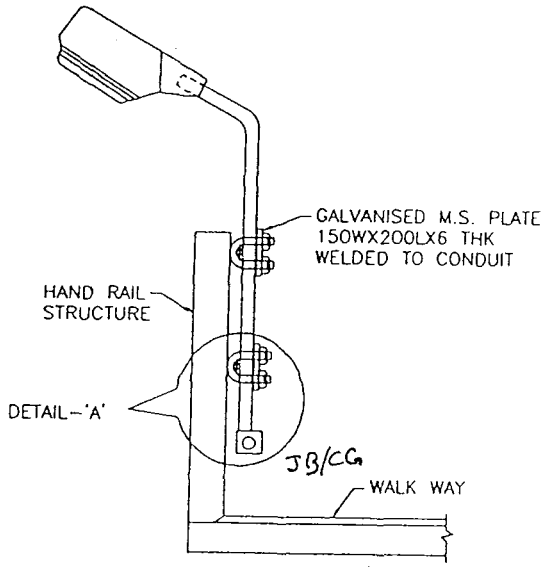
PROJECT: STANDARD

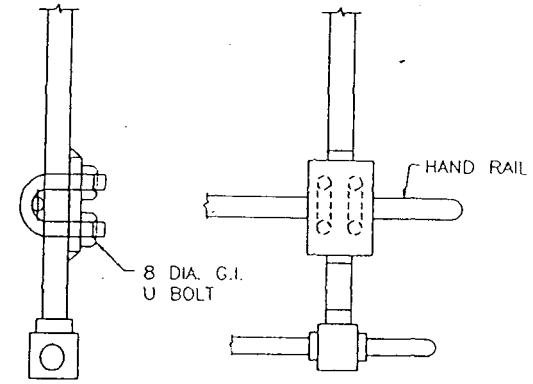
TITLE: TYPICAL MOUNTING DETAIL OF AREA LIGHTING FIXTURES

SIZE	SCALE	DRG. NO.	REV. NO.
A4	NTS	0000-217-POE-A-001 SH. 17 OF 20	RB

L16.DWG

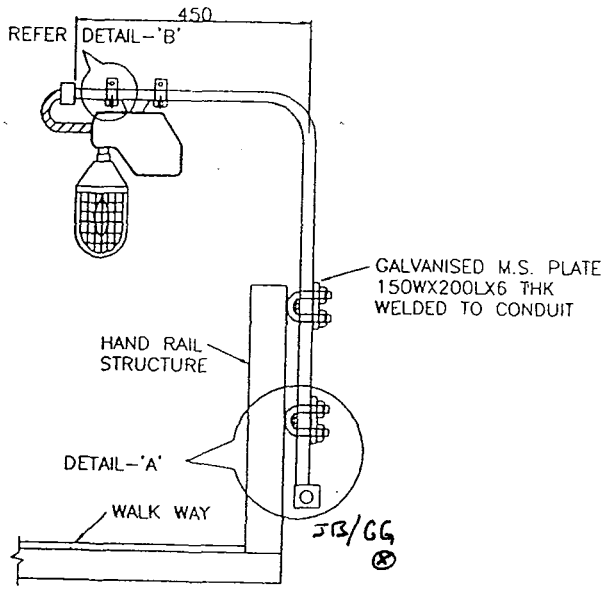


TYPE-T

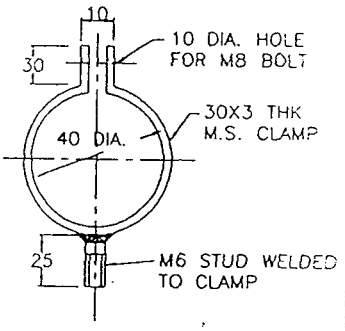


ELEVATION SIDE VIEW

DETAIL-'A'



TYPE-U



DETAIL-'B'

NOTES:

ALL DIMENSIONS ARE IN MM.

Ⓐ In case of non-integral control gear

REV. NO.	DESCRIPTION	DRAWN	DESIGN	CHKD	M	E	C	C&I	ARCH	APPD	DATE
		CLEARED BY									
RB	FOR TENDER PURPOSE						-	-	-		20.11.06
RA	FOR TENDER PURPOSE				-		-	-	-		

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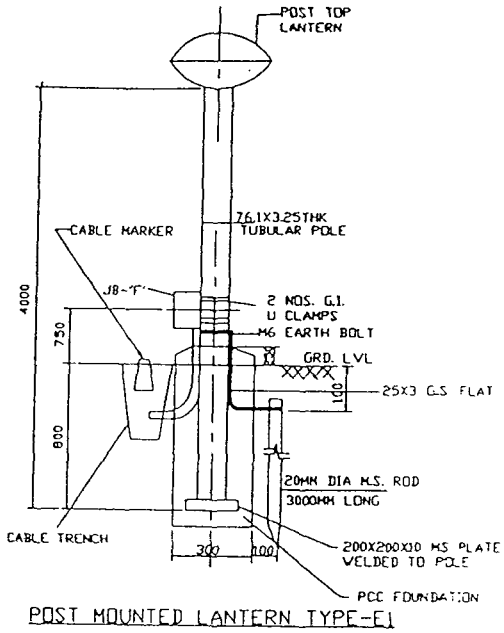
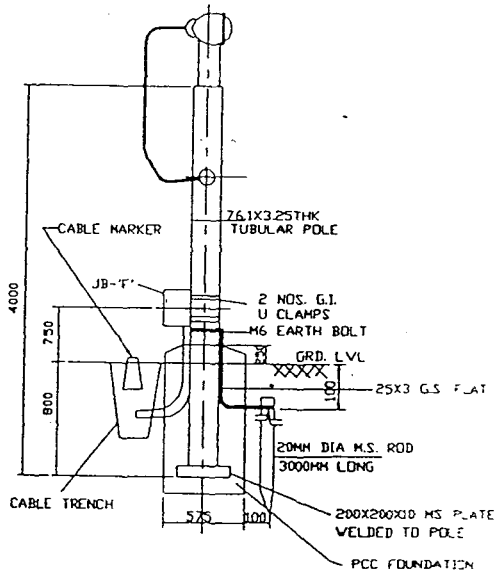
PROJECT	STANDARD		
TITLE	TYPICAL HANDRAIL MOUNTING DETAIL OF FIXTURES		
SIZE A4	SCALE NTS	DRG. NO. 0000-217-POE-A-001 SH. 18 OF 20	REV. NO. RB

L17.DWG



POST MOUNTED LANTERN TYPE-E1



POST MOUNTED FLOOD LIGHT TYPE-E2

NOTES:
1. ALL DIMENSIONS ARE IN MM.
2. FOUNDATION DIMENSIONS SHOWN ARE TENTATIVE ONLY.

REV. NO.	DESCRIPTION	DRAWN	DESIGN	CHKD	M	E	C	C&I	ARCH	APPD	DATE
					CLEARED BY						
RB	FOR TENDER PURPOSE				–		–	–	–		20.11.06
RA	FOR TENDER PURPOSE	NS			–		–	–	–		

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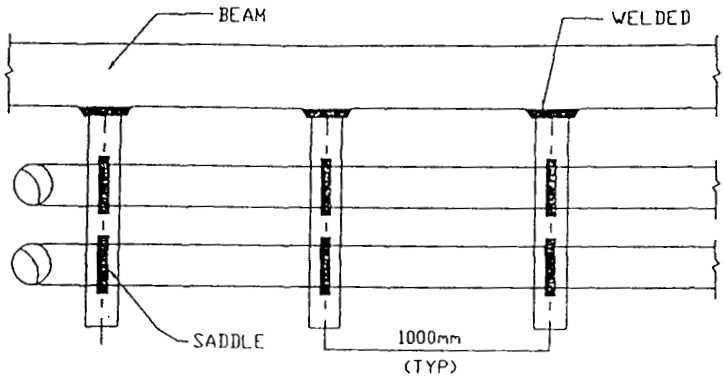
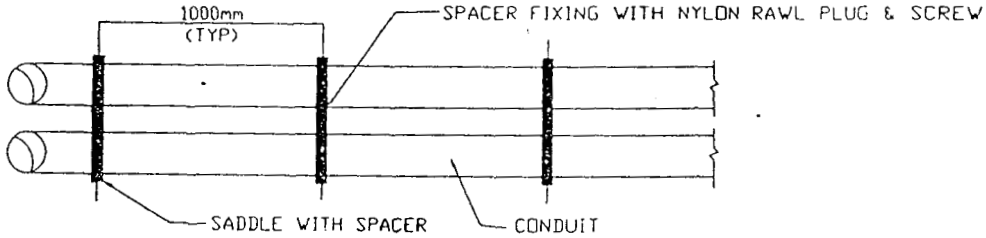
PROJECT	STANDARD		
TITLE	GENERAL ARRANGEMENT OF POST MOUNTED FIXTURES		
SIZE A4	SCALE NTS	DRG. NO. 0000-217-POE-A-001 SH. 19 OF 20	REV. NO. RB

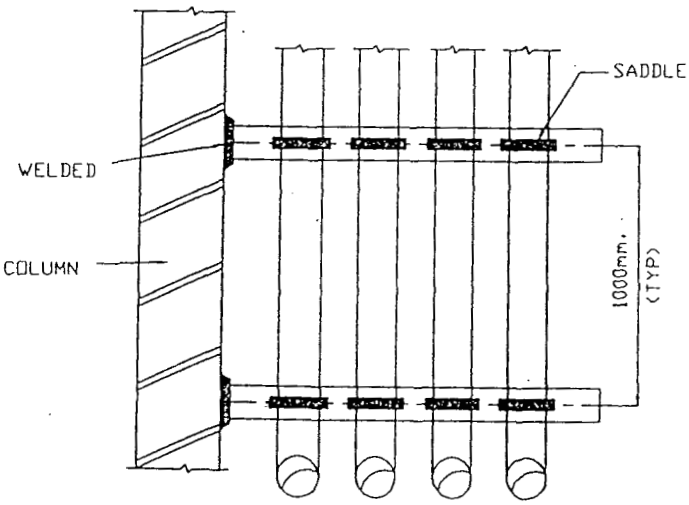
LS.DWG



CONDUIT FIXING ARRANGEMENT OF STEEL STRUCTURE



CONDUIT FIXING ARRANGEMENT OF CEILING/WALL



NOTES:

1. THE CONDUIT SUPPORT SHALL BE PROVIDED AT AN INTERVAL OF 1000mm.
2. SIZE OF STEEL FOR:
   a) SINGLE RUN OF CONDUIT- 25X5 MS FLAT.
   b) TWO & THREE RUNS OF CONDUIT- 25X25X3 MS ANGLE.
   c) FOUR RUNS OF CONDUIT ONWARD- 35X35X6 MS ANGLE.
3) ALL STEEL FABRICATION SHALL BE PAINTED WITH COATS OF METAL PRIMER FOLLOWED BY THE TWO COATS OF AL. PAINT.

REV. NO.	DESCRIPTION	DRAWN	DESIGN	CHKD	M	E	C	C&I	ARCH	APPD	DATE
RB	FOR TENDER PURPOSE						-	-	-		10.11.06
RA	FOR TENDER PURPOSE				-		-	-	-		

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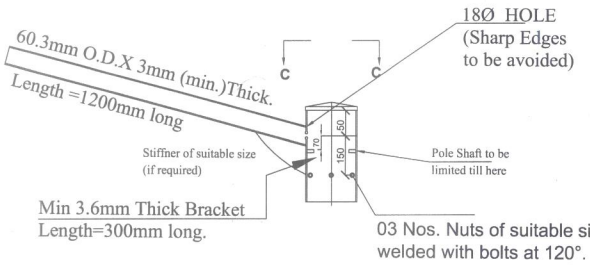
ENGINEERING DIVISION

PROJECT: STANDARD

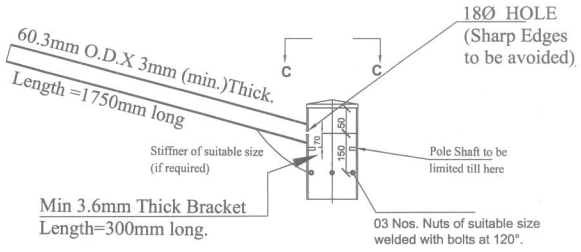
TITLE: CONDUIT FIXING ARRANGEMENT (TYPICAL)

SIZE	SCALE	DRG. NO.	REV. NO.
A4	NTS	0000-217-POE-A-001 SH. 20 OF 20	RB

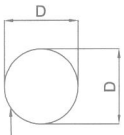
L20.DWG



BRACKET FOR
A1 POLE

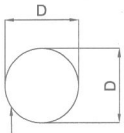


BRACKET FOR
A2 POLE



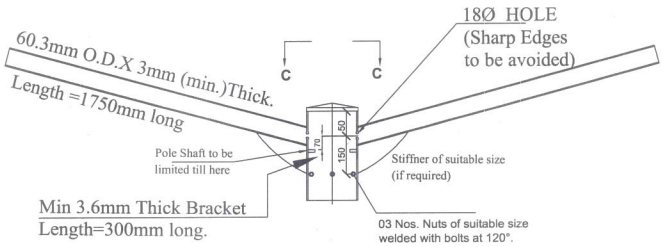
DX6 DIA CIRCULAR M.S.
GAL. PLATE (COVER PLATE).
TO BE WELDED AT TOP
OF BRACKET.

VIEW-C-C

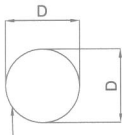


DX6 DIA CIRCULAR M.S.
GAL. PLATE (COVER PLATE).
TO BE WELDED AT TOP
OF BRACKET.

VIEW-C-C



BRACKET FOR
A3 POLE



DX6 DIA CIRCULAR M.S.
GAL. PLATE (COVER PLATE).
TO BE WELDED AT TOP
OF BRACKET.

VIEW-C-C

NOTE:-

1. ALL DIMENSIONS IN MM.
2. ALL HARDWARE SHALL BE GALVANISED/ ZINC PASSIVATED.

REV. NO.	DESCRIPTION	DRAWN	DESIGN	CHKD	M	E	C	C&I	ARCH	APPD	DATE
RA	FOR TENDER PURPOSE	SA	IA	RKD	—	VK	—	—	—		

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PROJECT	STANDARD		
TITLE	GENERAL ARRANGEMENT FOR ARM BRACKETS FOR LIGHTING POLE		
SIZE: A4	SCALE: NTS	DRG. NO.: 0000-217-POE-A-001A SH. 1 OF 1	REV. NO.: RA

SUB-SECTION-II-E11

DIESEL GENERATORS

DIESEL GENERATORS

1.00.00 CODES AND STANDARDS

DIESEL ENGINE	IS -10000, BS- 5514
INTERNAL COMBUSTION ENGINES (12 PARTS)	IS -10000
SPEED OF DIESEL GENERATOR	BS649 / 195B
ALTERNATOR	IS-4722/IEC-60034,IS12065, IS12075
PERMISSIBLE LIMITS OF NOISE LEVEL OF ROTATING MACHINES	IS 12065
MEASURE, EVALUATION AND LIMIT OF VIBRATION SEVERITY OF ROTATING ELECTRICAL MACHINES SHAFT 65 MM DIA OR HIGHER	IS 12075
DIESEL FUELS – SPECIFICATIONS	IS1460
RECOMMENDED PRACTICE FOR HOT-DIP GALVANIZING OF IRON AND STEEL	IS 2629
METHODS FOR TESTING UNIFORMITY OF COATING OF ZINC COATED ARTICLES	IS 2633
CODE OF PRACTICE FOR FIRE – SAFETY	IS 3034
RECIPROCATING INTERVAL COMBUSTION ENGINES	ISO 3046
OISD STANDARD ON Lightning Protection	OISD-GDN-180

1.01.00 The installation work shall conform to Indian Electricity Act and Indian Electricity Rules as amended up to the date this specification is issued. Any approval required from statutory authorities shall be obtained by the Contractor. Nothing in this specification shall be construed to relieve the Contractor of this responsibility.

1.02.00 Equipment complying with other internationally accepted standards such as ASA, IEC, BS, VDE etc. will also be considered if they ensure performance and constructional features equivalent to or superior to standards listed above. In such a case, the Bidder shall clearly indicate the standard(s) adopted and also furnish a copy in English of the latest revision of the standards alongwith copies of all official amendments in force as on date of opening of techno-commercial bid. Bidder shall clearly bring out the salient features for comparison.

2.00.00 **TYPE**

Diesel Engine — Stationary type, turbo charged and water cooled.

DG set including stack height, acoustics, air emission and fuel oil installation shall meet the requirement given by gazette notification of Ministry of Environment & Forest dated 17/05/02, 01/07/03, CPCB guidelines, all statutory requirement of Govt. of India and State Pollution Board Guidelines & as updated as on date of techno-commercial bid opening.

3.00.00 **TECHNICAL REQUIREMENTS**

a)	Net Electrical output	As per system requirement
b)	Ambient temperature	50 degree. (to be considered for deration of alternator)
c)	Relative Humidity	100%
d)	Fuel	HSD Fuel as per IS 1460
e)	Rated Speed	1500 rpm
f)	Governor(Electronic Type)	A1 type as per BS:5514
g)	Vibrations	Max. 250 microns peak to peak with anti-vibration pads
h)	Starting	Electrical self-starting
i)	Fuel service tank	990 liters
j)	Air intake system	Dry type air filter, 15 micron size or better with 90% efficiency or better
k)	Cooling	Forced water cooled for Engine & Air cooled for Alternator.
l)	Paint Shade	Grey RAL9002

4.00.00 **GENERAL**

4.01.00 BHP rating of the engine shall be Limited-time running Power (LTP) as per ISO 8528-1 considering deration for 50 deg C ambient temperature.

4.02.00 The DG set shall be able to deliver specified net electrical output while supplying power / driving all electrical and mechanical auxiliaries connected to alternator terminals and engine shaft

4.03.00	The DG set shall also be able suitable for 12 hours continuous running of which one hour at 10% overload at rated speed.
4.04.00	The DG set shall be capable of starting largest DOL motor while meeting all other essential loads. Voltage drop at DG terminal shall not be more than 15%.
4.05.00	The DG Set shall be located inside the acoustic enclosure and kept outdoors. The exhaust shall be discharged through individual silencer & stack outside the enclosure. Necessary lightning protection as per OISD standard OISD-GDN-180 shall be provided by the bidder for the stack.
4.06.00	Critical speed of the machine shall not be lesser than 120% of the normal speed.
4.07.00	All couplings shall be capable of withstanding the maximum generator sudden short circuit torque.
5.00.00	**DUCTING, PIPING VALVES AND FITTINGS**
5.01.00	The engine shall be supplied with all necessary silencer, exhaust, piping, valves and fittings for the fuel oil, lubricating oil, engine starting, air inlet and engine exhaust system, along with expansion joints, drain plugs, flanges and their support structure etc.
5.02.00	Maintenance and erection tools and tackles required for all the equipment shall be provided by the Contractor.
5.03.00	Bidder shall provide two(2) number of 3 phase, 3 wire, 415V feeder and two(2) number of 220V DC supply at one point. Further distribution for bidder's equipment shall be carried out by the bidder. Necessary starters for ventilation fans/ exhaust fans / acoustic enclosure and priming pump motors etc. shall be in the bidder's scope along with necessary AC distribution board, cables and cabling. Distribution board shall be metal enclosed, compartmentalized, wall/structure mounted and shall be fabricated out of cold rolled sheet steel of thickness 1.6mm with degree of protection of IP-54. The same shall be provided inside the acoustic enclosure. The alternator outgoing supply of DG Set shall be fed into Bidder's breaker panel.
6.00.00	**OPERATIONAL REQUIREMENTS**
6.01.00	**Starting and Control**
6.01.01	All DG sets shall be controlled independently through separate control panel. The unit shall have integrated control with automatic starting sequence from the manually

	initiated command from a single push button. It shall also have auto initiation through command from remote from Bidder's panel. The DG set shall also issue automatic closing command to it's LT breaker on achieving rated voltage and frequency on it's terminals when controlled from remote. Necessary voltage and frequency relays for the purpose shall be included in the offer.
6.01.02	The starting time required from the initiating signal until the operating speed and voltage is attained and the engine and generator are ready to take load, shall not be greater than 30 seconds. Three attempt starting facility shall be provided either by using two impulse timer and a summation timer or by using microprocessor based controller along with auxiliary panel if any. The DG set shall lockout automatically in case of failure of above. The DG shall be capable of being stopped manually from remote as well as local. Interlock shall be provided in DG control panel to prevent shutting down operation (when in auto mode) as long as the circuit at generator output is closed.
6.01.03	Electrical self starting system shall be provided, the source of energy shall be batteries backed up by battery chargers which shall be supplied by the Contractor.
6.01.04	The starter motor shall conform to IS: 4722.
6.01.05	The fuel oil system and the lubricating oil shall also start operating simultaneously and automatically as soon as a starting impulse is received to obviate any chance of seizure of the piston and bearing as well as air locking in fuel supply system.
6.02.00	**Battery**
6.02.01	The battery shall be of at least 24V 360 AH or 2 sets of 2 numbers of 12 V, 180 AH battery connected in parallel and shall conform to the requirements of IS: 7372 /IEC:60095. The battery with Polypropylene containers meeting the other technical requirements of IS: 7372 may be acceptable.
6.02.02	The battery for starting the engine shall be capable of performing six (6) normal start without recharging. The charger shall be protected by a suitable current limiting device. The battery shall be sized for site minimum temperature. Battery and battery charger shall also feed the control supply of DG control panel.
6.02.03	The minimum voltage at the end of load cycle shall not be less than 1.75 volts per cell.

7.00.00	**DIESEL GENERATOR CONTROL PANEL**
7.01.00	**Construction details**
7.01.01	The local control panel shall be of robust construction, floor mounting, free standing type made of 2.0 mm thick CRCA sheet steel including doors and Partition. Neoprene gaskets shall be provided between all openings and joints. It shall be provided with hinged door with locking arrangement. The control panels shall have IP-54 degree of protection as per IS: 13947 Part-I.
7.01.02	The panel shall be painted with electro statically powder coated paint of shade RAL 7032 after necessary sheet metal treatment to remove dust, grease, oil, chemical compound, uneven surfaces and any foreign materials. The Gland plate shall be of at least 2.5mm thick sheet steel.
7.01.03	Control panel with provision for local starting shall be provided which shall incorporate all controls required for starting, monitoring, regulating and stopping DG set. It shall be equipped with all necessary instrumentation to provide adequate surveillance of DG set under all operating conditions including 'Standby'.
7.02.00	All indicating instruments shall be flush mounted conforming to industrial grade as per relevant IS.
7.03.00	All cables shall be bottom entry. Enough space shall be provided in the control panel for easy access during maintenance and repairs.
7.04.00	A tinned copper/ aluminium bar of adequate dimension shall be provided for earth connection complete with nuts and bolts as required for external connection to Bidder's earth grid.
7.05.00	The final paint shade shall conform to shade grey RAL 9002. The identification tag shall be white in colour shade RAL 9010.
7.06.00	CT shorting links, test terminal blocks etc. shall be provided. All the equipment mounted inside the control panel shall be identified by lamicoid labels/ stenciling by paint.
7.07.00	Panel shall be provided with panel illumination lamp operated by the door switch and thermostat-controlled space heater. Control panel shall be furnished complete with all accessories and wiring for safe and trouble free operation of the system.

7.08.00	**Fuses**
7.08.01	All fuses shall be of HRC cartridge link type. Screw type fuses are not acceptable.
7.09.00	**Relays**
7.09.01	A voltage relay for sensing the supply to control Panel shall be provided. The relay shall operate at about 90% of voltage and shall be English Electric type VAG 11 or equivalent.
7.10.00	**The Control panel shall be complete with the following**
7.10.01	**Microprocessor base control unit** Microprocessor base control unit with following. (a.) Voltage sensing mains supply failure monitor (b.) Auto engine start / stop & failure to start lock out. (c.) Generator voltage & frequency sensing (d.) Selector switch and push button to facilitate remote starting/stopping, speed & voltage control (e.) Manual / Auto / Test selector switches (f.) DG start /stop push button (g.) DG Incomer Breaker close / trip push button (h.) Mains breaker close / trip push button (i.) Auto manual Speed adjustment (j.) Auto manual Voltage adjustment (k.) Auto manual selector switch for priming pump motor (if required)
7.10.02	**LED indication lamps** LED indication lamp shall be provided for the following (a.) 'DG ON' indication lamp'

(b.) DG Breaker ON' indication lamp

(c.) 'Mains ON' indication lamp

(d.) 'Mains Breaker ON' indication lamp.

(e.) Charger ON indication lamp.

7.10.03 **Annunciation**

Annunciation for the following shall be provided with fault indication, alarm & trip contact, accept, reset and test facility. Any one or more of the following defects shall cause the alarm or running diesel generator to be tripped. In case of tripping, re-start shall be prevented until the fault(s) are removed and manual resetting is done. Separate indicators shall be provided for each of the following in control panel:

(a.) Engine fails to start(Alarm)

(b.) Low lube – oil pressure.(Trip)

(c.) High cooling water temperature.(Trip)

(d.) D.G. overload.(Alarm)

(e.) DC failure

(f.) DG over speed(Trip)

(g.) Fuel level low in day tank(Alarm)

(h.) Fuel level very low in day tank(Trip).

(i.) Generator stator temperature high.(Alarm)

(j.) Electrical protection operated.(Trip)

(k.) Incomer to emergency switchgear from DG closed.

(l.) Earth fault (alarm) input from Bidder's switchgear.

(m.) Lub Oil Priming Pump (if applicable) 'Fault' indication

7.10.04 **Metering**

Following meters shall be provided in the panel:

(a.) AC voltmeter

(b.) AC Ammeter

	(c.) Frequency meter (d.) Electronic Kwh meter with counter display. (e.) KW meter (f.) PF Meter
7.10.05	**Battery charger** (a.) A suitable battery charger shall be housed inside the panel to recharge the battery within ten hours. The battery charger shall be SMPS based automatic and shall be complete with the following (b.) DC voltmeter (c.) DC Ammeter (d.) Float / Boost selector switch (e.) Auto / Manual selector switch for Boost to float change over. (f.) The charger shall have necessary filters to reduce the ripple factor less than three (3) and suitable dropping characteristics by means of choke and/ or suitable input transformer impedance to automatically reduce the charging current as the battery gradually charges up.
7.11.00	Suitable 4-20mA transducers with dual output shall be provided in the control panel for voltmeter & frequency meter for Bidder's use at remote.
7.12.00	The bidder is required to provide coupling relays (with diodes) having 24V DC energising coil in the control panel for the followings for Bidder's use (a.) DG Start (b.) DG Stop (c.) DG Voltage raise (d.) DG voltage lower (e.) DG speed raise (f.) DG speed lower (g.) DG auto start
7.13.00	For issuing simultaneous start command to standby DG set, there shall be three (3) 'DG auto start' coupling relays in case of standby DG set.
7.14.00	Provision for following status/ signal for Bidder's information shall be provided in the DG control panel for both main & standby DG Sets: (a.) DG fail to start.

(b.) DG start command actuated/ reset.

(c.) DG working/ stop signal.

(d.) DG trouble/ normal signal.

(e.) DG control supply failure/ normal signal.

7.15.00 The requirement of CT, VTs, relays, timers, auxiliary contacts shall be as per the system requirement.

7.16.00 The bidder shall supply any other controls and indications for diesel generator set though not specifically mentioned here but which the supplier may recommend and are required to make system complete for satisfactory operation of DG sets.

7.17.00 Indicating lamps shall be of the panel mounting LED type with series resistor and of low power consumption. Lamps shall be provided with series resistor built-up lamp assembly.

7.18.00 Necessary pressure switches, level switches, thermostats, flow switches, auxiliary relays, etc. required for the above alarm and annunciation system shall be furnished under the scope of this specification.

8.00.00 DIESEL ENGINE

8.01.00 CONSTRUCTIONAL FEATURES

8.01.01 Diesel engine shall be mounted on visco damper type vibration dampening system or equivalent anti-vibration mounting system (as recommended by Engine manufacturer) and shall be complete with integral air intake through dry type air filters and exhaust systems, metering facility, speed regulation system, fuel injection system, lube oil system, primary cooling water system along with necessary filters, silencers, ducts, exhaust, piping and fittings, valves, instruments, etc. as required.

8.01.02 The generating unit shall be complete with all auxiliaries and its performance, torsional vibration, materials and workmanship, etc. shall be in accordance with the standard practices of diesel engine manufacturer's association in USA. IS-10000, BS-5514 or equivalent. The engine shall be properly balanced so as to transmit only small unbalanced forces to the foundation.

8.02.00	**DIESEL OIL SYSTEM**
8.02.01	The diesel oil system as provided shall be complete with simplex type filters, hoses, piping, fittings, relief valves, supports, control and instrumentation and all other accessories to make it complete.
8.02.02	The fuel consumption of the engine at full and three quarters of its rated power output shall be indicated by the bidder.
8.02.03	A day oil tank of 990 litres fuel capacity shall be provided by the bidder, mounted on fabricated steel platform outside the acoustic enclosure. The tank shall be complete with level indicator marked in Litres, two nos. of level switches, filling inlet with removable screen, an outlet, a drain plug, an air vent and necessary piping. The fuel tank shall be painted with oil resistant paint. All pipe joints shall be brazed/ welded.
8.03.00	**Lubricating oil System**
8.03.01	Automatic pressure lubrication shall be provided by a shaft driven gear type pump through an oil cooler and fin mesh filters to the end bearing, camshaft bearings, camshaft chain and gear drives, governor, air starting, distribution, auxiliary drive gears etc.
8.03.02	Hand driven and/ or A.C. motor driven lube oil priming pump (if applicable) along with starter is to be provided as recommended by the engine manufacturer.
8.03.03	All necessary accessories like pressure gauges, temperature and oil level indicators, pressure relief valves, bypass valves, pressure switches for alarm and control shall be furnished by the Contractor together with all inter connecting piping, fittings, supports, valves, etc.
8.03.04	A lubricating oil filter shall be provided for operation under normal conditions for period of a more than 250 hours without the necessity of its replacement or cleaning.
8.04.00	**Cooling System**
8.04.01	Jacket water cooling system is offered, same be in closed cycle and shall have radiator located in front of the engine with a fan driven mechanically from the engine shaft. Forced water circulation by means of pump driven by the engine shaft shall be employed. The radiator tubes shall be of copper with sufficient heat transfer area. However, radiator tubes designed with better heat transfer capability, as recommended by engine manufacturer, shall also be acceptable.

8.05.00 **Governing System**

8.05.01 The governor shall be electronic type with class A1 type as per BS-5514.

8.05.02 The governor shall have necessary characteristics to maintain the speed substantially constant even with sudden variation in load. However a tripping shall be provided even if speed exceeds the maximum permissible limit.

8.06.00 **Ancillary Equipment**

The following equipment as per system requirements shall be included:

(a.) Flywheel

(b.) Fuel piping

(c.) RPM indicator

(d.) Lubricating oil cooler (if applicable)

(e.) Exhaust silencer and piping

(f.) Fuel and lubricating oil filters, air filters.

(g.) Temperature gauges for water.

(h.) Pressure gauges for lubricating oil

(i.) Hand barring gear.

(j.) Necessary foundation bolts and base channels for the engine, alternator, fuel service tank and for all other equipment included in this package.

(k.) Base frames

(l.) Starting equipment

(m.) Protective equipment preferably in the form of fuel cut-off solenoid and suitable relays to protect the engine against low lubrication pressure.

(n.) Lifting attachment for lifting the complete set or the engine alternator separately.

(o.) Radiator.

(p) Any other ancillary equipment not specifically mentioned in the specification but are necessary for proper operation and maintenance of the set and safety of operating personnel.

9.00.00 GENERATOR

9.01.01 The generator shall be of totally enclosed or screen protected drip proof and self air cooled type. The generator shall be driven by the Diesel engine specified above and shall match the same in all respects. The generator shall conform to IS 4722 or IEC-60034.

9.01.02 AC generator shall be supplied along with it's excitation system, AVR and include all necessary auxiliaries.

9.02.00 Rating

9.02.01 The Generator shall be star connected-3-phase, 50 Hz synchronous generator and shall have a continuous rating. The continuous rating of the alternator under the specified ambient condition shall be at least equal to the net electrical output specified for the DG set plus the power requirements of all electrical auxiliaries connected to the alternator terminal including excitation (if it is taken from alternator terminals). The operating condition for each electric generator shall be as follows:

a)	Voltage	415V
b)	Frequency	50Hz (+3 to -5%)
c)	Power factor	0.80

9.03.00 Conductor, Insulation and Temperature Rise of Winding and Core

All insulated winding conductors of alternator shall be of copper. The generator stator and rotor windings core insulation and all connections including main and neutral leads shall have insulation conforming to IEC-60034 Pt.-I. The winding shall be given power house treatment i.e. two coats of varnish and backing followed by final coat of resin. The total insulation shall be non hygroscopic. The temperature rise of the stator core and mechanical parts in contact with or adjacent to winding shall not exceed the specified limits of IEC-60034 Pt.-I.

9.04.00 Temperature Detectors.

9.04.01 Six numbers of Duplex type or 12 nos. Simplex type Resistance element temperature detector (RTD) shall be suitably distributed at locations where highest temperatures may be expected in stator windings and one (1) element in each bearing. The RTD's shall comply with the latest edition of IS:2828.

9.05.00	**Space Heaters**
9.05.01	Suitably rated 240 V, single phase, 50 Hz, space heater located in lower part of alternator shall be provided to maintain the internal temperature above the dew point to prevent moisture condensation on the insulation when the set is not running. These heaters shall be switched on automatically, when DG set is not working.
9.06.00	**Terminal Box**
	For each DG set, separate terminal boxes shall be provided for phase and neutral side of leads. The terminal boxes shall be dust tight, weather proof having degree of protection of IP-54 as per IS: 13947. The terminal box shall be suitable for terminating LT bus ducts/cables. As far as possible connection between exciter and alternator shall be contained within the machine frame and connections carrying AC and DC current shall be segregated from each other. The necessary CT's for differential protection shall be provided on neutral side. The neutral point shall be brought to DG control panel and shall be connected to 300/100V VT, to be supplied and mounted inside the DG control panel by the bidder for earth fault detection.
9.07.00	Alternator vibration level shall not exceed the values as defined in IS:12075. Alternators in case driven by Diesel engine shall be able to withstand vibration level of 9mm/sec. as per BS 5000 Part III,
9.08.00	The generator shall be complete with voltage transformers necessary for AVR/ Synchronization. The VT turns ratio shall preferably be 440/110 V. The VTs shall be supplied and mounted inside the DG control panel.
9.09.00	**Excitation System**
9.09.01	The generator shall be provided with complete excitation system capable of supplying the excitation current of the generator under all conditions of output from no load to full load and capable of maintaining voltage of the generator constant within +/- 1% of set value. The setting range available on voltage regulator shall be at any value with +/- 10% of the rated voltage. It shall be possible to set the same from remote also.

9.10.00 TECHNICAL PARAMETERS OF CURRENT AND POTENTIAL TRANSFORMERS TO BE SUPPLIED BY THE BIDDER.

9.10.01 **Neutral side current transformers for differential protection:**

(a.)	Type	Cast resin, bar primary
(b.)	Voltage	660V, 50Hz
(c.)	Ratio	2500/1A
(d.)	KPV	>= 125V
(e.)	RCT	=< 3 ohm
(f.)	Class	PS
(g.)	One minute power frequency withstand voltage	2.5KV

9.10.02 **Single phase voltage Transformers (Neutral)**

(a.)	Type	Cast resin
(b.)	Voltage Ratio	300/100
(c.)	Accuracy	1.0 class
(d.)	Rated Voltage factor	1.2 continuous
(e.)	VA Burden	20VA
(f.)	One minute power frequency withstand Voltage	2.5kV rms

9.10.03 **Voltage Transformers for Metering**

(a.)	Type	Cast resin
(b.)	Voltage Ratio	440/110
(c.)	Accuracy class	1.0
(d.)	Rated Voltage factor	1.2 continuous
(e.)	Burden	100VA
(f.)	One min power frequency with stand voltage	2.5kV rms

10.00.00	**SOUND PROOFING SYSTEM**
10.01.00	Bidder shall furnish design calculation for sound proofing/ ventilation system. The detailed frequency response for noise absorbing characteristic of acoustic material shall be furnished.
10.02.00	The sound absorptive layer shall comprise of bonded type mineral wool/glass wool of adequate thickness and density to comply the design requirements.
10.03.00	DG shall be placed inside acoustic enclosure, the acoustic enclosure shall be placed in outdoor area. The requirements of acoustic enclosure are as following:
10.03.01	The acoustic enclosure shall be fabricated from 2.0 mm thick CRCA sheet with steel section & frame of suitable size. The construction shall be modular type to facilitate dismantling as required for maintenance. The frame shall be of sufficient stiffness and rigidity. The enclosure shall be suitable for outdoor duty. The sheet and all sections shall be powder coated shade of grey RAL9002. A minimum clear space of 800mm shall be kept inside the enclosure.
10.03.02	The exposed surface of lining shall be retained in place by minimum 1.0mm thick CRCA/ aluminium perforated sheet. Absorptive lining shall be provided between the perforated sheet and absorbing material. Necessary acoustic sealing shall be done in the panels/ modular unit joints.
10.03.03	Enclosure shall be provided with adequate lighting. Enclosure shall be provided with adequate number of door and viewing glass.
10.03.04	All hardware shall be of mild steel & shall be electro-galvanised.
10.04.00	The door design shall be generally compatible to the enclosure design. The bonded mineral wool slab of adequate thickness shall be used. The door shall be provided with heavy duty hinges and handles. The sealing shall be done with neoprene/ silicon rubber gasket to avoid leakage of noise. The size of the door shall be as per the functional requirements.
10.05.00	Suitable louvers with acoustic treatment shall be provided by the bidder as required.
10.06.00	Ventilation system of adequate capacity shall be provided. The system shall comprise of tubular axial flow fans for air intake and air exhaust with splitter silencer. The ventilation shall be design to ensure required air flow rate as per manufacturer

	recommendations, after providing necessary acoustic treatment/ silencers in air flow path. The ventilation system shall be design to prevent leakage of sound and temperature shall not increase by more than 5 degree centigrade when DG is running continuously at specified rating.
10.07.00	The construction of ventilation duct shall be from 1.6 mm thick CRCA perforated sheet. Other constructional details shall be similar to that of the acoustic enclosure.
10.08.00	The exhaust air from radiator shall be discharge through modular duct of adequate size.
10.09.00	The acoustic enclosure shall have suitable opening for routing out of LT bus ducts/cable from alternator terminal box. Further suitable acoustic treatment of the opening shall be done to achieve the desired acoustic level.
10.10.00	Any other facility required to achieve the desired acoustic level shall be in the bidder's scope.
11.00.00	**TYPE TESTS**
11.01.01	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 not earlier than ten years prior to the date of techno-commercial 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.
11.01.02	However if the contractor is not able to submit report of the type test(s) conducted within last ten years from the date of techno-commercial 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.
11.01.03	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.
11.01.04	Type test reports for the following type tests shall be submitted:
11.01.04	Type test reports on Engine

This shall be as per ISO-3046 (Table-1).

11.01.05 Type test reports on Alternator

(a.) Measurement of resistance

(b.) Phase sequence test

(c.) Regulation test

(d.) Measurement of open circuit and short circuit characteristics

(e.) Efficiency test

(f.) Temperature Rise Test

(g.) Momentary overload test

(h.) Over speed test

(i.) High Voltage test

(j.) Insulation resistance test (both before and after High Voltage Test)

(k.) Noise level as per IS:12065

(l.) Vibration as per IS: 12075.

(m.) Determination of Deviation of voltage waveform from sinusoidal.

(n.) Degree of protection test on control panel for IP-52

12.00.00 COMMISSIONING CHECKS

12.01.00 In addition to the checks and test recommended by the manufacturers, the contractor shall carryout the following commissioning test on each set at site. The contractor shall arrange the testing equipment, instruments, fuel and any other facility required to carry out these tests.

12.01.01 **Load Test**

The engine shall be given test run for a period of at least 6 hours. The set shall be subjected to the maximum possible load as decided by Project Manager without exceeding the specified DG set rating.

	During the load test half hourly records of the following shall be taken: (a.) Ambient temperature. (b.) Exhaust temperature if exhaust thermometer is fitted. (c.) Cooling water temperature at a convenient point adjacent to the water output from the engine jacket. (d.) Lubricating oil pressure. (e.) Speed. (f.) Voltage, wattage and current output. (g.) Oil tank level.
12.01.02	Insulation Resistance Test for Alternator Insulation resistance in mega-ohms between the coils and the frame of the alternator when tested with a 500 V megger shall not be less than IR= 2x (rated voltage in KV) + 1.
12.01.03	**Check of fuel consumption** A check of the fuel consumption shall be made throughout the load run test. The fuel consumption should not exceed the design values.
12.01.04	**Insulation Resistance of Wiring** Insulation resistance of control panel wiring shall be checked with 500V megger. The IR shall not be less than one mega ohm.
13.00.00	**FUNCTIONAL TESTS** Following functional tests are to be carried out at site:
13.01.00	Functional tests on control panel.
13.02.00	Functional tests on starting provision on the engine.
13.03.00	Functional tests on all field devices.
13.04.00	Functional tests on DG Set complete with AVR and speed governor.
14.00.00	**MEASUREMENT OF VIBRATION**

14.01.00	The vibration shall be measured at no load and at load as close to maximum achievable load and shall not exceed 250 microns. Any modification/rectification required to bring down the vibration level with in allowable limits specified by the manufacturer shall be done by the contractor. Vibration test is to be carried out at site.
15.00.00	**NOISE LEVEL (SOUND PRESSURE LEVEL) CHECK**
15.01.00	Noise level measurement shall be done generally following the guidelines given in IS:12065. The measurement shall be carried out with a calibrated integrating sound level meter as per IS:9779. This test is to be carried out at site.
16.00.00	**INSTALLATION OF DG SETS**
16.01.00	The installation, testing and commissioning of Diesel-Generator sets shall be carried out by the Contractor strictly in accordance with the applicable Codes of practice, the manufacturer's instructions, drawings etc., and/or as directed by the Employer.
16.02.00	The Contractor shall install and commission the DG set, control panels, along with other accessories, starting equipment (Battery & battery charger/ compressed air system), fuel oil tank and fuel oil piping upto the DG sets. Minor civil works like fixing of anchor bolts, grouting etc. wherever required shall be done by the Contractor.
16.03.00	The Contractor shall provide all tools, equipment and instruments required for installations, testing and commissioning.

SUB-SECTION-II-E12

TRANSFORMERS

1.00.00 TRANSFORMERS

1.01.00 TYPE & RATINGS (for continuous duty)

Sr. No.	TRANSFORMER	FGD Transformer – 400/11.5 kV	Auxiliary Transformer (including LT Outdoor)	
i)	Rating	As per system requirement/SLD		
ii)	Voltage Ratio (KV)	400/11.5	11/3.45kV	11/0.433kV
iii)	Winding	2	2	2
iv)	Nos. of Phase	Three	Three	Three
v)	Vector Group	As per system requirement/SLD		
vi)	Cooling	ONAN	ONAN	ONAN
vii)	Tap Changer	OLTC	As per system requirement/ SLD	
viii)	Impedance At 75^{0}C a) Principal Tap b) Other Taps	As per system requirement/ SLD – To match with existing transformers - Tolerance as per IEC standard		
ix)	Permissible Temperature rise over an ambient of 50 deg C (irrespective of tap)			
	a) Top Oil by thermometer	50 ^{o}C	50 ^{o}C (40 deg.C for upto & including 2.5MVA and 33KV rating)	
	b) Winding by resistance	55 ^{o}C	45 deg.C for upto & including 2.5MVA and 33KV rating)	

x)	**Insulation level**	As per chapter E1,	
xi)	**Earthing (Copper Flat)**	As per system requirement/ Sub section E6/SLD	
xii)	**Termination, SC withstand time & Fault Level**	As per system requirement/ Sub section E1/SLD	
xiii)	**Noise level**	As per NEMA TR-1	
xiv)	**Loading Capability**	Continuous operation at rated MVA on any tap with voltage variation of +/-10%, also transformer shall be capable of being loaded in accordance with IS:6600/ IEC60076-7.	
xv)	**Air Core Reactance**	At least 20% for HV winding	
xvi)	**Flux density**	Not to exceed 1.9 Wb/sq.m. at any tap position with +/-10% voltage variation from voltage corresponding to the tap. Transformer shall also withstand following overfluxing conditions due to combined voltage and frequency fluctuations:	
		a) 110% for continuous rating.	
		b) 125% for at least one minute.	
		c) 140% for at least five seconds.	
		Bidder shall furnish overfluxing char. upto 150% & 170 %	

Note:-

1). LT Auxiliary transformers shall be 3 phase, 4 wire system with additional LVN bushing for equipment earthing.

1.02.00 CODES AND STANDARDS

Transformers	IS:2026, IS:6600, IEC:60076,IS 1180
Bushings	IS:2099, IEC:60137
Insulating oil	IEC:60296
Bushing CTs	IS:2705, IEC 60185
Shunt reactor	IS 5553 & IEC 60076-6
Indian Electricity Act 2003, BEE Guideline & CEA notification	

1.03.00 OPERATIONAL REQUIREMENT

1.03.01 Transformers

a) Cooling requirements

i) FGD Transformers: - Transformers shall be provided with detachable type tank mounted radiator banks with 100% cooling capacity. Cooling fans shall not be directly mounted on radiator bank which may cause undue vibration, also fan shall be protected by galvanized wire guard. Each radiator bank shall have lifting lug, air release plug, top & bottom filling/shut-off valves, drain valve/plug etc. The number and capacity of cooling fans with radiator bank shall be such that outage of any fan does not reduce the continuous rating. Automatic operation/control of fans shall be provided (with temp. change) from contacts of winding temp. Indicator.

ii) For Auxiliary Transformers & FGD HT transformers: - the radiators shall be detachable type, mounted on the tank. Each radiator shall be provided with a drain plug/valve at the bottom, an air release plug at the top, shut off valve at each point of connection to the tank.

iii) The radiators shall be made of Hot Dipped Galvanized Steel conforming to ISO 12944-5, system no. A7.13 of paint and coating of the Table A.7.

b) LT Auxiliary outdoor transformers up to and including 2500KVA, 33kV shall have maximum losses of STAR-2 rating or better as per latest BEE guideline. The outdoor transformer up to 2500KVA, 33kV shall also comply with latest IS:1180.

1.04.00 DESIGN AND CONSTRUCTIONAL FEATURES

1.04.01 Tank

a) Tank shall be of welded construction & fabricated from tested quality low carbon steel of adequate thickness.

b) The main tank body including tap changer, radiators (except for Auxiliary transformers) and coolers shall be capable of withstanding full vacuum. Tank shall be provided with suitable lifting lugs, minimum 4 jacking pads & haulage holes for wheeling in all four directions.

c) FGD Transformer and FGD HT transformers shall be mounted on detachable type bi-directional rollers for rail gauge of 1676mm. Auxiliary transformers shall have suitable bi-directional skids, however auxiliary transformers above 2 MVA shall be provided with four no. of bi-directional detachable flat rollers. Suitable locking arrangement shall be provided to prevent accidental movement of transformer.

d) At least two adequately sized inspection openings, one at the each end of the tank for easy access to bushings and earth connections & suitable manhole shall be provided.

1.04.02 Core

Transformer	Requirement

FGD Transformer & FGD HT transformer	Core shall be high grade, non-ageing, cold-rolled, super grain oriented silicon steel laminations known as Hi B grade steels or equivalent. The insulation of core to tank, tank to clamp and clamp to core shall be able to withstand a voltage of 2 KVrms for 1 min in air. To facilitate testing of above during pre-commissioning stage, the core/clamp earthing has to be done outside the tank with suitable bushings.
Auxiliary Transformers	Core shall be high grade non-ageing cold rolled super grain oriented silicon steel laminations of M4 grade or better quality. The core isolation shall be able to withstand a voltage of 2 kV (rms.) for 1 minute in air.

1.04.03 **Insulating oil**

No inhibitors shall be used in the transformer oil. The oil supplied with transformers/ reactor shall be new and previously unused and must conform to following while tested at supplier's premises and shall have following parameters.

S.No.	Property	Permissible values
1.	Kinematic Viscosity, mm^2/s	≤ 12 at 40 ° C ≤ 1800.0 at (-)30 ° C
2.	Flash Point, ° C	≥ 140° C
3.	Pour point, ° C	≤ (-)40 ° C
4.	Appearance	Clear , free from sediment and suspended matter
5.	Density kg/dm^3 at 20 ° C	≤ 0.895
6.	Interfacial Tension N/m at 25° C	≥ 0.04
7.	Neutralisation value, mgKOH/g	≤ 0.01
8.	Corrosive sulphur	Non Corrosive
9.	Water content mg/kg	≤ 30 in bulk supply ≤ 40 in drum supply
10.	Anti oxidants additives	Not detectable
11.	Oxidation Stability -Neutralization value, mgKOH/g -Sludge, % by mass	 ≤ 1.2 ≤ 0.8
12.	Breakdown voltage As delivered, kV After treatment, kV	 ≥ 30 ≥ 70
13.	Dissipation factor, at 90° C And 40 Hz to 60 Hz	≤ 0.005
14.	PCA content	≤1%
15.	Impulse withstand Level, kVp	≥ 145
16.	Gassing tendency at 50 Hz after 120 min, mm^3/min	≤ 5

Subsequently oil samples shall be drawn at:

Sr. No.	Parameters	Before filling in main tank at site & tested for	Prior to energization at site for following properties & acceptance norms:	Applicability
i)	BDV	60 kV (min)	60 kV (min)	Applicable for all Transformers
ii)	Moisture content	10 ppm (max.)	10 ppm (max.)	
iii)	Tan delta at 90 deg. C	0.005 (max.)	0.05 (max.)	Applicable for Transformers (16 MVA & above).
iv)	Interfacial tension	0.04 N/m(min)	0.035 N/m (min)	

1.04.04 **Windings**

The conductors shall be of Electrolytic grade copper. All Windings of 66kV and below shall have uniform insulation. The contractor shall ensure that windings are made in dust proof & conditioned atmosphere. All windings of FGD Transformer, and HT transformers shall have Thermally upgraded paper covering insulation.
For FGD Transformer winding paper moisture shall be less than 0.5%.

1.04.05 **Oil preservation**

Main tank and OLTC (if applicable) shall be provided with conservator tanks of adequate capacity for expansion of oil from minimum ambient to 100 deg.C. The equipment rated 7.5MVA and above shall be provided with air bag breathing through indicating type cobalt free silica gel breather with transparent enclosure. However conventional type conservator with indicating type cobalt free breather (transparent enclosure) shall be offered for transformer below 7.5 MVA.

1.04.06 **Bushings**

(a.) The electrical & mechanical characteristics of bushings shall be in accordance with IS: 2099, IS: 3347 & IS: 12676.

(b.) Bushings below 52 kV shall with porcelain insulator and shall be of oil communicating / OIP (non-oil communicating type) / epoxy RIP type. All condenser bushings shall be non-communicating type.

(c.) Bushings from 52kV upto 420 kV class (including 52 kV and 420 kV class), shall be RIP (Resin Impregnated Paper) Type with composite insulator. It shall be provided with Tap for Capacitance and Tan delta test. All composite resin impregnated bushings (RIP) shall be provided with provision for long term storage to protect from moisture and rodents. The oil side shall be provided with tank which can be filled with oil. Tank shall have necessary provision for oil filling, level gauge etc. Suitable covering to be provided on air side to protect from any damage. The arrangement shall be suitable for storage in horizontal/ vertical direction in outdoor location.

(d.) The oil end dimension of RIP bushing shall be same for all bushings of similar voltage rating.

(e.) All condenser bushings shall be non-communicating type.

(f.) Condenser type bushings shall be provided with:

i) Oil level gauge
ii) Oil filling plug
iii) Tap for capacitance and Tan delta test

(g.) Clamps & fittings shall be of hot dip galvanized steel.

(h.) Bushing & fittings shall be provided with vent pipes that shall be connected to route any gas collection through the Buchholz relay.

(i.) No arcing horns shall be provided on the bushings.

(j.) LV Bushing palm shall be Silver/Tin plated.

BUSHING RATING: Please refer Annexure-A

1.04.07 **Bushing CTs**

Shall be of adequate rating for protection as required, WTI etc. All CTs (except WTI) shall be mounted in the turret of bushings, mounting inside the tank is not permitted. All CT terminals shall be provided as fixed type terminals on the M. Box/CCC/CMB to avoid any hazard due to loose connection leading to CT opening or any other loose connection in power circuit. In no circumstances Plug In type connectors shall be used for CT & Power connection.

1.04.08 **Tap changer (as applicable)**

i) Measurement for Tan delta values of OCTC & OLTC (as applicable) to be done before installing in the 132 kV & above class transformer.
ii) The OLTC chamber (as applicable) oil shall not come in contact with main tank oil.
iii) Tap Changer drive marshalling box shall be provided (as applicable).

1.04.09 **Marshalling box**

i) M. Box shall be of stainless steel (SS-316 or better), at least 2.5 mm thick, dust and vermin proof provided with proper lighting and thermostatically controlled space heaters. The degree of protection shall be IP 55. Marshalling Box of all transformers shall be preferably Tank Mounted. One dummy terminal block in between each trip wire terminal shall be provided. At least 20% spare terminals shall be provided on each panel. The gasket used shall be of neoprene rubber. The gasket used shall be of neoprene rubber. Also Marshalling Box gland plate shall be atleast 450 mm above ground level.

ii) FGD Transformer shall be provided with two auxiliary power supplies, 415V, three phase, 4 wire shall be drawn from two separate boards for the M. Box. In case of one power supply failure, loads shall be automatically transferred to other.

iii) Each cooling fan shall be provided with isolating switch, starter, thermal overload, single phase preventer and short circuit protection.

iv) The Automatic operation/control of fans shall be provided (with temp. change) from contacts of winding temp. Indicator.

v) For auxiliary transformer, wiring scheme shall be engraved in a stainless steel plate with viewable font size and the same shall be fixed inside the Marshalling Box door.

vi) TB shall be stud type for all CT & Power connections with ring type lugs.

1.04.10 **Valves**

(k.) All valves upto and including 50 mm shall be of gun metal or of cast steel. Larger valves may be of gun metal or may have cast iron bodies with gun metal fittings.

(l.) Sampling & drain valves should have zero leakage rate.

1.04.11 **Gaskets**

a) For FGD Transformer and HT transformers all the gasket shall be weather proof & hot oil resistant of 'O' ring of Nitrile rubber for all valves, flanges, HV, LV & Neutral Turrets, Bushings, Tank rim, etc. For this, all the flanges shall be machined.

b) For Auxiliary Transformers gasket shall be fitted with weather proof, hot oil resistant, rubberized cork gasket.

c) If gasket is compressible, metallic stops shall be provided to prevent over compression.

d) The gaskets shall not deteriorate during the life of transformer if not opened for maintenance at site. All joints flanged or welded associated with oil shall be such that no oil leakage or sweating occurs during the life of transformer. The quality of these joints is considered established, only if the joints do not exhibit any oil leakage or sweating for a continuous period of at least 3 months during the guarantee period. In case any sweating / leakage is observed, contractor shall rectify the same & establish for a further period of 3 months of the same. If it is not established during the guaranteed period, the guaranteed period shall be extended until the performance is established.

1.04.12 **Transformer/Shunt Reactor Transportation**

Transportation shall be N2/Dry Air/Oil filled. FGD HT transformers shall be transported with sufficient number (minimum two nos.) of impact recorders with necessary arrangement to maintain N2/Dry air pressure (as applicable) during transit and storage.

1.04.13 **PAINTING**

PARTS NAME	TYPE OF PAINT	NO.OF COATS	TOTAL DFT
Inside of tank and accessories (except CCC, CMB & M Box)	Oil & heat resistant fully glossy white	One coat	Atleast 30 micron
External surface of transformer/reactor and accessories (except coolers & radiators)	Chemical resistant epoxy zinc phosphate primer, MIO (Micaceious iron oxide) as intermediate paint followed by polyurethane finish paint (RAL 5012 Blue)	One coat each	Atleast 100 micron
External Cooler, Radiator surface	ISO 12944-5, system no. A7.13 of paint and coating of the Table A.7 with high quality full glossy outer finish paint (RAL 5012 Blue)	-	Atleast 100 micron
Internal Radiator surface	Hot oil proof, low viscosity varnish and subsequent flushing with transformer oil	---	---

1.05.00 Neutral Earthing Arrangement

The neutral of Transformers shall be brought through insulated support from tank to the ground level at a convenient point with copper flat, for connection to ground network (as applicable). However neutral may be connected to NGR as per system requirement.

1.06.00 NGR (Neutral Grounding Resistor) (As per system requirement)

1.	Resistance at 50^{o}C	As per system requirement
2.	Rated current	600A for 10 seconds
3.	Application	Neutral Grounding of Transformers as per system requirement
4.	Service	Outdoor
5.	Resistor material & connection	Punched stainless steel grid element type
6.	Max allowable temp rise over amb 50^{o}C	350 deg. C
7.	Mounting	As per system requirement
8.	Power frequency	As per system requirement

	level	
9.	) Stacking	Various sections comprising the neutral grounding resistor shall be capable of being stacked one above the other.
10.	Enclosure	NGR shall be housed in a 2.5 mm thick sheet steel enclosure & DOP IP-33. A heating circuit with Thermostat to be provided inside the enclosure to control humidity.
11.	Mounting Structure	The Contractor shall supply and erect a galvanized structure to support the NGR enclosure so that the base of the enclosure shall be at a minimum height of 2.4M above ground level.

1.07.00 FITTINGS

Following fittings shall be provided with Transformers, Shunt Reactor & Neutral Grounding Reactor covered under this specification.

a)	-Conservator for main tank with MOG (with low oil level alarm contact), drain valve & indicating type free Cobalt free breather with transparent enclosure (maximum height 1400 mm above rail level) etc. Aircell (for 7.5 MVA & above).
b)	-Buccholz relay (magnetic type), double float type with alarm and trip contacts, along with suitable gas collecting device. - Oil surge relay to be provided for OLTC.
c)	- For 2 MVA & above rating transformer, minimum two numbers of spring operated PRD (with trip contacts) with suitable discharge arrangement for oil shall be provided. Armored cable be used between PRD to Marshalling box. PRD shall have DOP of IP-67. Plugin type connector shall be provided for proper sealing for terminating cables/ glands. - For transformers below 2 MVA, diaphragm type explosion vent shall be provided.
d)	OTI & WTI shall be 150 mm dial type with alarm and trip contacts with max. reading pointer & resetting device. (maximum height 1500 mm above rail level) For FGD Transformer and HT transformers WTI shall be provided for all windings, also PT-RTD with 4-20 mA signals shall be provided with OTI & WTI of these transformers.
e)	Top & bottom filter valves with threaded male adapters, bottom sampling valve, drain valve/sludge removal valve at the bottom most point of the tank.
f)	Air release plug, bushing with metal parts & gaskets, terminal connectors on bushings (as applicable) & surge arrestor (as applicable).
g)	Prismatic/toughened glass oil gauge for transformers and OLTC chamber.
h)	Followings items are as applicable:- Bi-directional wheel & skids, M. Box, OCTC, Bushing CTs, Insulating Oil,

	Fans, pumps & oil flow indicator, Cooling equipment, Valve Schedule Plate.
i)	Cover lifting eyes, transformer lifting lugs, jacking pads, towing holes and core and winding lifting lugs, additional 4 nos. lifting lugs for bell tank cover, inspection cover, manhole, Bilingual R&D Plate, Terminal marking plates, two earthing terminals etc.
j)	Bolts & nuts (exposed to atmosphere) shall be galvanized steel/SS.
k)	Rain hoods to be provided on Buchholz, MOG & PRD. Entry points of wires shall be suitably sealed.
l)	1 no. Rapid Pressure Rise relay for each FGD Transformer.

The fittings listed above are only indicative and other fittings, which generally are required for satisfactory operation of the FGD Transformer and HT transformers are deemed to be included.

1.08.00 Testing Requirements

1.08.01 The contractor shall carry out the type tests as listed in this specification on the equipment to be supplied under this contract. The owner may waive conduction of any test subject to availability of test facility. The bidder shall indicate the charges for each of these type tests separately in the relevant schedule and the same shall be considered for the evaluation of the bids. The type tests charges shall be paid only for the test(s) actually conducted successfully under this contract and upon certification by the employer's engineer.

1.08.02 The type tests shall be carried out in presence of the employer's representative, for which minimum 15 days' notice shall be given by the contractor. The owner may waive conduction of any test subject to test facility anywhere in the world. The contractor shall obtain the employer's approval for the type test procedure before conducting the type test. The type test procedure shall clearly specify the test set–up, instruments to be used, procedure, acceptance norms, recording of different parameters, interval of recording, precautions to be taken etc. for the type test(s) to be carried out.

1.08.03 In case the contractor has conducted such specified type test(s) not earlier than ten years prior to the date of techno-commercial bid opening, he may submit during detailed engineering the type test reports to the owner for waiver of conductance of such type test(s). These reports should be for the tests conducted on the equipment similar to those proposed to be supplied under this contract and test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client. The owner reserves the right to waive conducting of any or all the specified type test(s) under this contract. In case type tests are waived, the type test charges shall not be payable to the contractor.

1.08.04 Following components to be supplied shall be of tested design. During detailed

engineering, the contractor shall submit for employer's approval the reports of all the type tests as listed below in specification and carried out within last ten years from the date of techno-commercial bid opening. The 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 witness by a client. However if the contractor is not able to submit report of the type test(s) conducted within last ten years from 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 employer either at third party lab or in presence of client/employer's representative and submit the reports for approval.

(o.) All type tests on 132 KV and above Bushings as per IEC 60137

(p.) All type test on OLTC as per IEC 60214 (wherever applicable)

(q.) Neutral Grounding Resistors

(r.) Tank Vacuum and Pressure test

(s.) All type tests on transformers upto and including 2.5 MVA (upto33kV class) transformers

1.08.05 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.

1.08.06 Each transformer shall be completely assembled with all fittings & accessories meant for the particular transformer/reactor before offering for inspection & testing by Employer.

1.08.07 **ROUTINE / TYPE TESTS ON TRANSFORMERS** :

I) ROUTINE TEST

S.N.	Transformer Type	FGD Tr. (3-PH)	HT/Auxiliary Trans.
	Voltage Class	400 kV Class	Um ≤ 72.5kV
1.	All routine test in accordance with IEC 60076 shall be carried out in all the transformers.	√	√
2.	Measurement of Voltage Ratio & phase displacement (as per IEC 60076-1)	√	√
3.	Measurement of winding resistance on all the taps (as per IEC 60076-1)	√	√
4.	Vector group and Polarity Check (as per IEC 60076-1)	√	√
5.	Magnetic Balance and Magnetising Current Test	√	√
6.	Measurement of no load current with 415 V, 50 hz AC supply	√	√

S.N.	Transformer Type	FGD Tr. (3-PH)	HT/Auxiliary Trans.
7.	Measurement of no load losses and current at 90%, 100% & 110% of rated voltage (as per IEC 60076-1)	√	√
8.	Load Loss & Short Circuit Impedance Measurement on principal & Extreme Taps	√	√
9.	IR measurement (As per IEC 60076-1)	√	√
10.	2KV KV core isolation (core-clamp, clamp-tank, core-tank)	√ (2KV)	X
11.	Measurement of capacitance & tan delta to determine capacitance between winding & earth. (for 132 kV & above class transformer, tan delta should not exceed 0.5% at 20 ^{0}C, also refer Note-iv below)	√	√
12.	Dielectric tests shall be carried out as per IEC 60076-3.	√	√
13.	Applied Voltage Withstand Test (as per IEC 60076-3)	√	√
14.	Lightning impulse (Full & Chopped Wave) test on windings (as per IEC 60076-3)	√	X
15.	Lightning impulse test on LV Neutral	X	X
16.	Switching impulse test (as per IEC 60076-3)	√	X
17.	IVPD test as per IEC 60076-3 shall be conducted (for U1 & U2 level refer Note & Table given below)	√	X
18.	LTAC test as IEC 60076-3 (also refer Table given below)	X	X
19.	Induced overvoltage test	X	√
20.	Repeat no load current/loss measurement & IR after completion of all electrical test	√	√
21.	Oil leakage test on completely assembled transformer along with unit coolers/ radiators (as per relevant clause of this sub section)	√	√
22.	Jacking test followed by D.P. test	√	√
23.	Frequency Response Analysis test	√	X
24.	Marshalling Box/Cable box: It shall not be possible to insert a thin sheet of paper under gaskets and through enclosure joints.	√	√
25.	IR measurement on wiring of Marshalling Box.	√	√

II) TYPE TEST (#)

S. N.	Transformer Type / Voltage Class	FGT Tie Tr. (3-PH) 400 kV Class	HT/Auxiliary Trans. Um ≤ 72.5kV
1.	IVPD test as IEC 60076-3 (also refer Table given below)	X	X
2.	Lightning impulse(Full & Chopped Wave) test on windings (as per IEC 60076-3)	X	√
3.	Lightning impulse test on Neutral	X	√*
4.	Short circuit test (special test) as per IEC 60076-5. In addition, For FGD tr. :- i) DGA & FRA shall also be conducted before & after S.C. test. ii) Physical inspection of transformer to be done before S.C. Test in presence of owner's inspector and photographs to be taken for reference.	√	√
5.	Temperature Rise test at a tap corresponding to maximum losses. Gas Chromatography shall be conducted on oil sample taken before & immediately after temp. rise test. Gas analysis shall be as per IS: 9434 (based on IEC: 60567), results will be interpreted as per IS: 10593 (based on IEC: 60599). For FGD tr. DGA results shall be interpreted as per IEC 61181. For FGD tr., infrared thermography shall be done during temp rise test, same needs to be measured during last hour of oil rise stabilization. Result shall be recorded for future reference.	√	√
6.	Zero sequence impedance measurement test (Special test)	√	X
7.	Measurement of power taken by the fans & pumps (as applicable)	√	X
8.	Measurement of harmonics of no load current (special test)	√	X
9.	Measurement of acoustic noise level as per NEMA TR-1 (special test)	√	√

NOTE:-

i) (#) All the type/special tests & temperature rise test shall be conducted after performing Short Circuit Test. If Tank Vacuum & Pressure Test is to be carried out then it shall be conducted before SC test.

ii) (√) mark indicates test to be carried out and (X) mark indicates test need not to be carried out.

iii) The power factors should not exceed 0.5% (at 20 °C). However in case of deviation from limiting values the same shall be resolved in line with IEEE Std-62.

iv) (*) this test is applicable on Transformer neutral earthed thru NGR.

iv) For IVPD Test U1 & U2 are as follows:-

a) U1(Enhancement Voltage) = 1.8Um/√3, U2(PD measurement voltage)= 1.6Um/√3 (for Um<400 KV)

b) U1(Enhancement Voltage)=510KV & U2(PD measurement voltage)= 460KV (for 400KV class Transformer)

Table-1	
Test	**IVPD**
Max allowed change in PD after voltage enhancement	100 pC
The background noise level shall not exceed 50 pC.	

Table-2 (if applicable) (Test Voltage for LTAC)	
Highest System Voltage (Um) for 400 kv class	**420 KV**
U1(LTAC Voltage level)	630 KV

1.08.08 **TANK TYPE TESTS**

(a) Routine tests

(1) Oil leakage test on assembled transformer

All tank and oil filled compartment shall be tested for oil tightness by being completely filled with oil of viscosity not greater than that of specified oil at the ambient temperature and applying pressure equal to the normal pressure plus 35 kN/m2 measured at the base of the tank. The pressure shall be maintained for a period of not less than 6(six) hours during which time no sweating shall occur. For FGD and HT Transformers this test shall be repeated as a pre-commissioning test at site for 24 hours.

(b) Type Tests

(1) Vacuum test

For FGD & HT transformers tank of each type shall be subjected to the specified vacuum. The tank designed for full vacuum shall be tested at an internal pressure of 3.33 kN/m2 absolute (25 torr) for one hour. The permanent deflection of the plate after the vacuum has been released shall not exceed the values specified below:

Horizontal Length of Flat Plate (in mm)	**Permanent deflection(in mm)**
Up to and including 750	5.0
751 to 1250	6.5
1251 to 1750	8.0
1751 to 2000	9.5

2001 to 2250	11.0
2251 to 2500	12.5
2501 to 3000	16.0
Above 3000	19.0

(2) Pressure Test

For FGD & HT transformers of each type shall be subjected to a pressure corresponding to twice the normal head of oil or to the normal pressure plus 35 kN /m2 whichever is lower, measured at the base of the tank and maintained for one hour. The permanent deflection of the plates after the excess pressure has been released shall not exceed the figure specified above for vacuum test.

For auxiliary transformers & Neutral Grounding Reactor, each type of tank shall be subjected to the vacuum & pressure tests as per CBIP norms.

1.08.09 **NEUTRAL GROUNDING RESISTANCE (NGR)TESTING**

(t.) The following routine tests shall be conducted on each resistor provided with transformer covered in this section.

(1.) Ohmic value measurement (For resistance & reactance separately).
(2.) Insulation resistance measurement before & after HV test
(3.) HV test for 1 min. at a voltage corresponding to the insulation level of the resistor.

(u.) DOP test on enclosure (routine test): It shall not be possible to insert a 2.5mm dia steel wire into the enclosure from any direction without using force.

(v.) Short time current test along with temperature rise test (type test).

(w.) Degree of protection test for IPX3 on enclosure (type test).

1.09.00 Commissioning Checks

Apart from general & prescribed commissioning checks following additional checks shall also be performed on FGD Transformer and HT transformers:-

1. FRA Test

2. Core isolation test

3. DGA test

1.10.00 Initial Operation for Transformers

a) Continuously observe the transformer operation at no load for 24 hrs. w.r.t. Voltage, no load current, temperature rise and noise.

b) Gradually put the transformer on load, check and measure increase in temperature in relation to the load and check the operation with respect to temperature rise and noise level etc.

c) For FGD Transformer Infra-red thermography shall be done after 12 hours of full load operation and results will be recorded for future reference.

1.11.00 TRANSPORTATION

The contractor shall be responsible to select and verify the route, mode of transportation and make all necessary arrangement with the appropriate authorities for the transportation of the equipment. All metal blanking plates and covers which are specifically required to transport the transformer shall be considered part of the transformer and handed over to owner/site incharge after completion of the erection. The total duration of storage at site with dry gas shall be limited to three (03) months after which transformer/reactor shall be processed and filled with oil.

The scope of any necessary modification/ extension/ improvement to existing road, bridges, culverts etc. shall be included in the scope of the bidder.

NOTE:
Despite all condition monitoring done by the Owner, the Contractor shall be responsible to obtain all required inputs such as DGA to evaluate the Transformer/ Reactor. The guarantee and costs of any repair done under the guarantee shall not be affected by any condition monitoring done or not done by the Owner during the guarantee period. A full DGA test shall be completed at the end but before expiry of the guarantee period.

2.00.00 DRY TYPE TRANSFORMER (LT INDOOR)

Sr. No.	PARAMETERS	INDOOR TRANSFORMER
i)	**Type**	Epoxy cast resin/resin encapsulated
ii)	**Service**	INDOOR
iii)	**MVA & Voltage ratio**	As per system requirement/ Sub section B-0
iv)	**Vector group**	
v)	**Impedance**	
vi)	**Tap changer type & range**	
vii)	**SC withstand time & Fault Level**	
viii)	**Termination**	
ix)	**Number of phases**	Three (3)
x)	**Type of cooling**	**AN** Additionally Transformer shall be provided with fans/blowers per limb (min. 450 W, 220 V) for

		forced air cooling however all tests and performance guarantee shall correspond to air natural (AN) cooling.
xi)	**Duty**	Continuous
xii)	**Insulation level**	As per chapter E1, Part-B
xiii)	**Maximum Temperature rise of winding over 50 deg. C ambient. (by resistance method) with Air Natural (AN) cooling.**	**70** deg.C.
xiv)	**Earthing**	Solidly earthed via Cu flat.
xv)	**Noise Level**	Not to exceed values specified in NEMA TR-1.
xvi)	**PD Level for HV coil (max.)**	20 pc
xvii)	**Loading Capability**	Continuous operation at rated KVA on any tap with voltage variation of +/-10% corresponding to the voltage of the tap as well as in accordance with IEC60076-7/IS: 6600.
xviii)	**Flux Density**	Not to exceed 1.9 Wb/sq.m. at any tap position with +/-10% voltage variation from voltage corresponding to the tap. Transformer shall also withstand following over fluxing conditions due combined voltage and frequency fluctuations: a) 110% for continuous rating. b) 125% for at least one minute. c) 140% for at least five seconds.

Note:- LT Indoor transformers shall be 3 phase, 4 wire system with additional LVN Bushing for equipment earthing.

2.01.00 CODES AND STANDARDS

Dry type transformers	IS: 11171, IEC 60076-11
Indian Electricity Act 2003 and Indian Electricity Rules, BEE notification & CEA guidelines	

2.02.00 DESIGN AND CONSTRUCTIONAL FEATURES

2.02.01 The core shall be constructed from high grade non-ageing cold rolled grain oriented silicon steel laminations of M4 grade or better quality. The insulation of core to clamp-plates shall be able to withstand a power frequency voltage of 2 kV (rms) for one (1) minute.

2.02.02 The transformers shall be housed in a metal protective housing, having a degree of protection of IP-23. Enclosure shall be of a tested quality sheet steel of minimum thickness 2mm & 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. Suitable bi-directional skids with pre-drilled holes shall be provided integral with the enclosure or bi-directional rollers shall be provided with suitable locking arrangement.

2.02.03 Winding conductor shall be electrolytic grade Copper. Windings shall be of class F insulation. All windings are to be uniformly insulated.

2.02.04 Transformer HV bushings and LV bushings can be either solid porcelain or epoxy type. Bushing shall be suitable for satisfactory operation in the high ambient temperature inside Bus Duct enclosure (if applicable). LV flange area shall be of non-magnetic material.

2.02.05 Bushing CTs shall be provided in the LV neutral side of adequate rating for REF protection, WTI, etc.

2.02.06 For Marshalling Box the sheet steel used shall be at least 1.6 mm thick cold rolled. The box shall be tank mounted type. The degree of protection shall be IP-54 in accordance with IS-13947. Wiring Scheme shall be engraved in a stainless steel plate with viewable font size and the same shall be fixed inside the Marshalling Box door.

2.02.07 Transformer shall be provided with fans/blowers (with 100 % standby) for forced air cooling however all tests and performance shall correspond to air natural cooling.

2.03.00 PAINTING

The inside of enclosure and accessories (except M. Box) shall be painted with two coats of fully glossy white colour with total DFT of 25 to 60 microns. The external paint colour of transformer & accessories shall be blue corresponding to RAL 5012. The external surface of transformer & accessories shall have two coats of chemical resistant epoxy zinc phosphate primer and two coats of polyurethane finish paint with total DFT of 80 to 150 microns. The internal surface of M.Box shall have two coats of chemical resistant epoxy zinc phosphate primer and two coats of chemical & thermal resistant epoxy enamel white paint with total DFT of 80 to 150 microns.

2.04.00 FITTING

Winding temperature indicator (WTI)	Shall be Platinum resistance type temperature detector in each limb. Single Indicating meter may be provided for display of temperature of all limbs. Accuracy class of Indicating meter shall be +/- 1% or better and it shall have least count of 0.1 ^{o}C or better. 1 no. 4-20 mA signal shall be provided for remote monitoring of winding Temperature. Blowers (AF cooling) shall have Manual and Auto control (with WTI user programmable temperature).
RTD/Thermistors	1 No. PT-RTD shall be embedded in each limb with alarm and trip contacts for remote annunciation. Additional 1 No. thermistor/RTD shall be embedded in each limb.
Fittings which are generally required for satisfactory operation of the transformers are deemed to be included, in the scope of supply of the Contractor.	

2.05.00 TESTING REQUIREMENTS

2.05.01 All equipments to be supplied shall be of type tested design. During detailed engineering, the contractor shall submit for Employer'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 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.

2.05.02 However if 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 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 Employer either at third party lab or in presence of client /Employers representative and submit the reports for approval.

2.05.03 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.

2.05.04 All routine tests in accordance with IS: 11171 shall be carried out on each transformer.

2.05.05 Transformer shall be short circuit tested after conducting the routine tests. Rest of the type tests shall be conducted after successful short circuit testing.

Routine / Type Tests (Dry Type Transformers)			
a.)	Measurement of winding Resistance for each tap position.		Routine Test
b.)	Measurement of voltage ratio at each taps position.		Routine Test
c.)	Vector group and polarity check		Routine Test
d.)	Measurement of impedance voltage/short circuit impedance & load loss at principal tap and extreme taps		Routine Test
e.)	Measurement of no load losses and magnetising current at rated frequency and 90%, 100% and 110% rated voltage.		Routine Test
f)	Measurement of insulation resistance		Routine Test
g)	Measurement of capacitance and tan delta		Routine Test
h)	Dielectric Tests		
	1)	PF/Separate source AC withstand voltage test.	Routine Test
	2)	Chopped wave lightning impulse voltage test on all the three limbs as per IEC 60076-3	Type Test
	3)	Induced over voltage withstand test	Routine Test
i)	Partial discharge measurement (However if it is conducted as routine test on all the coils, this test can be performed as type test).		Routine Test
j)	Measurement of iron loss & IR (repeat after induced voltage test)		Routine Test
k)	Short Circuit test as per IEC		Type Test
l)	Noise Level Measurement		Type Test
o)	Temperature rise test as per IEC (HV & LV winding)		Type Test

High voltage withstand test shall be performed on auxiliary equipment and wiring after assembly.

ANNEXURE-A

40MVA FGD TRANSFORMER (400 KV CLASS)

Winding Details						
S.No.	**Parameter**	**Unit**	**HV**	**HVN**	**LV1 & LV2**	**LV1N & LV2N**
1.	Lightning impulse withstand voltage	kVp	1425	95	75	75
2.	CW Lightning impulse withstand voltage	kVp	1570	-	82.5	-
3.	Switching impulse withstand voltage	kVp	1175	-	-	-
4.	One min power frequency withstand voltage	kV	630/38*	38	28	28
5.	Winding connection	-	Star	Solidly grounded	Star	through NGR.
* In case of non-uniformly insulated.						

	Bushing Details					
S.No.	**Parameter**	**Unit**	**HV**	**HVN**	**LV1& LV2**	**LV1N & LV2N**
1.	Rated Voltage	kV	420	36	12	12
2.	Rated Current (min.)	A	800	800	4000	800
3.	Lightning impulse withstand voltage	kVp	1550**	170	75	75
4.	Switching impulse voltage	KVp	1175			
5.	One min power frequency withstand voltage	kV	750	77	30	30
6.	Minimum total creepage distances	mm	10500	900	300	300

**The bushing shall be suitable for chopped wave lightning impulse test on transformer at 1570 KVp

SUB-SECTION-II-E13

ELEVATOR ELECTRICAL

ELEVATORS (ELECTRICALS)

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 130(B) or better insulation**

3.00.00 **CAR ELECTRICAL ACCESSORIES**

The following accessories shall be provided :

i) LED light fittings for illumination level of 100 lux on car floor.

ii) Portable light and alarm bell with battery and charger ventilation fan with control.

iii) Car control station with position indicator inside the car and at landing platforms (both visual and audio).

iv) Emergency stop switch.

v) 5/15A, 3 pin plug socket with switch on top of lift car.

vi) Hand free speaker telephone set connected to plant network.

vii) AUTOMATIC RESCUE DEVICE (ARD)-(BATTERY DRIVE) :

Contractor to provide a modern Advanced electronic drive system of “RESCUING Passenger Trapped in a ELEVATOR”.

viii) 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 trailing cables if offered shall be in accordance with IEC-60227-6.

All wiring / cabling between the equipments in the lift machine room and that between the machine room and equipments in the lift well and at the landings shall be wired in HDP conduits/ galvanized steel conduits to be supplied by the contractor. Alternatively armored cables may be used.

7.00.00 **Earthing:**
The elevator 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.

SUB-SECTION-II-E14

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 alongwith 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.

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. The area given in BOQ is for guidance to the vendor. 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/galvanising/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 size 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. The Contractor shall be paid for this work at the unit rates for the respective brickwork/ R.C.C.
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 workmen 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 relevant 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.
6.09.00	Any work like chipping, breaking of existing structure like wall, floors, fabrications, any civil work etc. shall be done after taking prior approval of the Project Manager.
6.10.00	The following jobs are also in the scope of contractor's work and shall be carried out at no extra cost to the Employer: a) Reasonable amount of drilling, cutting and welding surface preparation to fix the fire stops. b) Supply of necessary cement, gravel, sand etc. required for grouting necessary supports.

c) All supporting arrangement.

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 not earlier than ten years prior to the date of techno-commercial 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 ten years from the date of techno-commercial 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 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 test

b) Water absorption test

c) Fire rating test

d) Hose stream test

e) Vibration test followed by fire rating test

7.04.01 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.

7.04.02 Test indicated in clause 7.04.00 (e) above should have been carried out on a separate sample and as per the procedure indicated under clause 9.05.00.

7.04.03 Physical, chemical and mechanical properties of various components/ingredients used should have been also be tested as a part of type tests.

7.04.04 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.

7.05.00 **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.

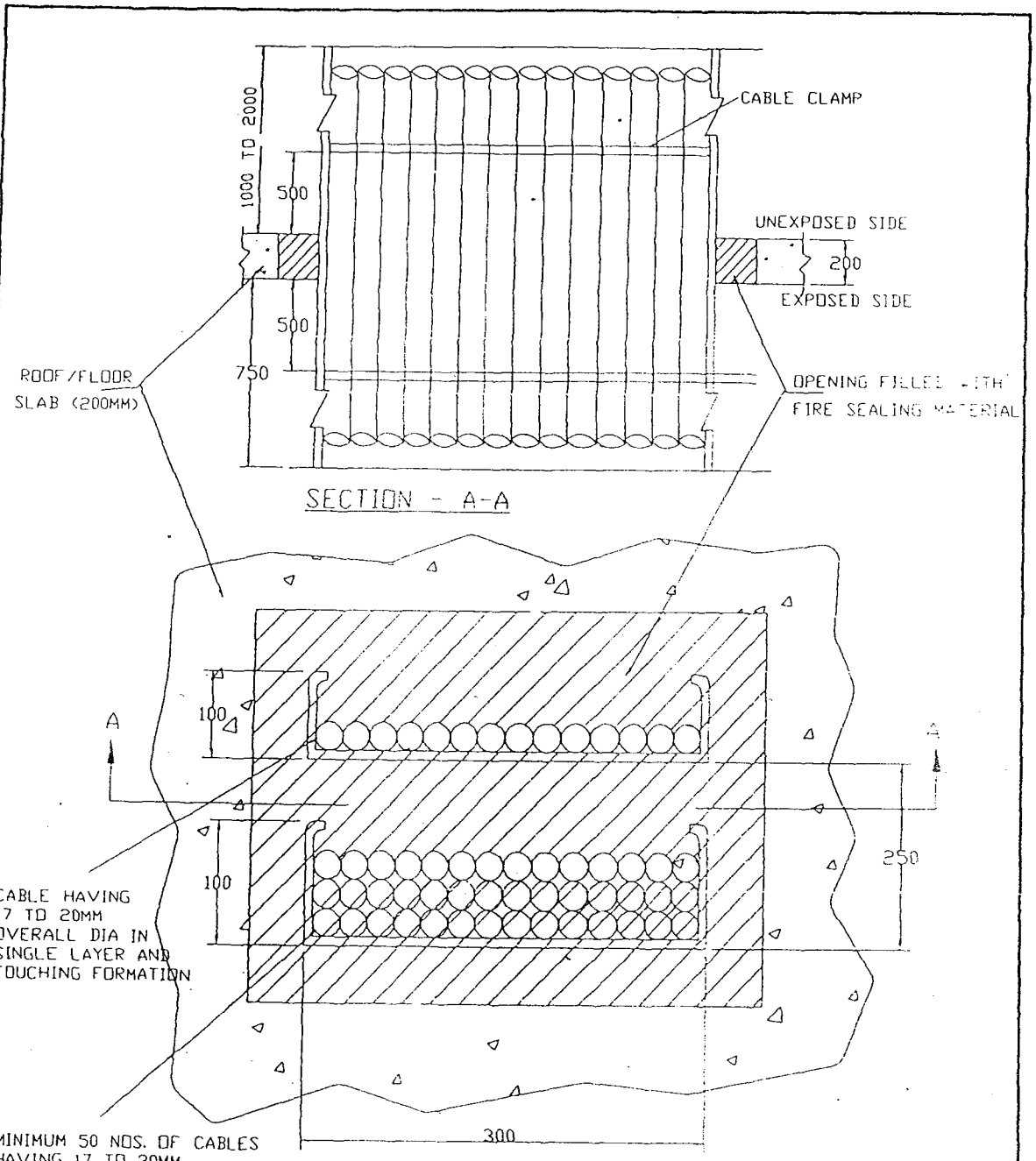
8.02.00 The test specimen shall be designed to seal an opening of adequate size in a concrete slab of 200 mm thickness. Two lengths of 300/600 mm wide ladder type cable tray shall be assembled with required layer of XLPE/PVC insulated, PVC sheathed unarmoured cables in touching formation. Type and number 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 metre, 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 characterised 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.



NOTES:

1. IN CASE OF BLOCK TYPE SYSTEM ARRANGEMENT SHALL BE WITH FRAME & BLOCKS HOWEVER NUMBER OF CABLES SHALL REMAIN SAME.
2. ALL DIMENSIONS ARE IN MM ONLY.
3. CABLES TO BE USED SHALL BE OF DIFFERENT DIA. ALL THE CABLES SHALL NOT BE OF SAME DIA.

REV. NO.	DESCRIPTION	DRAWN	DESIGN	CHKD	CLEARED BY M	E	C	C&I	ARCH	APPD	DATE
RB	FOR TENDER PURPOSE				-		-	-	-		15.7.06
RA	FOR TENDER PURPOSE				-		-	-	-		17.1.2006

एन टी पी सी NTPC

NTPC Limited
(A GOVERNMENT OF INDIA ENTERPRISE)
ENGINEERING DIVISION

PROJECT: STANDARD

TITLE: FIRE PROOF CABLE PENETRATION SYSTEM TEST SETUP

SIZE	SCALE	DRG. NO.	REV. NO.
A4	NTS	0000-211-PDE-A-051	RB

211-051.dwg

SUB-SECTION-II-E15

BATTERY

BATTERY

1.00.00 BATTERY RATINGS

1.	**For Ni-Cd Type Battery**	
a)	Battery Voltage	220V/110V/48 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 five(5)hour rate	As per requirement
e)	Nominal discharge voltage per Cell	1.2 V
f)	Float voltage	As per manufacturer's standards for float application
2.	**For Lead Acid Plante type Battery**	
a)	Battery Voltage	220V/110V/48 V DC
b)	No. of Cells	As per Sizing Calculations
c)	Battery type	Stationary Lead Acid Plante high discharge type
d)	Capacity for ten(10)hour rate	As per requirement
e)	Nominal voltage per cell discharge	2.0 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.

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.

PART-A: NICKEL-CADMIUM BATTERY

2.00.00 CODES AND STANDARDS

2.01.00 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 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:

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

Indian electricity rules

Indian Electricity Acts

2.02.00 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 along with 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.

3.00.00 GENERAL TECHNICAL REQUIREMENT

3.01.00 Equipments

(a.) DC Batteries shall be stationary Nickel Cadmium Pocket plate type (KPH)/ (KPL) conforming to IS 10918. The batteries shall be high discharge performance type as specified. For the purpose of design an ambient temperature of 50 degree centigrade and relative humidity of 85% shall be considered.

(b.) 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 1.54 to 1.7 volts per cell maximum and float charged at about 1.42 V/cell.

(c.) Batteries should be suitable for continuous operation for the maximum ambient temperature as defined in technical parameters.

3.02.00 Construction Features

3.02.01 Containers

Containers shall be made of polypropylene plastic material. Containers shall be robust, heat resistance, leak proof, non absorbent, alkali resistant, non-bulging type and free from flaws, such as wrinkles, cracks, blisters, pin holes etc. Electrolyte level lines shall be marked on container in case of translucent containers.

3.02.02 Vent Plugs

Vent plugs shall be provided in each cells. They shall be anti-splash type, having more than one exit hole shall allow the gases to escape freely but shall prevent alkali from coming out. The design shall be such that the water loss due to evaporation is kept to minimum. In addition the ventilator shall be easily removed for topping up the cells and of such dimensions that the syringe type hydrometer can be inserted into the vent to take electrolyte samples.

3.02.03 Plates

The plates shall be designed for maximum durability during all service conditions including high rate of discharge and rapid fluctuations of load. The construction of plates shall conform to latest revisions of IS 10918.

The separators shall maintain the electrical insulation between the plates and shall allow the electrolyte to flow freely. Separators should be suitable for continuous immersion in the electrolyte without distortion.

The positive and negative terminal posts shall be clearly marked.

3.02.04 Sediment Space

Sufficient sediment space shall be provided so that cells will not have to be cleaned during normal life and prevent shorts within the cells.

3.02.05 Electrolyte

The electrolyte shall be prepared from battery grade potassium hydroxide conforming to IEC 60993.

The cells can be shipped either in charged condition or in dry condition.

Necessary electrolyte for make-up shall be supplied separately.

3.02.06 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. The thickness of Nickel coating of connectors should be not less than 0.02 mm. All the terminals and cells inter-connectors shall be fully insulated or have insulation shrouds. End take off connections from positive and negative poles of batteries shall be made by single core cables having stranded AL conductors and XLPE insulation. 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 30 minutes discharge current of the respective batteries and through fault short circuit current which the battery can produce and withstand for the period declared. Contractor shall furnish necessary sizing calculations to prove compliance to the same. Suitable number of Inter-rack connectors shall be supplied by the Bidder to suit the battery room layout during detailed engineering.

3.02.07 Battery racks

Mild steel racks for all the batteries shall be provided. They shall be free standing type mounted on porcelain/hard rubber/PVC pads insulators/High impact plastic insulators. Batteries shall preferably be located in the single tier arrangement. However, batteries having a complete cell weight of lower than 50 Kg could be located in the double tier arrangement. The batteries racks and supports for cable termination shall be coated with three (3) coats of anti-alkali paint of approved shade. Name plates, resistant to alkali, for each cell shall be attached on to the necessary racks. The bottom tier of the stand shall not be less than 150 mm above the floor.

Wherever racks are transported in dismantled conditions, match markings shall be provided to facilitate easy assembly.

3.02.08 Manufacturer's Identification System

The following information shall be indelibly marked on outside of each cell.

(a.) Manufacturers' name and trade marks

(b.) Country and year of manufacture.

(c.) Manufacturer type designation.

(d.) AH capacity at 5 hour discharge rate.

(e.) Serial number

4.00.00 **THE FOLLOWING INFORMATION SHALL BE GIVEN ON THE INSTRUCTION CARDS SUPPLIED WITH THE BATTERY:**

(a.) Manufacturer's instructions for filling and initial charging of the battery together with starting and finishing charging rate.

(b.) Maintenance instructions.

(c.) Designation of cell in accordance with IS 10918.

(d.) Storing conditions of electrolyte.

5.00.00 **TESTS**

5.01.00 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 ten years from the date of techno-commercial 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.

5.02.00 However, if the contractor is not able to submit report of the type test(s) conducted within last ten years from the date of techno-commercial 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.

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 GENERAL

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.

5.05.00 Routine and Acceptance tests shall be as per Quality Assurance & Inspection table of battery.

5.06.00 Commissioning Checks:

All tests as listed below shall be carried out on sample cell selected at random by the employer at site after completion of installation.

(a.) Physical Examination

(b.) Dimensions, Mass & layout

(c.) MARKING

(d.) Polarity and absence of short circuit.

(e.) Ampere - hour capacity--4 Cycles

(f.) Insulation resistance

The Contractor shall arrange for all necessary equipment, including the variable resistor, tools, tackles and instruments.

PART-B: LEAD –ACID PLANTE BATTERY

6.00.00 CODES & STANDARDS

6.01.00 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:

IEC 60896	Stationary Lead-Acid Batteries
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

6.02.00 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.

7.00.00 GENERAL TECHNICAL REQUIREMENTS

7.01.00 Equipments

DC Batteries shall be stationary lead acid Plante positive plate type conforming to IS 1652. The battery shall be high discharge performance type. For the purpose of design an ambient temperature of 50 degree centigrade and relative humidity of 85% shall be considered.

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:

Batteries should be suitable for continuous operation for the maximum ambient temperature as defined in technical parameters.

7.02.00 Construction Features

7.02.01 Containers

Containers shall be made of transparent glass, hard rubber, suitable robust, heat resistance, leak proof, non absorbent, acid resistant, non-bulging type and free from flaws, such as wrinkles, cracks, blisters, pin holes etc. Electrolyte level lines shall be marked on container in case of transparent containers. Float type level indicator shall be provided in case of opaque containers. The stem portion of the float should be long enough to prevent falling of the float inside the container even if there is no electrolyte in the container. The marking for the electrolyte level should be for the upper and lower limits. The material of level indicator shall be acid proof and oxidation proof. Container shall be closed/sealed lid type. Lid and sealing compound shall be non-cracking type. The container made of hard rubber and plastics shall be type tested as per IS 1146. All type tests shall be carried out for sealing compound as per IS 3116.

The pole sealing arrangement should be such that no acid particle get entrapped due to acid creep as a result of capillary action and it should be possible to remove and refix the sealing to carry out the maintenance.

7.02.02 Vent Plugs

Vent plugs shall be provided in each cells. They shall be antis-plash type, having more than one exit hole shall allow the gases to escape freely but shall prevent acid from coming out. The design shall be such that the water loss due to evaporation is

kept to minimum. In addition the ventilator shall be easily removed for topping up the cells and of such dimensions that the syringe type hydrometer can be inserted into the vent to take electrolyte sample.

7.02.03 Plates

The plates shall be designed for maximum durability during all service conditions including high rate of discharge and rapid fluctuations of load. The construction of plates shall conform to latest revisions of IS 1652 as applicable.

The separators shall maintain the electrical insulation between the plates and shall allow the electrolyte to flow freely. Separators should be suitable for continuous immersion in the electrolyte without distortion. The positive and negative post shall be clearly marked.

7.02.04 Sediment Space

Sufficient sediment space shall be provided so that cells will not have to be cleaned during normal life and prevent shorts within the cells.

7.02.05 Cell Insulator

Each cell shall be separately supported on PVC/porcelain/hard rubber insulators fixed on the racks with adequate clearance between adjacent cells. Minimum distance between adjacent cells shall be more than the bulge allowed for two cells in accordance with IS 1146.

7.02.06 Electrolyte

The electrolyte shall be prepared from battery grade sulphuric acid conforming to IS 266 and distilled water conforming to IS 1069. The cells shall be shipped dry uncharged. The electrolyte shall be supplied separately.

7.02.07 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. The thickness of lead-coating of connectors should not be less than 0.025 mm. The lead coating thickness shall be measured in accordance with APPENDIX F of IS 6848 (latest edition). All the terminals and cells inter-connectors shall be fully insulated or have insulation shrouds. End take off connections from positive and negative poles of batteries shall be made by single core cables having stranded copper conductors and PVC insulation. 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 30 minutes discharge current of the respective Batteries and through fault short circuit current which the battery can produce and withstand for the period declared. Contractor shall furnish necessary sizing calculations to prove compliance to the same.
7.02.08	Battery racks Wooden racks for all the batteries shall be provided. These racks shall be made of good quality first class seasoned teak wood in line with CPWD specification. They shall be free standing type mounted on porcelain/hard rubber/PVC pads insulators/High impact plastic insulators. Batteries shall preferably be located in the single tier arrangement. However, batteries having a complete cell weight of lower than 50 Kg could be located in the double tier arrangement. The batteries rack and wooden support for cable termination shall be coated with three (3) coats of anti-acid paint of approved shade. Numbering tags, resistant to acid, for each cell shall be attached on to the necessary racks. The bottom tier of the stand shall not be less than 150 mm above the floor. Wherever racks are transported in dismantled condition, suitable match markings shall be provided to facilitate easy assembly.
7.02.09	Manufacturer's Identification Systems The following information shall be indelibly marked on outside of each cell. (a.) Manufacturer's name and trade marks (b.) Country and year of manufacture. (c.) Manufacturer type designation. (d.) AH capacity at 10 hour discharge rate. (e.) Serial number
8.00.00	**TESTS**
8.01.00	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 ten years from the date of techno-commercial 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.
8.02.00	However if the contractor is not able to submit report of the type test(s) conducted within last ten years from the date of techno-commercial 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.
8.03.00	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.
8.04.00	GENERAL 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.
8.05.00	Routine and Acceptance tests shall be as per Quality Assurance & Inspection table of battery.
8.06.00	Commissioning Checks: All tests as listed below shall be carried out on sample cell selected at random by the employer at site after completion of installation. 1) Verification of markings. 2) Verification of dimensions. 3) Test for capacities for 10 hrs discharge rate alongwith the test for voltage during discharge. The Contractor shall arrange for all necessary equipment, including the variable resistor, tools, tackles and instruments.
9.00.00	**DC HEALTH MONITORING SYSTEM**
9.01.00	DC Health Monitoring System shall include microprocessor based hardware and software to monitor the condition of each battery cell of 220V DC systems battery banks on-line on 24x7 basis. With DC Health Monitoring System it shall be possible to measure & analyse the individual cell and battery parameters so that any damage to battery shall be prevented by pro-active maintenance. A typical Architecture is shown in Drg. No. 0000-209-POE- A-002. Each Battery set shall have its own independent DC Health Monitoring System.
9.02.00	DC Health Monitoring System shall measure and store the following parameters at pre-determined time interval as decided by the employer during detail engineering:

a) Each Cell Voltage

b) Battery DC Current

c) Ambient temperature (1No.) and Cell temperature (1No.)

Further, DC Health Monitoring System module shall have provision of accepting at least 6 Nos. of Digital inputs and 2 Nos. of Analog inputs(4-20mA). DC Health Monitoring System shall also be able to store these inputs status for future reference.

9.03.00 **Technical Parameters**

a)	Input Power Supply	230V AC(UPS) / 220V DC
b)	Voltage Measurement Accuracy	0.5% or better
c)	Current Measurement Accuracy	0.5% or better
d)	Operating Temperature Range	0-50^0 C
e)	Mounting	Panel Mounting
f)	IP Protection	IP42

9.04.00 **Communication**

DC Health Monitoring System shall communicate with the Switchgear SCADA System and provide alarms for abnormal condition of Cell/Battery as finalized by Employer during detailed engineering. DC Health Monitoring System modules shall have one port suitable for connecting laptop locally and one port suitable for TCP/IP protocol for communication to SCADA system. The Cable required for connecting the cells to DC Health Monitoring System and DC Health Monitoring System to SCADA system shall also be under Bidder's scope.

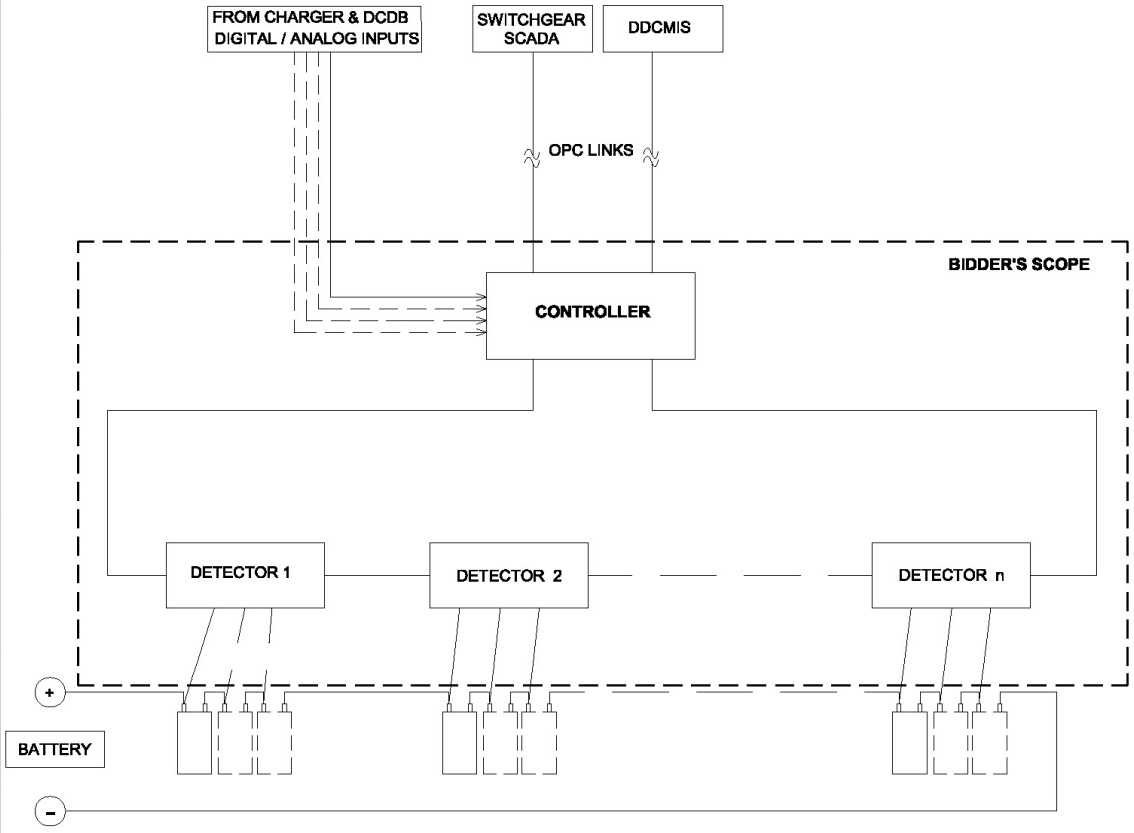
DC FAIL alarm shall be generated and given in Control Room buzzer (Audio Visual Fascia).

9.05.00 **Software**

Necessary software for communication between DC Health Monitoring System and Switchgear SCADA System as well as for analysis of stored data shall be provided by the bidder. The software for analysis shall be capable of showing graphical representation of various stored parameters and shall give some corrective suggestion based on the abnormal parameters. The software shall calculate and show battery Ah during charge/discharge cycles.

9.06.00 Logging of cell/battery parameters (voltage, current and temperature) and alarm conditions as well as event log of all activities affecting the battery bank shall be possible with date/time stamp. Logged data can be exported in MS Excel format.

10.00.00



TYPICAL ARCHITECTURE FOR DC HEALTH MONITORING SYSTEM

REV. NO.	DESCRIPTION	DRAWN	DESIGN	CHKD	M	E	C	C&I	APPD	DATE
RA.	FOR TENDER PURPOSE	MV	M. PANDIT						C.SAROJ	07.05.12
		CLEARED BY								

NTPC Limited
(A Govt. of India Enterprise)
ENGINEERING DIVISION

PROJECT: STANDARD

TITLE: BLOCK DIAGRAM OF DC HEALTH MONITORING SYSTEM

SIZE	SCALE	DRG. NO.	REV. NO.
A4	NTS	0000-209-POE-A-002	RA

ENGINEERING DIVISION

SUB-SECTION-II-E16

BATTERY CHARGER

BATTERY CHARGER

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 techno-commercial 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 and codes.

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: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.

1.02.00 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 along with 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.

2.00.00 EQUIPMENT DESCRIPTION

2.01.00 PART-I BATTERY CHARGER FOR LEAD ACID PLANTE TYPE BATTERY

(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. The Batteries shall be Trickle charged at 2.25 Volts per cell. All chargers shall also be capable of Boost Charging the associated D.C. Battery at 2.3 to 2.7 Volts per cell at the desired rate. The Chargers shall be designed to operate, as mentioned above, at an ambient air temperature of 50°C.

(b.) All Battery Chargers shall have provision to receive two input supplies along with suitable automatic changeover between the sources.

(c.) Battery Chargers shall have a selector switch for selecting the battery charging mode i.e. whether Trickle or Boost charging.

(d.) All Battery Chargers shall be provided with facility for both automatic and manual control of output voltage and current. A selector switch shall be provided for selecting the mode of output voltage/current control, whether automatic or manual. Means shall be provided to avoid current/voltage surges of harmful magnitude/nature which may arise during changeover from Auto to Manual mode or vice-versa under normal operating condition.

(e.) Soft start feature shall be provided to build up the voltage to the set value slowly within fifteen seconds. The chargers shall have load limiters which shall cause, when the voltage control is in automatic mode, a gradual lowering of the output voltage when the 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 Charger shall not trip on overload or external short circuit. After clearance of fault, the Charger voltage shall build up automatically when working in automatic mode.

(f.) When on automatic control mode during Trickle charging, the Charger output voltage shall remain within +/-1% of the set value for AC input voltage variation of +/-10%, frequency variation of +3/-5%, a combined voltage and frequency (absolute sum) variation of 10% and a continuous DC load variation from zero to full load. Uniform and step-less adjustments of voltage setting (in both manual and automatic modes) shall be provided on the front of the Charger panel covering the entire Trickle charging output range specified & shall be capable of matching the float voltage correction recommendations(w.r.t. temperature) as suggested by the respective battery manufacturer. Step-less adjustment of the load limiter setting shall also be possible from 80% to 100% of the rated output current for Trickle charging mode.

(g.) During Boost charging, the Battery Chargers shall operate on constant current mode (When automatic regulator is in service). It shall be possible to adjust the Boost charging current continuously over a range of 50 to 100% of the rated output current for Boost charging mode. The charger output voltage shall automatically go on rising, when it is operating on boost mode, as the battery charges up. For limiting the output voltage of the charger, a potentiometer shall be provided on the front of the panel, whereby it shall be possible to set the upper limit of this voltage anywhere in the output range specified for boost charging mode. All voltage and current setting potentiometers shall be vernier type.

(h.) Energizing the Charger with fully charged battery connected plus 10% load shall not result in output voltage greater than 110% of the voltage setting. Time taken to stabilize, to within the specified limits as mentioned elsewhere, shall be less than fifteen seconds.

(i.) Momentary output voltage of the Charger, without the Battery connected shall be within 94% to 106% of the voltage setting during sudden load Change from 100% to 20% of full load or vice-versa. Output voltage shall return to, and remain, within the limits

specified as mentioned elsewhere in less than 2 seconds after the above mentioned change.

(j.) The Charger manufacturer may offer an arrangement in which the voltage setting device for Trickle charging mode is also used as output voltage limit setting device for Boost charging mode, and the load limiter of the trickle charging mode is also used as Boost charging current setting device.

(k.) Suitable filter circuits shall be provided in all the Chargers to limit the ripple content (peak to peak) in the output voltage to 1% irrespective of the DC load, even when they are not connected to a battery.

(l.) The DC System shall be ungrounded and float with respect to the ground potential when healthy.

2.02.00 PART-II BATTERY CHARGER FOR NICKEL-CADMIUM TYPE BATTERY

(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 Nickel-Cadmium Batteries while supplying the D.C. loads. The Batteries shall be Trickle charged at 1.4 to 1.42 Volts per cell. All chargers shall be capable of Boost Charging the associated D.C. Battery at 1.53 to 1.7 Volts per cell at the desired rate. The Chargers shall be designed to operate, as mentioned above, at an ambient air temperature of 50°C.

(b.) All Battery Chargers shall have provision to receive two input supplies along with suitable automatic changeover between the sources.

(c.) Battery Chargers shall have a selector switch for selecting the battery charging mode i.e. whether Trickle or Boost charging.

(d.) All Battery Chargers shall be provided with facility for both automatic and manual control of output voltage and current. A selector switch shall be provided for selecting the mode of output voltage/current control, whether automatic or manual. Means shall be provided to avoid current/voltage surges of harmful magnitude/nature which may arise during changeover from Auto to Manual mode or vice-versa under normal operating condition.

(e.) Soft start features shall be provided to build up the voltage to the set value slowly within fifteen seconds. The chargers shall have load limiters which shall cause, when

the voltage control is in automatic mode, a gradual lowering of the output voltage when the 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 not damage the Charger, nor shall it cause blowing of any of the charger fuses. The Charger shall not trip on overload or external short circuit. After clearance of fault, the Charger voltage shall build up automatically when working in automatic mode.

(f.) When on automatic control mode during Trickle charging, the Charger output voltage shall remain within +/-1% of the set value for AC input voltage variation of +/-10%, frequency variation of +3 to -5%, a combined voltage and frequency (absolute sum) variation of 10% and a continuous DC load variation from zero to full load. Uniform and stepless adjustments of voltage setting (in both manual and automatic modes) shall be provided on the front of the Charger panel covering the entire Trickle charging output range specified & shall be capable of matching the float voltage correction recommendations(w.r.t. temperature) as suggested by the respective battery manufacturer. Stepless adjustment of the load limiter setting shall also be possible from 80% to 100% of the rated output current for Trickle charging mode.

(g.) During Boost charging, the Battery Chargers shall operate on constant current mode (When automatic regulator is in service). It shall be possible to adjust the Boost charging current continuously over a range of 50 to 100% of the rated output current for Boost charging mode. The charger output voltage shall automatically go on rising, when it is operating on boost mode, as the battery charges up. For limiting the output voltage of the charger, a potentiometer shall be provided on the front of the panel, whereby it shall be possible to set the upper limit of this voltage anywhere in the output range specified for boost charging mode. All voltage and current setting potentiometers shall be vernier type.

(h.) Energising the Charger with fully charged battery connected plus 10% load shall not result in output voltage greater than 110% of the voltage setting. Time taken to stabilise, to within the specified limits as mentioned elsewhere shall be less than fifteen seconds.

(i.) Momentary output voltage of the Charger, without the Battery connected shall be within 94% to 106% of the voltage setting during sudden load Change from 100% to 20% of full load or vice-versa. Output voltage shall return to, and remain, within the limits specified as mentioned elsewhere in less than 2 seconds after the above mentioned change.

(j.) The Charger manufacturer may offer an arrangement in which the voltage setting device for Trickle charging mode is also used as output voltage limit setting device for Boost charging mode, and the load limiter of the trickle charging mode is also used as Boost charging current setting device.

(k.) Suitable filter circuits shall be provided in all the Chargers to limit the ripple content (peak to peak) in the output voltage to 1% irrespective of the DC load, even when they are not connected to a battery.

(l.) The DC System shall be ungrounded and float with respect to the ground potential when healthy.

2.03.00 Printed Circuits Boards (PCB)

PCB shall be made of glass epoxy of 1.6 mm thick, fire resistant, bonded with 99.8% pure copper foil, free of wrinkles, blisters, scratches and pinholes. The contact surface of the edge connectors of the PCBs shall be plated with hard gold to a minimum thickness of 5 microns. Component identification shall be printed on PCB by silk screen method. All PCBs shall be tropicalised and masked.

2.04.00 CONTACTORS

All Battery Chargers shall have an AC contactor on the input side. It shall be of air break type and suitable for continuous duty. The operating coil shall be rated for 415 Volts AC.

2.05.00 Thermal Overload Relay

A thermal overload relay incorporating a distinct single phasing protection (using differential movement of bimetal strips) shall also be provided for the AC input. The relay shall trip the above contactor.

2.06.00 Rectifier-Transformers and Chokes

The rectifier transformer and chokes shall be dry and air cooled (AN) type. The rating of the rectifier-transformers and chokes shall correspond to the rating of the associated rectifier assembly. The rectifier-transformers and chokes shall have class-B insulation with temperature rise limited to class-A insulation value.

2.07.00 Rectifier Assembly

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°C absolute duly considering the maximum charger panel inside temperature. The Contractor shall submit calculations to show what maximum junction temperature will be and what the heat sink temperature will be when operating at 200% and 100% load current continuously duly considering the maximum surrounding air temperature for these devices inside the charger panel assuming air ambient temperature of 50°C outside the panel. Necessary surge protection devices and rectifier type fast acting fuses shall be provided in each arm of the rectifier connections.

2.08.00 DIGITAL INDICATING INSTRUMENTS

Digital indicating instruments with built in communication port for remote data transfer shall be provided for all chargers. The instruments shall indicate DC current, DC voltage & AC voltage and instrument shall be 96 x 96 mm^2, with display accuracy 0.5%, 4 digit-7 segment LED/LCD display and RS 485 Serial Bus port.

2.09.00 AIR BREAK SWITCHES

All Chargers shall have AC input and DC output switches of air break, single throw, load break and fault make type. The contacts of the switches shall open and close with a snap action. Switches shall be rated for 120% of the maximum continuous load. 'ON' & 'OFF' position of the switch shall be clearly indicated.

2.10.00 CONTROL AND SELECTOR SWITCHES

Control and selector switches shall be of rotary stayput type with escutcheon plates showing the functions and positions. The switches shall be of sturdy construction and suitable for mounting on panel front. Switches with shrouding of live parts and sealing of contacts against dust ingress shall be preferred. The contact ratings shall be atleast the following:

(a.) Make and carry continuously – 10 Amps.

(b.) Breaking current at 220 V DC – 0.5 Amp. (inductive)

(c.) Breaking current at 240 V AC – 5 Amp. At 0.3 p.f.

2.11.00 FUSES

Fuses shall be of HRC cartridge fuse link type. Fuses shall be mounted on fuse carriers which are mounted on fuse bases. Wherever it is not possible to mount fuses on fuse carriers, fuses shall be directly mounted on plug in type bases. In such cases one insulated

fuse pulling handle shall be supplied for each charger. Kick-off fuses (trip fuses) with alarm contacts shall be provided for all D.C. fuses.

2.12.00 Indicating Lamps

Three (3) indicating lamps shall be provided to indicate A.C. supply availability. The indicating lamp shall be of panel mounting, filament type low wattage or LEDs and capable of clear status indication under the normal room illumination. The lamps shall be provided with series resistors (non-hygroscopic) preferably built in the lamp assembly and replaceable from front. The lamp covers shall be preferably screwed type, unbreakable and moulded from heat resistant material

2.13.00 Blocking Diode

Blocking diode shall be provided in the output circuit of each Charger to prevent current flow from the D.C. Battery into the Charger.

2.14.00 Annunciation System

Visual indications through indicating lamps/LEDs or annunciation fascia shall be provided in all Chargers for the following:

(a.) A.C. supply failure

(b.) Rectifier fuse failure

(c.) Surge circuit fuse failure

(d.) Filter fuse failure

(e.) Load limiter operated

(f.) Charger trip

(g.) Battery on Boost

Potential free NO contacts of all above conditions shall be provided for following remote alarms in the PLC/DCS:

(a) Battery on Boost

(b) Charger trouble (this being a group alarm initiated by any of the faults other than 'Battery on Boost')

2.15.00 Name Plates and Marking

The name plates shall be made of non-rusting metal/3 ply Lamicoid and shall have black back-ground with white engraved letters and secured by screws. These shall be provided near top edge on the front as well as on rear side of Charger. Name plates with full and clear inscriptions shall also be provided on and inside the panels for identification of the various equipments.

3.00.00 CONSTRUCTION

3.01.00 The Chargers shall be indoor, floor mounted, self supporting sheet metal enclosed cubicle type. The Contractor shall supply all necessary base frames, anchor bolts and hardware. The Charger shall be fabricated using cold rolled sheet steel shall not less than 1.6 mm and shall have folded type of construction. The panel frame shall be fabricated using cold rolled sheet steel of thickness not less than 2.0 mm. Removable undrilled gland plates of at least 3.0 mm sheet steel and lugs for all cables shall be supplied by the Contractor. The lugs for cables shall be made of electrolytic copper with tin coat. Cable sizes shall be advised to the Contractor at a later date for provision of suitable lugs and gland plates. The Charger shall be tropicalised and vermin proof. Ventilation louvers shall be backed with fine brass wire mesh. All doors and covers shall be fitted with synthetic rubber gaskets. The Chargers shall have hinged double leaf doors provided on front and/or backside for adequate access to the Charger internals. All the Charger cubicle doors shall be properly earthed. The degree of protection of Charger enclosure shall be atleast IP-42.

3.02.00 All indicating instruments, control & selector switches and indicating lamps shall be mounted on the front side of the Charger. Design of panels shall be based on the following dimensions.

1)	Overall height	-	Maximum 2350 mm
2)	Operating handles (highest and lowest positions reached by operator's hands), protective mechanical	-	Maximum 1800 mm Minimum 350 mm

		indicators		
	3)	Doors and panel handles and locks	-	Maximum 1800 mm Minimum 300 mm

3.03.00 The layout of Charger components shall be such that their heat losses do not give rise to excessive temperature within the Charger panel surface. Location of the electronic modules will be such that temperature rise of the location, in no case, will exceed 10°C over ambient air temperature outside the Charger.

3.04.00 Each Charger panel shall be provided with an illuminating lamp and one 5 Amp. Socket. Switches and fuses shall be provided separately for each of the above.

3.05.00 Locking facilities shall be provided as following:

1. For locking Trickle/Boost selector switch in the respective position.
2. The Charger enclosure door locking requirements shall be met by the application of padlocks. Padlocking arrangement shall allow ready insertion of the padlock shackle but shall not permit excessive movement of the locked parts with the padlock in position.

3.06.00 Wiring

3.06.01 Each Charger shall be furnished completely wired upto power cable lugs and terminal blocks ready for external connection. The power wiring shall be carried out with 1.1 KV grade PVC insulated cables conforming to IS:1554 (Part-I). The control wiring shall be of 1.1KV grade PVC insulated stranded copper conductors of 2.5 sq.mm. conforming to IS:694. Control wiring terminating at electronic cards shall not be less than 1.0 sq. mm. Control terminal shall be suitable for connecting two wires with 2.5 sq.mm. stranded copper conductors. All terminals shall be numbered for ease of connections and identification. At least 20% spare terminals shall be provided for circuits.

3.06.02 Power and control wiring within panels shall be kept separate. Any terminal or metal work which remains alive at greater than 415 V, when panel door is opened, shall be fully protected by shrouding.

3.06.03 An air clearance of at least ten (10) mm shall be maintained throughout all circuits, except low voltage electronic circuits, right upto the terminal lugs. Whenever this clearance is not available, the live parts should be insulated or shrouded.

3.07.00 PAINTING

Treatment as per IS:6005. Two coats of lead oxide primer followed by powder painting with final shade of RAL9002 for complete panel except end covers & RAL 5012 for end covers.

4.00.00 TESTS

4.01.00 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 ten years from the date of techno-commercial 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.

4.02.00 However if the contractor is not able to submit report of the type test(s) conducted within last ten years from the date of techno-commercial 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.

4.03.00 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.

4.04.00 GENERAL

1. For chargers of rating more than 60A, 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) Ripple content test at

i) No load

ii) Half load

iii) Full load

f) Automatic voltage regulator operation test at specified A.C. supply variations at

i) No load

ii) Half load

iii) Full load

g) Load limiter operation test

h) Efficiency and power factor measurement.

i) 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).

j) Environmental Tests

Steady state performance tests (f) and (g) shall be carried out before and after each of the following tests.

i) Soak Test

The electronic modules shall be subjected to continuous operation for a minimum period of 72 hours. During last 48 hours, the ambient temperature shall be maintained at 50 deg. C. The 48 hour test period shall be divided into four equal 12 hour segments. The input voltage during each 12 hours shall be nominal voltage for 11 hours followed by 110% of nominal voltage for 30 minutes, followed by 90% of nominal voltage for 30 minutes.

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.

5.00.00 COMMISSIONING

5.01.00 The contractor shall carryout the following commissioning tests and checks after installation of the equipment at site:

a) Complete physical examination.

b) Checking of proper operation of annunciation system.

c) Insulation resistance test.

d) Load limiter operation.

SUB-SECTION-II-E17

HT POWER CABLE

HT CABLES

1.00.00 CODES & 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 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.
IEC-332	Tests on electric cables under fire conditions. Part-3: Tests on bunched wires or cables (Category-B).

2.00.00 TECHNICAL REQUIREMENTS

2.01.00 The cables shall be suitable for laying on racks, in ducts, trenches, conduits and under ground (buried) installation with chances of flooding by water.

2.02.00 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 continuous conductor temperature of 90 deg. C and short circuit conductor temperature of 250 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 shall have distinct extruded PVC inner sheath of black colour as per IS: 5831.

2.06.00 For single core armoured cables, armouring shall be of aluminium wires. For multicore armoured cables armouring shall be of galvanised steel as follows : -

	Calculated nominal dia 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	0.8 mm thick GS formed wire/ 2.0 mm dia GS wire
iv)	Above 40 & upto 55mm	1.4 mm thick GS formed wire/ 2.5 mm 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 aluminium 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 aluminium armouring shall be same as mentioned for galvanised steel at 2.06.00 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 wires / formed wires. 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 GS wires/formed wires.

2.07.00 Distinct extruded PVC inner sheath of black colour 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.

2.08.00 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.

2.09.00 Cores of three core cables shall be identified by colouring of insulation or by providing coloured tapes helically over the cores, with Red, Yellow & Blue colours.

2.10.00 In addition to manufacturer's identification on cables as per IS, following marking shall also be provided over outer sheath :

(a.) Cable size and voltage grade - To be embossed
(b.) Word 'FRLS' at every 5 metre - To be embossed
(c.) Screen Fault current _ _ _KA for _ _ _ Sec. (Value of current & time shall be indicated as per BOQ)
(d.) Sequential marking of length of the cable in metres at every one metre

- To be embossed / printed

The embossing / printing shall be progressive, automatic, in line and marking shall be legible and indelible.

2.11.00 All cables shall meet the fire resistance requirement as per Category-B of IEC-332 Part-3.

2.12.00 Allowable tolerances on the overall diameter of the cables shall be +\-2 mm maximum over the declared value in the technical data sheets.

2.13.00 In plant repairs to the cables shall not be accepted. Pimples, fish eye, blow holes etc. are not acceptable.

2.14.00 The cross-sectional area of the metallic screen strip/tape/wires shall be considered in sizing calculations.

2.15.00 The eccentricity shall be calculated as

$$\frac{t_{max} - t_{min}}{t_{max}} \times 100$$

and the ovality shall be calculated as

$$\frac{d_{max} - d_{min}}{d_{max}} \times 100$$

Where t-max/t-min is the maximum/minimum thickness of insulation and d-max/d-min is the maximum / minimum diameter of the core.

The eccentricity of the core shall not exceed 10% and ovality not to exceed 2%.

2.16.00 **Cable selection & sizing**

2.16.01 HT cables shall be sized based on the following considerations:

a) Rated current of the equipment

b) The voltage drop in the cable, during motor starting condition, shall be limited to 10% and during full load running condition, shall be limited to 3% of the rated voltage

c) Short circuit withstand capability

2.16.02 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.

2.16.03 Cable lengths shall be considered in such a way that straight through cable joints is avoided.

2.16.04 All Cables shall be armoured type.

3.00.00 CONSTRUCTIONAL FEATURES

3.01.00 19/33 KV Grade Power Cables:

Cables shall conform to IS 7098 Part-II. These cables shall be multi-stranded, compacted circular aluminium conductor, XLPE-insulated, metallic screened suitable for carrying the system earth fault current as specified in B.O.Q, 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 19/33 KV Cables shall be " dry curing / gas curing " . The metallic screen for each core shall consist of copper tape with minimum overlap of 20%. However, for single core armoured cables , the armouring shall constitute the metallic part of the screening .

3.02.00 11/11kV & 6.6/6.6kV, Grade Power Cables:

Cables shall conform to IS-7098 Part-II. These cables shall be multi-stranded, compacted circular aluminium 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 shall be "dry curing / gas curing / steam curing ". The metallic screen for each core shall be capable of carrying earth fault current as specified in B.O.Q 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.

3.03.00 3.3/3.3 kV Grade Power Cables:

Cables shall conform to IS: 7098 Part - II. These cables shall be multi- stranded, compacted circular aluminium 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 earth fault current as specified in B.O.Q. Method of curing for cables shall be "dry curing / gas curing / steam curing".

4.00.00 CABLE DRUMS

4.01.01 Cables shall be supplied in non returnable wooden or steel drums of heavy construction. The surface of the drum and the outer most cable layer shall be covered with water proof cover. Both the ends of the cables shall be properly sealed with heat shrinkable PVC/ rubber caps secured by 'U' nails so as to eliminate ingress of water during transportation, storage and erection. Wood preservative anti-termite treatment shall be applied to the entire drum. Wooden drums shall comply with IS: 10418.

4.01.02 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.

4.01.03 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.

5.00.00 TESTS

5.01.00 **TYPE, ROUTINE AND ACCEPTANCE TESTS**

1. All equipments to be supplied shall be of type tested design. During detailed engineering, the contractor shall submit for Employer'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 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 ten 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 Employer either at third party lab or in presence of client /Employers 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.

5.01.01 The following type tests reports to be submitted for one size each of 19/33 kV, 11/11kV, 6.6/6.6kV and 3.3/3.3kV 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
23.	Insulation resistance test	Volume Resistivity method
24.	High voltage test	
25. *	Partial discharge test	
26. *	Bending test	
27. *	Dielectric power factor test a) As a function of voltage b) As a function of temperature	
28. *	Heating cycle test	
29. *	Impulse withstand test	

* Not applicable for 3.3/3.3kV grade cables.

5.02.00 Indicative list of tests/ checks, Routine and Acceptance tests shall be as per Quality Assurance & Inspection table of H.T. Cables enclosed with this chapter.

SUB-SECTION-II-E18

SWITCHYARD ELECTRICAL

CHAPTER: E-18 SWITCHYARD ELECTRICAL

1.00.00 SCOPE, GENERAL INFORMATION AND DESIGN CRITERIA

1.01.00 In addition to the detailed scope and other requirements specified in Part-A, the intent of the specifications for various electrical equipments shall also cover the following scope:

1.01.01 Contractor shall be responsible for design and engineering of overall system/station, and all elements, systems, sub-systems, facilities, equipments, material, etc. The Contractor shall submit design calculations, drawings, codes, codes of practices, construction drawings, etc. for Employer's approval.

1.01.02 The basic design shall include, but not limited to, the following:

a) Development of general arrangement.
b) Development of detailed layout (plan & section/elevation) drawings.
c) Development of single line diagram with parameters of equipment and details of protection.
d) Protection and control philosophy and selection of protection, control and annunciation schemes.
e) Development of interlocking schemes.
f) Development of switchyard structure loading details.
g) Development of earthing system.
h) Development of direct stroke lightning protection system.
i) Calculation of static and dynamic force load, and selection of spacer spans and equipment terminal loading.
j) Development of clearance diagrams.
k) Lighting design, Lux level calculation and conduit wiring diagram.
l) Development of power & control cable laying and termination schedules.
m) Relay setting calculations.
n) Development of erection key diagram with bill of material.
o) Foundation design and construction drawings.
p) Development of cable trench layout and sections and construction drawings.

1.01.03 Contractor shall furnish detailed drawings for the various equipments covered in their scope for Employer's approval.

1.01.04 Contractor shall furnish design calculations and construction drawings for all civil works showing details of pockets to be left in foundations and embedments to be provided in cable trenches.

1.01.05 Contractor shall furnish the schematics, general arrangement drawings, cable schedules, interconnection schedules, panel wiring diagrams, etc. for various control and relay panels for Employer's approval. Contractor shall also furnish the recommended relay settings to be adopted.

1.1.6	The Contractor shall note that the list of standards specified elsewhere in this specification is not complete. Whenever necessary the list of standards shall be considered in conjunction with specification, IS & IEC. In case governing standards for the equipment is different from IS or IEC, the salient points shall be clearly brought out along with English language version of the same.
1.01.07	Exposed live parts shall be placed high enough above ground to meet the requirements of Indian Electricity Rules and other statutory codes. All responsibilities regarding co-ordination with Electrical Inspection Agencies and obtaining clearance certificate from them rests with the Contractor.
1.01.08	For 220kV Switchyard, the existing Busbar is of quad/twin moose. The equipment interconnections shall be through IPS Aluminium tube. The rigid busbars shall have not more than one joint per span. Corona Bell shall be provided at the end of the rigid busbar. The spacing for quadruple and twin moose ACSR conductor shall be 450 mm. As far as possible the conductor shall pass without cut/joints unless otherwise necessary for planned shutdown/ maintenance. For 400kV Switchyard, the Busbar shall be of 4" IPS tube. The equipment interconnections shall be through 4" IPS Al. tube for 400kV. The rigid busbars shall have not more than one joint per span. Corona Bell shall be provided at the end of the rigid busbar. The spacing for quadruple and twin moose ACSR conductor shall be 450 mm for 400kV. All the 'T' off connections at 'A' row associated with transformers shall be provided with a bye pass utilizing two PG clamps for each 'T' off. As far as possible the conductor shall pass without cut/joints unless otherwise necessary for planned shutdown/ maintenance.
1.01.09	All equipment shall be supplied with suitable terminal connectors. The terminal connector shall be well coordinated with the type/size of conductor and equipment to be connected. The conductor terminations for equipment shall be either rigid or expansion type suitable for tube or horizontal or vertical take off suitable for quadruple/ twin/ moose ACSR and single zebra conductor. The exact requirement to terminal clamps would be finalised by the Contractor in consultation with Employer based on layout requirement. The terminal pads shall preferably be capable of taking the required conductor span under normal, short circuit and meteorological conditions, without effecting the performance of the equipment.
1.01.10	The rigid busbars for equipment inter connections shall have rigid connections at one end and expansion /flexible at other end. The tubular Al .connections shall have not more than one joint per span. Since no wastages are permissible, the bidder shall workout the cut lengths of Aluminium tube based on the finalised layout, & dispatch the same to site without requiring Owner's approval. Corona Bell shall be provided at the end of the rigid busbars.
1.01.11	The minimum vertical distance from the bottom of the lowest porcelain part of the bushing, porcelain enclosures or supporting insulators to the bottom of the equipment structure, where it rests on the foundation pad shall be 2550 mm.

	The various minimum heights of the switchyard shall be same as followed in existing switchyard.
1.01.12	The Bay width (Beam Span) for 220kV Switchyard Gantry structures should be 18m.
1.01.13	The Bay width (Beam Span) for 400kV Switchyard Gantry structures should be 27m.
1.01.14	Short circuit force of 400 kg is to be considered for designing of equipment structure and foundation.
1.01.15	Circuit breakers shall be supplied with necessary interpole cabling, and its cost shall be included in the cost of equipment.
1.01.16	All equipment shall be suitable for hot line washing.
1.01.17	The Contractor shall cooperate in all respects and exchange the necessary technical data/ drawings with other agencies and Employer's other Contractors under intimation to Employer to ensure proper coordination and completion of work in time.
1.01.18	The sag tension, conductor spacing, short circuit forces, spacers location, conductor swing and clearances shall be carried out in accordance with IEC 60865 to achieve the specified clearances.
1.01.19	All overhead stringing shall be carried out by minimum double tension string insulator assembly.
1.01.20	Post insulators shall be provided at line entry and near transformers and other jumpers so as to avoid mechanical forces on the LA's and Bushings etc.
1.01.21	The pit size of transformer shall be designed for minimum 1000 mm beyond the physical dimension of the transformer
1.01.22	Entire area of Switchyard shall be provided with broken stone filling which shall consist of two layers. The first layer shall be 75mm thick base course of 20mm of normal size and second layer shall be 75 mm thick surface course of 40 mm nominal size. 75mm thick base layer of M5 grade PCC shall be provided over the prepared sub grade in the entire area of the Switchyard inside the fence excluding foundations, roads, drains, cable trenches as per detailed engineering drawing. For easy drainage of water, adequate slope is to be provided from the ridge to the nearest drain. A final layer of minimum 75mm thickness of stone aggregate of 40mm nominal size shall be spread uniformly over PCC layer.

	Before laying of PCC layer, the subgrade shall be properly compacted and the top layer of the soil shall be treated for anti-weed considering the type of weeds found in the vicinity
1.01.23	The towers and gantries shall be suitable for a normal conductor tension of minimum 2T/conductor in case of Twin Moose/ Single moose and 1.5T/conductor in case of Quad Moose conductor. The foundations and structures etc. shall be designed accordingly.
1.01.24	One number marshalling boxes (BMK) are to be provided for each bay. The duplicated power supplies for two (2) BMKs shall be looped.
1.01.25	The AC Kiosk if applicable shall be located suitably in the switchyard. The kiosk shall be provided with fire alarm system with at least two detectors and it shall be wired to SAS. Two nos. of suitable separate power supply from LT switchgear shall be provided to each AC kiosk to cater power supply to panels and AC separately. All internal power supply distribution shall be provided accordingly.
1.01.26	The cable trenches as required for the scope work shall be constructed by the Contractor.
1..01.28	For earthing 50x6 mm GS flat shall be used in all cabinets, MOM boxes, panels and balance all other earthing such as all equipments, towers cable trenches etc. shall be through 75x12mm GS Flat. The Switchyard earthing criteria is given elsewhere in installation portion of the specification.
1.01.29	Voltage drop for sizing of power cables shall not be more than 6%.
1.01.30	The illumination level shall be minimum 20 lux in general and minimum 50 lux on equipment boxes.
1.01.31	The connectors and clamps shall be rated same as the connected equipments.
1.01.32	For miscellaneous items of supply (clamps, connectors, insulator strings & hardware, power & control cables, lighting systems), the Bidder shall supply equipment/accessories from the Manufacturer who have designed, manufactured and type tested similar items.

2.00.00 **CLEARANCES**

The minimum clearances for 220kV switchyards shall be as given below:

	220kV
Phase to earth clearance	2100 mm
Phase to phase clearance	2100 mm
Section clearance	5000 mm

The minimum clearances for 400kV switchyards shall be as given below:

	400kV
Phase to earth clearance	3500 mm
Phase to phase clearance	4000 mm
Section clearance	6500 mm

The Contractor shall supply the structures suitable to meet the above clearances.

3.00.00 **SITE SUPERVISION OF EQUIPMENTS**

Bidder/subcontractor shall undertake supervision of site erection, testing and commissioning of equipments from respective equipment manufacturer(s) for all the major equipments (CB, CT, CVT, Isolator, LA).

04.00.00 SYSTEM PARAMETERS

The system parameters shall be as under:

Sl. No.	**System Parameters**	**400kV**	**220kV**
1	Highest system voltage	420 kV rms	245kV rms
2	Lightning Impulse voltage	±1425kVp	±1050kVp
3	Switching impulse voltage	±1050kVp	--
4	Power frequency withstand for 1 min. (rms)	630 kV(rms)	460 kV(rms)
5	Max. fault level (1 sec.)	50 kA	40 kA
6	Minimum creepage distance	10500mm	6125mm

5.00.00	**TYPE TEST REQUIREMENTS**
5.01.00	**TYPE TEST REQUIREMENTS**
a)	All equipments 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 ten 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.
b)	However if 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 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.
c)	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.
2.00.00	**CIRCUIT BREAKER**
2.01.00	**GENERAL**
	Circuit Breakers shall be outdoor type, comprising three identical single pole units, complete in all respects with all fittings and wiring. The circuit breakers and accessories shall conform to IEC- 62271-100 or equivalent Indian Standard. The requirement of control switching is at Annexure-II of this chapter.
2.02.00	**DUTY REQUIREMENTS**
2.02.01	Circuit breaker shall be C2/M1class under all duty conditions and shall be capable of performing their duties without opening resistor. The circuit breaker shall meet the duty requirement of any type of fault or fault location and shall be suitable for line charging and dropping when used on 400kV/220 kV effectively grounded or ungrounded systems and perform make and break operations as per the stipulated duty cycles satisfactorily.
2.02.03	The circuit breaker shall be capable of breaking line charging currents as per IEC-62271-100 with a voltage factor of 1.4.
2.02.04	The rated transient recovery voltage for terminal fault and short line faults shall be as per IEC:62271-100.

2.02.05	The circuit breakers shall be reasonably quiet in operation. Noise level in excess of 140 dB measured at base of the breaker would be unacceptable. Bidder shall indicate the noise level of breaker at distance of 50 to 150 m from base of the breaker.
2.02.06	The Bidder may note that total break time of the breaker shall not be exceeded under any duty conditions specified such as with the combined variation of the trip coil voltage, pneumatic/hydraulic pressure and arc extinguishing medium pressure, etc. While furnishing the proof of the total break time of complete circuit breaker, the Bidder may specifically bring out the effect of non-simultaneity between same pole and poles and show how it is covered in the guaranteed total break time.
2.02.07	While furnishing particulars regarding the D.C. component of the circuit breaker, the Bidder shall note that IEC-62271-100 requires that this value should correspond to the guaranteed minimum opening time under any condition of operation.
2.02.08	The critical current which gives the longest arc duration at lock out pressure of extinguishing medium and the duration shall be indicated.
2.02.09	All the duty requirements specified above shall be provided with the support of adequate test reports to be furnished along with the bid.
2.03.00	**CONSTRUCTIONAL FEATURES**
2.03.01	All making and breaking contacts shall be sealed and free from atmospheric effect. In the event of leakage of extinguishing medium to a value, which cannot withstand the dielectric stresses specified in the open position, the contacts shall preferably self close. Main contacts shall be easily accessible for inspection and replacement. If there are no separately mounted arcing contacts, then the main contacts shall be easily accessible for inspection and replacement. Main contacts shall have ample area and contact pressure for carrying the rated current under all conditions. The interrupter sectional drawing showing the following conditions shall be furnished for information with the bid:
a)	Close position
b)	Arc initiation position
c)	Full arcing position
d)	Arc extinction position
e)	Open position.
2.03.02	All the three poles of the breaker shall be linked together either electrically/pneumatically or electro hydraulically in case of single phase reclosing.
2.03.03	Circuit breakers shall be provided with two (2) independent trip coils, suitable for trip circuit supervision. The trip circuit supervision relay would also be provided.

	Necessary terminals shall be provided in the central control cabinet of the circuit breaker.
2.04.00	**SULPHUR HEXAFLOURIDE (SF6) GAS CIRCUIT BREAKER**
2.04.01	Circuit breakers shall be single pressure type.
2.04.02	Design and construction of the circuit breaker shall be such that there is minimum possibility of gas leakage and entry of moisture. There should not be any condensation of SF6 gas on insulated surfaces of the circuit breaker.
2.04.03	In the interrupter assembly, there shall be absorbing product box to eliminate SF6 decomposition products and moisture. The details and operating experience with such filters shall be brought out in additional information schedule.
2.04.04	Each pole shall form an enclosure filled with SF6 gas independent of two other poles. Common monitoring of SF6 gas can be provided for the three poles of circuit breaker having a common drive. The interconnecting pipes in this case shall be such that the SF6 gas from one pole could be removed for maintenance purposes.
2.04.05	Material used in the construction of circuit breakers shall be such as fully compatible with SF6.
2.04.06	The SF6 gas density monitor shall be adequately temperature compensated to model the density changes due to variations in ambient temperature within the body of circuit breaker as a whole. It shall be possible to dismantle the monitor without removal of gas. Temperature compensated SF6 pressure gauge shall be provided which will be visible from ground level.
2.04.07	Sufficient SF6 gas shall be supplied to fill all the circuit breakers installed plus an additional 20% of the quantity as spare.
2.05.00	**OPERATING MECHANISM**
2.05.01	Circuit breaker shall be operated by pneumatic mechanism or electrically spring charged mechanism or electro-hydraulic mechanism or a combination of these. It shall be gang operated in case of 3-phase reclosing operation as applicable.
2.05.02	The pneumatically operated mechanism shall offer unit compressor with each circuit breaker with the breaker local air receivers having a capacity for two 'CO' operations of the breaker at the lowest pressure for reclose duty without refilling.
2.05.03	The Spring operated mechanism shall be complete with motor, opening spring & closing spring with limit switch for automatic charging and other necessary accessories to make the mechanism a complete operating unit. As long as power is available to the motor, a continuous sequence of closing and opening operations shall be possible. The motor shall have adequate thermal rating for this duty. After

failure of power supply to the motor, one close-open operation shall be possible with the energy contained in the operating mechanism. Motor ratings shall be such that it requires not more than 30 seconds for fully charging the closing spring.

2.05.04 The hydraulic mechanism shall be suitable for at least two close open operations after failure of ac supply to the motor starting at pressure equal to lowest pressure of auto-reclose duty. All hydraulic joints shall have no oil leakage under the site conditions and joints shall be tested at factory against oil leakage at a minimum of 1.5 times maximum working pressure.

2.06.00 **FITTINGS AND ACCESSORIES**

2.06.01 The insulators and terminal connectors shall conform to requirements stipulated elsewhere. All routine tests shall be conducted on the insulators as per relevant IEC.

2.07.00 **UNIT COMPRESSED AIR SYSTEM**

a) The unit compressed air system for each breaker shall be provided with compressed air piping, piping accessories, control and non-return valves, filters, coolers of adequate capacity, pressure reducing valves(if any), isolating valves, drain ports, etc. The air compressor shall be driven by automatically controlled motor. It shall be of air cooled type complete with preferably oil-less cylinder lubrication. The compressors or pumps shall be mounted within the operating mechanism housing or a separate weather-proof and dust-proof housing. Each compressor shall be equipped with a time totaliser.

b) The compressor size shall be such that it is capable of performing following operations satisfactorily:

i) Total running time of compressor not exceeding 45 minutes per day, considering 2% leakage and 2 CO-operations.

ii) Air charging time not exceeding 20 minutes after one CO operation of the breaker.

c) Air Receivers**:**

i) The capacity of receivers shall be sufficient for two (2) CO operations of the breaker.

ii) Air receiver shall be designed in accordance with the latest edition of the ASME Code for Pressure Vessel - Section VIII of BS: 5179. A corrosion allowance of 3.0 mm shall be provided for shell and dished ends. Receivers shall be hot dip galvanized.

d) Controls and Control Equipment**:**

i) The compressor control shall be of automatic start stop type initiated by pressure switches on the receiver. Supplementary manual control shall also be provided.

ii) All control equipment shall be housed in a totally enclosed cabinet. Pressure gauges and other indicating devices, control switches shall be mounted on the control cabinet.

iii) Facility to annunciate failure of power supply to the compressor control shall also be provided.

e) Compressed Air Piping, Valves and Fittings:

i) The flow capacity of all valves shall be at least 20% greater than the compressor capacity.

ii) The high pressure system shall be such that after one 0 - 0.3 Sec - CO operation, the breaker shall be capable of performing one CO operation within 3 minutes.

iii) All compressed air piping shall be bright annealed, seamless phosphorous Deoxidized Non-Arsenical Copper alloy or stainless steel pipe (C-106 of BS: 2871).

2.08.00 **TESTS**

2.08.01 In accordance with the requirements stipulated under Part-A, the circuit breakers alongwith its operating mechanism shall be type tested for all the type tests as per annexure-I to this chapter.

2.09.00 **ROUTINE TESTS**

Routine tests as per IEC-62271-100 on the complete breaker/ pole alongwith its own operating mechanism and pole column shall be performed on all circuit breakers.

2.10.00 **SITE TESTS**

All routine tests except power frequency voltage dry withstand test on breaker shall be repeated on the completely assembled breaker at site.

2.11.00 **PARAMETERS**

2.11.01 **General**

a) Type of circuit breaker Outdoor SF6, single pressure, Live tank type

b) Rated frequency 50 Hz

c)	Number of poles	Three (3)
d)	Rated operating duty cycle	O - 0.3 sec. - CO - 3min. – CO
e)	Rated line charging breaking Current (voltage factor of 1.4)	As per IEC
f)	Reclosing	Single and three phase high speed auto reclosing (as required)
g)	Total closing time	Not more than 150 ms.
h)	Maximum difference in the instants of closing/opening of contacts	As per standard
i)	Trip and closing coil voltage	220V DC
j)	Auxiliary contacts	As required plus 10 NO and 10 NC contacts per pole as spare. The contacts shall have continuous rating of 10A and breaking capacity of 2A with circuit time constant of minimum 20 millisecond at 220V DC.
k)	Noise level	Maximum 140dB at 50m distance from base of circuit breaker
l)	Rated terminal load	Adequate to withstand 100kg static load as well as wind, seismic and short circuit forces without impairing reliability or current carrying capacity.
m)	Temperature rise over Ambient	As per IEC: 62271-100
n)	Type of operating mechanism	Pneumatic/spring/hydraulic/or a combination of these
o)	Minimum creepage distance	As indicated in elsewhere in specification.
p)	Rated ambient temperature	50 degree Centigrade
q)	System neutral earthing	Effectively earthed
r)	Seismic acceleration	0.3 g horizontal
s)	Support structure height	Adequate so that lowest part of support insulator of equipment is minimum 2550 mm from ground/ plinth level.

2.11.02 **400/220kV Class Circuit Breakers**

Sl. No.	Parameter	400kV	220kV
1	Rated voltage	420kV	245 kV rms
2	Rated continuous current		2000A
3	Rated short circuit breaking current at rated voltage	50kA with percentage of DC component as per IEC corresponding to minimum opening time under operating conditions specified.	40kA with percentage of DC component as per IEC corresponding to minimum opening time under operating conditions specified.
4	Symmetrical interrupting Capability	50 kA rms	40 kA rms
5	Short time current carrying Capability	50 kA rms for One (1) second	40 kA rms for One (1) second
6	Short circuit making current Capability		100 kAp
7	Rated out-of-phase breaking		10 kA rms
8	Rated line charging breaking Current (voltage factor of 1.4)	600A at 90° C leading power factor with maximum permissible switching overvoltage of 2.3 pu.	As per IEC
9	First pole to clear factor	1.3	1.3
10	Rated break time	40 ms under test duties 2, 3 & 4 at rated values 45 ms under test duties 1 to 5 and short line fault test duties and combined variation of trip coil voltage, operating pressure and quenching media pressure etc.	60 ms under test duties 2, 3 & 4 at rated values 65 ms under test duties 1 to 5 and short line fault test duties and combined variation of trip coil voltage, operating pressure and quenching media pressure etc.
11	Rated one minute power frequency withstand voltage	520 kV rms between live terminals and earth. 610 kV rms across isolating distance.	460 kV rms between live terminals and earth. 530 kV rms across isolating distance.
12	Rated lightning impulse withstand	±1425 kVp between live terminals and earth.	±1050 kVp between live terminals and earth.

	voltage	± 1425 kVp impulse on one terminal and 240 kVp power freq. voltage of opposite polarity on other terminal (across isolating distance).	± 1050 kVp impulse on one terminal (across isolating distance).
13	Max. Radio interference voltage	1000 micro volts for freq. between 0.5 MHz and 2.0 MHz at voltage 156	

3.00.00 DISCONNECTORS

3.01.00 GENERAL

3.01.01 The isolators and accessories shall conform in general to IEC 62271-102 (or equivalent Indian standard) except to the extent explicitly modified in specification.

3.01.02 Earth switches shall be provided on isolators as marked on SLD.

3.01.03 The isolators and earth switches shall be A.C motor operated.

3.01.04 Complete isolator with all the necessary items for successful operation shall be supplied.

3.01.05 Isolators shall be horizontal centre break type.

3.02.00 **DUTY REQUIREMENTS**

3.02.01 Isolators and earth switches shall be capable of withstanding the dynamic and thermal effects of the maximum possible short circuit current of the system in their closed position. They shall be constructed such that they do not open under influence of short circuit current and wind pressure together. The earth switches wherever provided shall be constructional interlocked so that the earth switches can be operated only when the isolator is open and vice-versa.

3.02.02 In addition to the constructional interlock, isolator and earth switches shall have provision to prevent their electrical and manual operation unless the associated and other interlocking conditions are met. All these interlocks shall be of fail safe type. Suitable individual interlocking coil arrangements shall be provided. The interlocking coil shall be suitable for continuous operation from DC supply and within a variation range as stipulated in relevant section. The interlock coil shall be provided with adequate contacts for facilitating permissive logic for 'DC' control scheme of the isolator as well as for AC circuit of the motor to prevent opening or closing of isolators when the interlocking coil is not energised.

3.02.03	The earthing switches shall be capable of discharging trapped charges of the associated lines. Isolator and earth switches shall be able to bear on the terminals the total forces including wind loading and electro dynamic forces on the attached conductor without impairing reliability or current carrying capacity.
3.02.04	The isolator shall be capable for making / breaking normal currents when no significant change in voltage occurs across the terminals of each pole of the isolator on account of making / breaking operation.
3.02.05	All isolators of class 72.5kV above shall be of mechanical endurance class M1as per IEC. All earth switches shall be of class M1 duty. Electrical endurance duty for earth switches shall be as per IEC.
3.03.00	**CONSTRUCTIONAL FEATURES**
3.03.01	The isolators shall be provided with high pressure current carrying contacts on the hinge/ jaw ends and all contact surfaces shall be silver plated. The thickness of silver plating should not be less than 25 microns. The contacts shall be accurately machined and self aligned.
3.03.02	The isolator shall be provided with a galvanised steel base provided with holes and designed for mounting on a lattice/pipe support structure. The base shall be rigid and self supporting. The position of movable contact system (main blades) of each of the isolator and earthing switch shall be indicated by a mechanical indicator at the lower end of the vertical rod of shaft for the isolator and earthing switch. The indicator shall be of metal and shall be visible from operating level.
3.03.03	All metal parts shall be of non-rusting and non-corroding metal. Current carrying parts shall be from high conductivity electrolytic copper/aluminium. Bolts, screws and pins shall be provided with lock washers. Keys or equivalent locking facilities, if provided on current carrying parts, shall be made of copper silicon alloy or equivalent. The live parts shall be designed to eliminate sharp joints, edges and other corona producing surfaces.
3.03.04	The isolators shall be so constructed that the switch blade will not fall to the closed position if the operating shaft gets disconnected. Isolators and earthing switches including their operating parts shall be such that they cannot be dislodged from their open or closed positions by gravity, wind pressure, vibrations shocks or accidental touching of the connecting rods of the operating mechanism. The switch shall be designed such that no lubrication of any part is required except at very infrequent intervals.
3.03.05	The insulator of the isolator shall conform to the requirements stipulated elsewhere in the specification and shall have a min. cantilever strength of 800 kg for 400kV. Pressure due to the contact shall not be transferred to the insulators after the main blades full close. The insulators shall be so arranged that leakage current will pass to earth and not between terminals of the same pole or between phases.

3.03.06	The terminal connectors shall conform to requirements stipulated elsewhere in the specification
3.04.00	**EARTHING SWITCHES**
	Where earthing switches are specified these shall include the complete operating mechanism and auxiliary contacts. The earthing switches shall form an integral part of the isolator and shall be mounted on the base frame of the isolator. Earthing switches shall be suitable for local operation only. The earthing switches shall be constructional interlocked with the isolator so that the earthing switches can be operated only when isolator is open and vice versa.
3.05.00	**OPERATING MECHANISM AND CONTROL**
3.05.01	The Contractor shall offer, motor operated switches having padlock arrangement on both 'ON' and 'OFF' positions.
3.05.02	Limit switches for control shall be fitted on the isolator/ earth switch shaft, within the cabinet to sense the open and close positions of the isolators and earth switches.
3.05.03	It shall not be possible, after final adjustment has been made for any part of the mechanism to be displaced at any point in the travel sufficient enough to allow improper functioning of the isolator when the isolator is opened or closed at any speed.
3.05.04	Control cabinet/operating mech. box shall conform to requirements stipulated elsewhere in the specification and IS:5039/IS 8623/IEC 439 as applicable.
3.06.00	**OPERATION**
3.06.01	Isolator shall be gang operated for main blades and earth switches. The operation of the three poles shall be well synchronised and interlocked.
3.06.02	The design shall be such as to provide maximum reliability under all service conditions. All operating linkages carrying mechanical loads shall be designed for negligible deflection. The length of inter insulator and interpole operating rods shall be capable of adjustments.
3.06.03	The design of linkages and gears be such so as to allow one man to operate the handle with ease for isolator and earth switch.
3.07.00	**TESTS**
3.07.01	In continuation to the requirements stipulated under Part-I the isolator alongwith operating mechanism shall conform to the type tests and shall be subjected to routine tests and acceptance tests in accordance with IEC 62271-102. Minimum 50 nos. mechanical operations will be carried out on 1 (one) isolator assembled completely with all accessories as acceptance test. During final testing of isolator

sequential closing/ opening of earth switch shall also be checked only after isolator is fully open/close. Acceptance test shall be carried out with operating box.

3.07.02 The insulator shall conform to all the type tests as per IEC 168. In addition to all type, routine and acceptance tests, as per IEC-168, the following additional routine/ acceptance tests shall also be carried out:

a) Bending load test in four directions at 50% min. bending load guaranteed in all insulators.
b) Bending load test in four directions at 100% min. bending load guaranteed on sample insulators in a lot.
c) Torsional test on sample insulator of a lot.

3.08.00 **PARAMETERS**

3.08.01 **General**

a)	Type of isolator	Outdoor type
b)	Rated frequency	50 Hz
c)	Number of poles	Three (3)
d)	Operating time	Not more than 12 sec.
e)	Control voltage	220V DC
f)	Auxiliary contacts on Isolator	As required plus 8NO and 8NC contacts per pole/isolator as spare. The contacts shall have continuous rating of 10A and breaking capacity of 2A with circuit time constant of minimum 20 millisecond at 220V dc. Additionally MBB contacts as required shall also be provided.
g)	Auxiliary contacts on earth switch	Total 6NO and 6NC
h)	Rated mechanical terminal load	As per table III of IEC 62271-102
i)	Temperature rise over ambient	As per IEC:62271-102
j)	Minimum creepage distance	As considered in existing swyd
k)	Rated ambient temperature	50 degree Celsius

l)	System neutral earthing	effectively earthed
m)	Seismic acceleration	0.3 g horizontal
n)	Support structure height	Adequate so that lowest part of support Insulator of equipment is minimum 2550 mm from ground or plinth level.
o)	Rated mechanical terminal Load	As per table III of IEC 62271-102
p)	Operating mechanism of Isolator and Earth Switch	A. C./ D.C./ Universal Motor operated
q)	Temperature rise	As per Table III of IEC 60694 for an ambient of 50 deg. C.
3.08.02	**400kV Class Isolators:**	
a)	Rated voltage	420 kV rms
b)	Rated continuous current	Minimum 3150/2000 A at rated ambient temperature(as per SLD)
c)	Rated short time withstand current of isolator and earthswitch	50 kA rms for One (1) second
d)	Rated dynamic short circuit withstand current of isolator and earthswitch	125 kAp
e)	Rated Insulation levels	
	i. Rated one minute power Frequency withstand voltage	i) 520 kV rms between live terminals and earth. ii) 610 kV rms across isolating distance.
	ii. Rated lightning impulse Withstand voltage	i) ±1425 kVp between live terminals and earth. ii) ± 1425 kVp impulse on one terminal and 240 kVp power freq. Voltage of opposite polarity on other terminal (across isolating distance).
	iii. Rated switching impulse Withstand voltage	i) ± 1050 kVp between live terminals and earth. ii) ± 900 kVp impulse on one terminal and 345 kVp power freq. voltage of opposite polarity on other terminal (across isolating distance).
f)	Max. Radio interference	1000 micro volts for freq. between 0.5 MHz and 2.0

	voltage	MHz at voltage 266 kV rms.
g)	Corona extinction voltage	Not less than 320 kV rms
h)	Phase to phase spacing	7000 mm

220kV Class Isolators:

a)	Rated voltage	220 kV rms
b)	Rated continuous current	As per SLD
c)	Rated short time withstand current of isolator and earth switch	40 kA rms for One (1) second
d)	Rated dynamic short circuit withstand current of isolator and earth switch	100 kAp
e)	Rated Insulation levels	
	i. Rated one minute power Frequency withstand voltage	i) 460 kV rms between live terminals and earth. ii) 530 kV rms across isolating distance.
	ii. Rated lightning impulse Withstand voltage	i) ±1050 kVp between live terminals and earth. ii) ± 1200 kVp impulse (across isolating distance).
f)	Max. Radio interference voltage	1000 micro volts for freq. between 0.5 MHz and 2.0 MHz at voltage 156 kV rms.

4.00.00 INSTRUMENT TRANSFORMERS

4.01.00 **CODES AND STANDARDS**

Current transformers	IEC 60044, BS:3938, IS: 2705
Voltage transformers	IEC 60186, IEC 186A, IEC 358, IS:3156
Insulating oil	IS: 335

4.02.00 **GENERAL REQUIREMENTS**

a) The instrument transformers i.e. current and voltage transformers shall be single phase transformer units and shall be supplied with a common marshaling box for a set of three single phase units.

b)	All exposed mild steel metallics shall be hot dip galvanised or painted with Grey color RAL 9002. No oil shall come in contact with Zinc galvanised surface.
c)	The instrument transformers shall be hermetically sealed units. The instrument transformers shall be provided with filling and drain plugs.
d)	Polarity marks shall indelibly be marked on each instrument transformer and at the lead terminals at the associated terminal block.
e)	The Instrument transformer shall be with Polymer Insulator. Current transformer shall have cantilever strength of not less than 350kg for 220kV and not less than 500kg for 400kV. For CVT cantilever strength shall not be less than 250kg.
4.03.00	**CURRENT TRANSFORMERS (CTs)**
4.03.01	The CTs shall have single primary of either ring type or hair pin type or bar type. Wound primary is not acceptable.
4.03.02	In case of "Bar Primary" inverted type CTs, the following requirements shall be met:
4.03.03	The secondaries shall be totally encased in metallic shielding providing a uniform equipotential surface for even electric field distribution.
4.03.04	The lowest part of insulation assembly shall be properly secured to avoid any risk of damage due to transportation stresses.
4.03.05	The upper part of insulation assembly sealing on primary bar shall be properly secured to avoid any damage during transportation due to relative movement between insulation assembly and top dome.
4.03.06	The insulator shall be one piece without any metallic flange joint.
4.03.07	The CT shall be provided with oil sight glass/ oil level indicator.
4.03.08	The core lamination shall be of cold rolled grain oriented silicon steel or other equivalent alloys. The cores shall produce undistorted secondary current under transient conditions at all ratios with specified parameters.
4.03.09	Different ratios shall be achieved by secondary taps only, and primary reconnections shall not be accepted.
4.03.10	The guaranteed burdens and accuracy class are to be intended as simultaneous for all cores.
4.03.11	The instrument security factor at all ratios shall be less than five (5) for metering core. If any auxiliary CT/reactor is used, then all parameters specified shall be met

	treating auxiliary CTs/reactors as integral part of CT. The auxiliary CT/reactor shall preferably be in-built construction of the CT. In case it is separate, it shall be mounted in secondary terminal box.
4.03.12	The physical disposition of protection secondary cores shall be in the same order as given under CT requirement table(s) given below.
4.03.13	The CTs shall be suitable for high speed auto-reclosing.
4.03.14	The secondary terminals shall be terminated on stud type suitable no's of non-disconnecting and disconnecting terminal blocks inside the terminal box of degree of protection IP: 55 at the bottom of CT.
4.03.15	The CTs shall be suitable for horizontal transportation.
4.03.16	The CTs shall have provision for taking oil samples from bottom of CT without exposure to atmosphere to carry out dissolved gas analysis periodically. Contractor shall give his recommendations for such analysis, i.e. frequency of test, norms of acceptance, quantity of oil to be withdrawn, and treatment of CT. Contractor shall supply 2nos. oil sampling device for every 20nos. CT supplied, with minimum of 2nos. oil sampling device for each substation.
4.03.17	The CT shall have provision for measurement of capacitance and tan delta as erected at site.
4.04.00	**VOLTAGE TRANSFORMERS (CVTs)**
4.04.01	Voltage transformers shall be of capacitor voltage divider type with electromagnetic unit.
4.04.02	The CVTs shall be thermally and dielectrically safe when the secondary terminals are loaded with guaranteed thermal burdens.
4.04.03	The electro-magnetic unit (EMU) shall comprise of compensating reactor, intermediate transformer, and protective and damping devices. The oil level indicator of EMU with danger level marking shall be clearly visible to maintenance personnel standing on ground.
4.04.04	The secondaries shall be protected by HRC cartridge type fuses for all windings In addition fuses shall also be provided for protection and metering windings for connection to fuse monitoring scheme. The secondary terminals shall be terminated on stud type non-disconnecting terminal blocks via the fuse inside the terminal box of degree of protection IP: 55. The access to secondary terminals shall be without the danger of access to high voltage circuit.

4.04.05	The damping device shall be permanently connected to one of the secondary winding and shall be capable of suppressing ferro-resonance oscillations.
4.04.06	CVTs shall be suitable for high frequency (HF) coupling for power line carrier communication. Carrier signals must be prevented from flowing into potential transformer (EMU) metering circuit by means of RF choke/reactor suitable for effective blocking the carrier signals over the entire frequency range of 40 to 500 kHz. HF terminal shall be brought out through a suitable bushing and shall be easily accessible for connection to the coupling filters of the carrier communication equipment. The HF terminal shall be provided with earthing link with fastener.
4.04.07	A protective surge arrester/spark gap shall preferably be provided to prevent break down of insulation by incoming surges and to limit abnormal rise of terminal voltage of shunt capacitor, tuning reactor, RF choke, etc. due to short circuit in transformer secondary. The details of this arrangement (or alternative arrangement) shall be furnished by Contractor for Employer's review.
4.04.08	The protection cores shall not saturate at about 1.5 times the rated voltage for a min. duration of 30 secs.
4.04.09	The accuracy of metering core shall be maintained through the entire burden range upto 50VA for 400kV/220kV, on all three windings without any adjustments during operations.
4.05.00	**MARSHALLING BOX**
4.05.01	Marshaling box shall conform to all requirements as given elsewhere in the specification. The wiring diagram for the interconnection of three phase instrument transformer shall be pasted inside the box in such a manner so that it is visible and it does not deteriorate with time. Terminal blocks in the marshaling box shall have facility for star/delta formation, short circuiting and grounding of secondary terminals. The box shall have enough terminals to wire all control circuits plus 20 spare terminals.
4.06.00	**PARAMETERS FOR CURRENT TRANSFORMERS**
4.06.01	**General Parameters**

a)	One minute power frequency withstand voltage between secondary terminal and earth	5 kV
b)	Partial discharge level	10 pico Coulombs max.
c)	Temperature rise	As per IEC 60044
d)	Type of insulation	Class A

e)	Number of cores	Five (5): Details are given in table below. **Table-1A**
f)	Rated frequency	50 Hz
g)	System neutral earthing	Effectively earthed
h)	Installation	Outdoor (up right)
i)	Seismic acceleration	0.3 g horizontal
j)	Number of terminals in marshalling box	All terminals of control circuits wired upto marshalling box plus 20 terminals spare.

4.06.02 **400 kV Current Transformers (oil filled type)**

a)	Rated short time thermal current	50 kA for 1 sec.
b)	Rated dynamic current	125 kA (peak)
c)	Rated system voltage (Um)	420 kV (rms)
d)	Corona extinction voltage (min)	320 kV (rms)
e)	Radio Interference Voltage at 266 kV at frequency range 0.5 to 2 MHz (rms)	1000 micro volts
f)	Rated insulation levels	
	i. 1.2/50 micro-sec. impulse	1425 kVp
	ii. 250/2500 micro-sec. switching surge withstand voltage (dry & wet)	1050 kVp
	iii. One minute power frequency withstand voltage	630 kV rms
g)	Rated extended primary current	120% of rated primary current as per SLD

` **220 kV Current Transformers (oil filled type)**

a)	Rated short time thermal current	40 kA for 1 sec.

b)	Rated dynamic current (	100 kA (peak)
c)	Rated system voltage (Um)	245 kV (rms)
d)	Radio Interference Voltage at 156 kV at frequency range 0.5 to 2 MHz (rms)	1000 micro volts
f)	Rated insulation levels	
	i. 1.2/50 micro-sec. impulse ii. One minute power frequency withstand voltage	1050 kVp 460 kV rms
g)	Rated extended primary current	120% of rated primary current as per SLD

4.07.00 **PARAMETERS FOR VOLTAGE TRANSFORMERS**

4.07.01 **General Parameters**

a)	Rated frequency	50 Hz
b)	System neutral earthing	Effective earthed
c)	Installation	Outdoor
d)	Seismic acceleration	0.3 g horizontal
e)	System fault level	40 kA for 1 sec (50 kA for 1 sec for 400kV)
f)	Standard reference range of frequencies for which the accuracies are valid	96% to 102% for protection and 99% to 101% for measurement.
g)	High frequency capacitance for carrier frequency range	Within 80% to 150% of rated entire capacitance
h)	Equivalent resistance over entire carrier frequency range	Less than 40 ohms
i)	Stray capacitance and stray conductance of LV terminal over entire carrier frequency range	As per IEC:358
j)	One minute power frequency withstand voltage	

	a) between LV (HF) terminal and earth	10kV rms for exposed terminals or 4 kV rms for terminals enclosed in a weather proof box.
	b) For secondary winding	2 kV rms
k)	Temp. rise over an ambient temp. of 50 deg. C	As per IEC 60044
l)	Number of terminals in control Cabinet	All terminals of control circuits wired upto marshalling box plus 10 terminals spare.
m)	Rated total thermal burden	750 VA
n)	Partial discharge level	10 pico Coulombs max.
o)	Number of cores	As per details given in Tables below.
p)	Rated Voltage factor	1.2 continuous, 1.5 – 30sec
4.07.02	**400kV VOLATAGE TRANSFORMERS**	
a)	Rated system voltage	420 kV (rms)
b)	Rated insulation levels	
	i) 1.2/ 50 micro sec. impulse	1425 kV (peak)
	ii) 250/2500 micro sec. switching surge withstand voltage (dry & wet)	1050 kV (peak)
c)	Radio Interference voltage at 266 kV at frequency range 0.5 to 2 MHz(rms)	1000 micro volts (max.)
d)	Corona extinction voltage (min.)	320 kV (rms)
e)	HF Capacitance	4400 pf / 8800pf (nominal)
	220kV VOLATAGE TRANSFORMERS	
a)	Rated system voltage	245 kV (rms)
b)	Rated insulation levels	
	i) 1.2/ 50 micro sec. impulse	1050 kV (peak)

	ii) One min PF withstand Voltage	460kV (rms)
c)	Radio Interference voltage at 156 kV at frequency range 0.5 to 2 MHz(rms)	1000 micro volts (max.)
e)	HF Capacitance	4400 pf / 8800pf (nominal)

Voltage Transformer shall also comply with requirement of TABLE – II.

4.08.00 **TESTS**

The current and voltage transformers shall confirm to type tests and shall be subjected to routine & acceptance tests in accordance with the relevant IS/IEC. CTs and CVTs shall also conform to the following additional type tests as applicable:

1) Radio Interference Voltage & Corona test.
2) Thermal withstand test i.e. application of rated voltage and rated current simultaneously by synthetic circuit (For CT only).
3) Seismic withstand test along with structure for 400kV only.
4) Thermal co-efficient test i.e. measurement of Tan- Delta as a function of temperature (at ambient, 80 deg. C, 85 deg. C and 90 deg. C) and voltage (at 0.3, 0.7, 1.0 and 1.1 Um/√3) (For CT only).
5) Multiple chopped impulse test on primary winding.

In addition to routine tests as per IEC/IS, measurement of partial discharge in continuation with power frequency withstand test required for 220 kV current transformer. ISF (Instrument Security Factor) test will be done as part of Routine acceptance test.

TABLE– IA

CORE DETAILS OF 400 KV CT (3000 A)

Core No.	Application	Current Ratio(A)	Output Burden(VA)	Accuracy Class as per IEC 185	Min. knee point voltage (V)	Max. CT Sec. wdg. Resistance (ohms)	Max. exciting current in mA at knee point voltage
1	Bus Differential Check	3000/ 2000/ 1000/1	-	PS	3000/ 2000/ 1000	15/ 10/ 5	20 on 3000/1 TAP 30 on 2000/1 TAP 60 on 1000/1 TAP
2	Bus Differential Main	3000/ 2000/ 1000/1	-	PS	3000/ 2000/ 1000	15/ 10/ 5	20 on 3000/1 TAP 30 on 2000/1 TAP 60 on 1000/1 TAP
3	Metering and synchronizing	3000/ 2000/ 1000/ 500/1	20 20 20 20	0.2s	-	-	-
4	Transformer back up/ Line protection	3000/ 2000/ 1000/ 500/1	-	PS	6000/ 4000/ 2000/ 1000	15/ 10/ 5/ 2.5	20 on 3000/1 TAP 30 on 2000/1 TAP 60 on 1000/1 TAP 120 on 500/1 TAP
5	Transformer Differential /Line protection	3000/ 2000/ 1000/ 500/1	-	PS	6000/ 4000/ 2000/ 1000	15/ 10/ 5/ 2.5	20 on 3000/1 TAP 30 on 2000/1 TAP 60 on 1000/1 TAP 120 on 500/1 TAP

All relaying CTs shall be of accuracy class PS as per IS: 2705. The rated extended primary current of the CTs shall be 120 % continuous of 3000 A. ISF for metering core should be less than 5.

CORE DETAILS OF 220 KV CT (1600 A)

Core No.	Application	Current Ratio(A)	Output Burden (VA)	Accuracy Class as per IEC	Min. knee point voltage (V)	Max. CT Sec. wdg. Resistance (ohms)	Max. exciting current in mA at Vk
1	Bus Diff. Check	1600/ 800/1	-	PS	1600/ 800	8/4	30/60
2	Bus Diff. Main	1600/ 800/1	-	PS	1600/ 800	8/4	30/60
3	Metering and synchronizing	1600/ 800/ 400/200/ 1	20/20/ 20	0.2	-	-	-
4	Trans. back up/ Line protn	1600/ 800/ 400/200/ 1	-	PS	3200/ 1600/ 800/ 400	8/4/2/1	30/60/120/240
5	Trans. back up/ Line protn	1600/800 /400/200/ 1	-	PS	3200/ 1600/ 800/ 400	8/4/2/1	30/60/120/240

The All relaying CTs shall be of accuracy class PS as per IS: 2705. The rated extended primary current of the CTs shall be 120 % continuous of 1600 A. ISF for metering core should be less than 5.

TABLE-II

CORE DETAILS OF 400 KV CVTs

Particulars	Secondary I	Secondary II	Secondary III
Rated secondary voltage	110 / v 3	110 / v 3	110 / v 3
Application	Protection	Protection	Metering
Accuracy	3P	3P	0.2
Output Burden (minimum)	75 VA	75 VA	75 VA

The accuracy of 0.2 on secondary III should be maintained through the entire burden range up to 75 VA on all the three windings without any adjustments during operation.

TABLE-II

CORE DETAILS OF 220 KV CVTs

Particulars	Secondary I	Secondary II	Secondary III
Rated secondary voltage	110 / v 3	110 / v 3	110 / v 3
Application	Protection	Protection	Metering
Accuracy	3P	3P	0.2
Output Burden (minimum)	75 VA	75 VA	75 VA

The accuracy of 0.2 on secondary III should be maintained through the entire burden range up to 75 VA on all the three windings without any adjustments during operation.

5.00.00 **SURGE ARRESTORS**

5.01.00 **GENERAL**

5.01.01 The surge arrestors shall conform in general to IEC-60099-4 and IS:3070 except to the extent modified in the specification and shall be in accordance with requirements under Part-A.

5.01.02 Arrestors shall be hermetically sealed units, self supporting construction, suitable for mounting on lattice/tubular type support structures.

5.02.00 **DUTY REQUIREMENTS**

5.02.01 The Surge Arresters (SAs) shall be capable of discharging over-voltages occurring due to switching of unloaded transformers, reactors and long lines.

5.02.02 The reference current of SAs shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage. Values and calculations shall be furnished with offer.

5.02.03 The SAs shall be fully stabilised thermally to give a life expectancy of one hundred (100) years under site conditions and take care of effect of direct solar radiation.

5.02.04 The SAs shall be suitable for circuit breaker duty cycle in the given system.

5.02.05 The SAs shall protect power transformers, circuit breakers, disconnecting switches, instrument transformers, shunt reactors, etc. with insulation levels specified in this

	specification. The Contractor shall carry out the insulation coordination studies for deciding the exact location and quantity of the SAs.
5.02.06	The SAs shall be capable of withstanding meteorological and short circuit forces under site conditions.
5.03.00	**CONSTRUCTIONAL FEATURES**
5.03.01	Each Surge Arrester (SA) shall be hermetically sealed single phase unit.
5.03.02	The non linear blocks shall be sintered metal oxide material. The SA construction shall be robust with excellent mechanical and electrical properties.
5.03.03	SAs shall have pressure relief devices and arc diverting ports suitable for preventing shattering of porcelain housing and to provide path for flow of rated fault currents in the event of SA failure.
5.03.04	The SA shall not fail due to porcelain contamination.
5.03.05	Seals shall be effectively maintained even when SA discharges rated lightning current.
5.03.06	Polymer housing shall be so coordinated that external flashover will not occur due to application of any impulse or switching surge voltage upto maximum design value for SA. The cantilever strength of the insulator shall be minimum 250kg for 220kV (500kg for 400kV). The insulator shall meet the bending load test requirements in 4 directions.
5.03.07	The end fittings shall be non-magnetic and of corrosion proof material.
5.03.08	The sealing arrangement of the Surge Arrester stacks shall be done incorporating grooved flanges with O-rings/elliptical cross section gasket of Neoprene or Butyl rubber
5.04.00	**FITTINGS AND ACCESSORIES**
5.04.01	Each SA shall be complete with insulating base for mounting on structure.
5.04.02	SAs shall be provided with grading and/or corona rings as required.
5.04.03	Self contained discharge counters, suitably enclosed for outdoor use (IP:55 degree of protection) and requiring no auxiliary or battery supply shall be fitted with each SA alongwith necessary connections to SA and earth. Suitable leakage current meters shall also be supplied in the same enclosure. The reading of milli-ammeter and counter shall be visible through an inspection glass panel to a man standing on

ground. A pressure relief vent/suitable provision shall be made to prevent pressure build up.

5.04.04 The Contractor shall also supply micro-processor based portable maintenance equipment for monitoring resistive current of SA as listed elsewhere in the specification.

5.05.00 **PARAMETERS**

5.05.01 **General**

a)	System neutral earthing	Effectively earthed
b)	Installation	Outdoor
c)	Discharge Current	
	i) Nominal discharge current	10 kA of 8/20 micro-sec. wave (For 220kV)
	ii) Discharge current at which insulation coord. is done	20 kA of 8/20 micro-sec. wave
d)	Rated frequency	50 Hz
e)	Long duration discharge class	3
f)	Current for pressure relief test	40kA rms for 220kV/50kA for 400kV
g)	Prospective symmetrical fault current	40 kA/50kA rms for 1 second for 220kV/400kV respectively
h)	Low current long duration test value (2000 micro sec.)	800 A
i)	Pressure relief class	Class A of Table VII of IS:3070 or equivalent IEC.
j)	Partial discharge at 1.05 MCOV (Continuous operating voltage)	Not more than 50 p.C.
k)	Siesmic acceleration	0.3 g horizontal
l)	Reference ambient temp.	50 deg. C

5.05.02 **400 kV class Surge Arrestor**

a)	Rated system voltage	420 kV

b)	Rated arrestor voltage	390 kV
c)	Minimum discharge capability	8kJ/kV or corresponding to minimum discharge characteristics given in clause m) below whichever is higher.
d)	Continuous operating voltage (COV) at 50 deg. C	303 kV rms
e)	Min. Switching surge residual voltage at 1 kA	730 kVp
f)	Max. Switching Surge voltage at 1KA	780 kVp
g)	Maximum residual voltage at	
	i) 10kA nominal discharge current	900 kVp
	ii) 20kA nominal discharge current	975 kVp
h)	Steep fronted wave residual voltage at 20kA	1050kVp
i)	High current short duration test value (4/10 microsec. wave)	100 kAp
j)	One minute dry/wet power frequency withstand voltage of arrestor housing	630 kV (rms)
k)	Impulse withstand voltage of arrestor Housing with 1.2/50 micro sec. wave.	1425 kVp
l)	RIV at 266 kV (rms)	Less than 1000 micro volts

m) The surge arrestors are provided to protect the following equipment whose insulation levels are indicated in the table I given below. The contractor shall carry out the insulation coordination studies for deciding the location of the surge arrestors.

220 kV class Surge Arrestor

a)	Rated system voltage	245 kV
b)	Rated arrestor voltage	216 kV
c)	Minimum discharge capability	5kJ/kV or corresponding to minimum discharge characteristics given in clause m) below whichever is higher.
d)	Continuous operating voltage (COV) at 50 deg. C	168 kV rms
e)	Max. Switching surge residual voltage at 1 kA	500 kVp
f)	Maximum residual voltage at	
	i) 10kA nominal discharge current	600 kVp
h)	Long duration discharge class	3
i)	High current short duration test value (4/10 microsec. wave)	100 kAp
j)	One minute dry/wet power frequency withstand voltage of arrestor housing	460 kV (rms)
k)	Impulse withstand voltage of arrestor Housing with 1.2/50 micro sec. wave.	1050 kVp
l)	RIV at 156 kV (rms)	Less than 1000 micro volts

m) The surge arrestors are provided to protect the following equipment whose insulation levels are indicated in the table I given below. The contractor shall carry out the insulation coordination studies for deciding the location of the surge arrestors.

TABLE – I (for 400kV)

S.NO.	EQUIPMENT TO BE PROTECTED	INSULATION LEVEL	
		LIGHTNING IMPULSE (kVp) FOR 400 KV SYSTEM	SWITCHING SURGE 250/2500 (kVp) FOR 400 kV SYSTEM
1.	Power Transformer	± 1300	± 1050
2.	Instrument Transformer	± 1425	± 1050
3.	Reactor	± 1300	± 1050
4.	CB/Isolator		
	- Phase to ground	± 1425	± 1050
	- Across open contacts	± 1425 (± 240)	± 900 (± 340)

m) Surge arrestors shall be capable of discharge on severe re-energisation switching surges on a 400 kV line upto 450 km. length with surge impedance of 300 ohms and capacitance of 11.986 nF/km and over voltage factor of 2.3 p.u.
Surge arrestor shall be capable of discharging energy equipment to class 4 of IEC for a 420 kV system on two successive operations followed immediately by 50 Hz energisation with a sequential voltage profile as specified below:

650 kVp for 3 peaks
575 kVp for 0.1 second
550 kVp for 1 second
475 kVp for 10 seconds

n) 400 kV line circuit breakers are equipped with closing resistor of 400 ohms with pre insertion time switching over voltage to 2.3 p.u.

TABLE-I (FOR 220kV)

S.NO.	EQUIPMENT TO BE PROTECTED	INSULATION LEVEL	
		LIGHTNING IMPULSE (kVp) FOR 220 KV SYSTEM	SWITCHING SURGE FOR 220 kV SYSTEM
1.	Power Transformer	± 950	NA
2.	Instrument Transf.	± 1050	NA
3.	CB/Isolator		
-	Phase to ground	± 1050	NA
-	Across open contacts	± 1200	NA

5.06.00 **TESTS:**

Surge Arrestors shall conform to all type tests as per IEC and shall be subjected to routine and acceptance tests in accordance with IEC -60099-4.

The resistive current drawn by the arrestor at rated voltage shall be indicated in the routine test report.

6.00.00 POST INSULATOR

6.01.00 **GENERAL**

6.01.01 The post insulators shall conform in general to latest IS:2544 and IEC – 60815, 60168.

6.02.00 **CONSTRUCTIONAL FEATURES**

6.02.01 Post type insulators shall consist of a porcelain part permanently secured in a metal base to be mounted on the supporting structures. They shall be capable of being mounted upright. They shall be designed to withstand any shocks to which they may be subjected to by the operation of the associated equipment. Only solid core insulators shall be accepted.

6.02.02 The other requirements of insulator as given elsewhere in the specification shall also be applicable.

6.03.00	**TESTS**	
6.03.01	In accordance with the stipulations under part-I the post insulators shall conform to type tests and acceptance, sample and routine tests as per IS:2544, IEC-60168 shall be carried out.	
6.03.02	In addition to acceptance/sample/routine tests as per IS:2544, IEC-60168, the following tests shall also be carried out.	
a)	Ultrasonic tests on all cutshells as routine check.	
b)	Visual examination and magnaflux test on all flanges prior to fixing.	
c)	Check for uniformity of thickness and weight of zinc coating as a sample test from each lot of flanges prior to fixing.	
d)	Bending load test shall be carried out at 50% minimum failing load in four directions as a routine test.	
e)	Bending load in four directions at 100% minimum bending load guaranteed on samples as per clause-2.3 of IEC. Subsequently this post insulator shall not be used.	
f)	Tests for deflection measurement at 20, 50, 70% of specified minimum failing load on sample.	
6.04.00	**PARAMETERS**	
I.	**400 kV class Bus Post Insulator**	
a)	Type	Solid core type
b)	Voltage class (kV)	400
c)	Dry and wet one minute power frequency withstand voltage (kV)	680
d)	Dry impulse withstand positive and negative (kVp)	1550
e)	Wet switching surge withstand voltage (kVp)	1175 (As per IEC)
f)	Max. radio interference voltage (μ V) for any frequency between 0.5 MHz to 2 MHz at voltage of 266 kV (rms) between phase to ground.	1000

g)	Corona extinction voltage (kV rms)	320
h)	Total min. cantilever strength (Kg)	800
i)	Min. torsional moment (Kg m)	As per IEC
j)	Total height of insulator (mm)	3650
k)	i) Top p.c.d. (mm) ii) Bottom p.c.d. (mm)	127 300
l)	No. of bolts : Top : Bottom	4 8
m)	Diameter of bolt holes (mm) : Top : Bottom	 M16 dia 18

Note: If corona extinction voltage is to be achieved with the help of corona ring or any other similar device, the same shall be deemed to be included in the scope of the bidder without any price implication.

n)	pollution level as per IEC-815	Class III, Heavy

I. 220 kV class Bus Post Insulator

a)	Type	Solid core type
b)	Voltage class (kV)	245
c)	Dry and wet one minute power frequency withstand voltage (kV)	460
d)	Dry impulse withstand positive and negative (kVp)	1050
e)	Max. radio interference voltage (μ V) for any frequency between 0.5 MHz to 2 MHz at voltage of 156 kV (rms) between phase to ground.	1000
f)	Total min. cantilever strength (Kg)	600
i)	Min. torsional moment (Kg m)	As per IEC
j)	Total height of insulator (mm)	2300

k)	No. of bolts : Top	4
	: Bottom	8
l)	Diameter of bolt holes (mm)	
	: Top	M16
	: Bottom	dia 18
m)	pollution level as per IEC-815	Class III, Heavy

7.00.00 REQUIREMENT OF AUXILIARY ITEMS

7.01.00 **ALUMINIUM TUBULAR CONDUCTOR**

7.01.01 The aluminium tube shall be grade 63401 WP(range2) as per IS 5082.

7.01.02 There shall be no negative tolerance on OD and thickness of the tube. Other tolerances shall be as per IS:2678 and 2673.

7.01.03 Tests: In accordance with stipulations of specification routine tests shall be conducted on tubular conductor as per IS:5082. Also the wall thickness and ovality shall be measured by ultrasonic method. In addition 0.2% proof tests on both parent material and aluminium tube after welding shall be conducted.

Parameters:

For 400kV/220kV

a)	Size	4" IPS (EH type),
b)	Outer diameter	114.20 mm with no negative tolerance
c)	Thickness of tube	8.51 mm with no negative tolerance
d)	Cross-sectional area	2825.61 sq. mm.
e)	Weight	7.7 kg/m
f)	Aluminum grade	63401 WP(range 2) conforming to IS:5082.

7.02.00 **ACSR CONDUCTOR**

a)	Code and standard	IS 398
b)	Name	MOOSE ACSR
c)	Overall diameter	31.77 mm
d)	Weight	2.004 kg/m
e)	Ultimate tensile strength	161.2 kN minimum
f)	Strands and wire diameter of	
	- Aluminium	54 / 3.53 mm
	- Steel	7 / 3.53 mm

7.04.00	**CLAMPS AND CONNECTORS**
7.04.01	The material of clamps and connectors shall be Aluminium alloy casting conforming to designation A6 of IS:617 for connecting to equipment terminals and conductors of aluminium. In case the terminals are of copper, the same clamps/connectors shall be used with 2mm thick bimetallic liner.
7.04.02	The material of clamps and connectors shall be Galvanised mild steel for connecting to shield wire.
7.04.03	Bolts, nuts and plain washers shall be hot dip galvanised mild steel for sizes M12 and above. For sizes below M12, they shall be electro-galvanised mild steel. The spring washers shall be electro-galvanised mild steel.
7.04.04	All castings shall be free from blow holes, surface blisters, cracks and cavities. All sharp edges and corners shall be rounded off to meet specified corona and radio interference requirements.
7.04.05	They shall have same current rating as that of the connected equipment. All current carrying parts shall be at least 10 mm thick. The connectors shall be manufactured to have minimum contact resistance.
7.04.06	Flexible connectors, braids or laminated strips shall be made up of copper/aluminium.
7.04.07	Current rating and size of terminal/conductor for which connector is suitable shall be put on a suitable sticker on each component which should last at least till erection time.
7.05.00	**INSULATOR STRING AND HARDWARES**
7.05.01	The insulator hardware shall be of bolted type and shall be of forged steel except for insulator cap, which can be of malleable cast iron. It shall also generally meet the requirements of clamps and connectors as specified above.
7.05.02	In one span, Tension string assembly at one end shall be supplied with suitable turn buckle.
7.05.03	Disc Insulator The disc insulator shall meet the following parameters: a. Type : Antifog type insulator b. Size of insulator : 255x145 c. Electro mechanical strength : 120kN

d. Leakage distance (mm) : 430mm minimum or as required to meet the total creepage.

e. Power frequency withstand voltage: 85 kV (dry), 50kV (wet)

7.05.04 Insulator string

The insulator string shall meet the following parameters

		220 KV	400KV
a)	Type	Porcelain type	Porcelain type
b)	Creepage distance	min.25mm/kV	min.25mm/kV
c)	PF withstand voltage (dry and wet)	460 KV 1 min(rms)	680kV 1 minute (rms)
d)	L / I withstand voltage	+/- 1050 KV	+/- 1550 KV
e)	S / I Withstand voltage	—	+/- 1050kV
f)	No. of disc insulator	16 nos.	25
g)	Electro mechanical strength	120 KN/ String	120 KN/ String

The Bidder may offer composite insulator with silicone profile as an alternate to porcelain disc insulator string with identical creepage distance.

7.06.00 **SPACERS**

7.06.01 Spacers shall conform to IS: 10162. They shall be of non-magnetic material except nuts and bolts, which shall be of hot dip galvanised mild steel.

7.06.02 Spacers shall generally meet the requirements of clamps and connectors as specified above. Its design shall take care of fixing and removing during installation and maintenance.

7.06.03 In addition to the type tests as per IS:10162, clamp slip test should have been conducted. In this test the sample shall be installed on test span of twin/quad bundle string at a tension of 44.2 kN (4500 kg). One of the clamps when subjected to a longitudinal pull of 2.5 kN (250 kg) parallel to the axis of conductor shall not slip, i.e. permanent displacement between conductor and clamp after the test shall not exceed 1.0 mm. This test should have been performed on all other clamps of the sample.

7.07.00 **EARTHING CONDUCTOR**

a) The main conductor buried in earth shall be 40mm dia rod for main and auxiliary mat. The earthing conductors over the ground shall be of 75x12 mm GS flat. The earthing leads for columns and auxiliary structures, cable trenches shall be of 75x12 mm GS flat. The earthing of the lighting fixtures shall be carried out by 16 SWG wire.

b) All conductors above the ground level shall be galvanised steel.

7.08.00 **Earthwire for Lightning Protection**

a)	Number of strands	7 of steel
b)	Strand diameter	3.66 mm
c)	Overall diameter	10.98 mm
d)	Weight	583 kg/km approx.
e)	Ultimate tensile strength	68.4 kN minimum
f)	Total cross-sectional area	73.65 sq.mm.
g)	Calculated d.c. resistance	2.5 ohms/km at 20 deg.C.
h)	Direction of lay of outer layer	Right hand
i)	Protective coating for storage	Boiled linseed oil to avoid wet storage stains (white rust)

The earth wire shall be of preformed and post formed quality.

7.09.00 **BUSHINGS, HOLLOW COLUMN INSULATORS, SUPPORT INSULATORS, AND DISC INSULATORS**

7.09.01 Bushings shall be manufactured and tested in accordance with IS:2099 & IEC:137 while hollow column insulators shall be manufactured and tested in accordance with IEC 233/IS 5284. The support insulators shall be manufactured and tested as per IS:2544 / IEC 168/IEC 273. The insulators shall also conform to IEC 815 as applicable.
Support insulators/ bushings/ hollow column insulators shall be designed to have ample insulation, mechanical strength and rigidity for the conditions under which they will be used.

7.09.02 Porcelain used shall be homogenous, free from laminations, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture. Hollow porcelain should be in one integral piece in green & fired stage.

7.09.03 Glazing of the porcelain shall be uniform brown in colour, free form blisters, burns and other similar defects.

7.09.04 When operating at normal rated voltage there shall be no electric discharge between conductor and insulators which would cause corrosion or injury to conductors or when operating at normal rated voltage.

7.09.05 The design of the insulator shall be such that stresses due to expansion and contraction in any part of the insulator shall be lead to deterioration. All ferrous parts shall be hot dip galvanised.

7.09.06 Contractor shall make available data on all the essential features of design including the method of assembly of shells and metal parts, number of shells per insulator, the manner in which mechanical stresses are transmitted through shells

	to adjacent parts, provision for meeting expansion stresses, results of corona and thermal shock tests, recommended working strength and any special design or arrangement employed to increase life under service conditions.
7.09.07	Post type insulators shall consist of a porcelain part permanently secured in metal base to be mounted on supporting structures. They shall be capable of being mounted upright. They shall be designed to withstand all shocks to which they may be subjected to during operation of the associated equipment.
7.09.08	Bushing porcelain shall be robust and capable of withstanding the internal pressures likely to occur in service. The design and location of clamps, the shape and the strength of the porcelain flange securing the bushing to the tank shall be such that there is no risk of fracture. All portions of the assembled porcelain enclosures and supports other than gaskets, which may in any way be exposed to the atmosphere shall be composed of completely non hygroscopic material such as metal or glazed porcelain.
7.09.09	All iron parts shall be hot dip galvanised and all joints shall be air tight. Surface of joints shall be trued, porcelain parts by grinding and metal parts by machining. Insulator/ bushing design shall be such as to ensure a uniform compressive pressure on the joints.
7.09.10	Bushings, hollow column insulators and support insulators shall conform to type tests and shall be subjected to routine tests and acceptance test/ sample test in accordance with relevant standards.
7.10.00	**CABINETS, BOXES, KIOSKS, PANELS, ETC.**
7.10.01	All types of control cabinets, junction boxes, marshaling boxes, lighting panels, terminal boxes, operating mechanism boxes, Kiosks etc. shall be of AL/SS and generally conform to IS:5039, IS:8623 and IEC:60439 as applicable. They shall meet all other requirements specified elsewhere in the specification.
8.11.00	**BAY MARSHALLING BOX**
8.11.01	Each bay of the switchyard shall be provided with a Bay Marshaling Box located at a convenient location to receive and distribute cables within the bay. It shall meet all the requirements as specified for cabinets/boxes above.
8.11.02	It shall have three separate distinct compartments for following purposes: - To receive two incoming 415V, three phase, AC supplies controlled by 100A four pole MCBs with auto changeover provision, and to distribute five (5) three phase ac supplies controlled by 32A four pole MCBs. It shall also be provided with 63A, 3 phase 4 pin industrial grade receptacle with rotary switch. - To receive three phase incoming from first compartment and to distribute ten (10) single phase ac supplies controlled by 16A two pole MCBs. - 150 nos. terminal blocks in vertical formation for interlocking facility.

8.11.03 **AUXILIARY SWITCH**

The auxiliary switch shall conform of following type tests:

a) Electrical endurance test - A minimum of 1000 operations for 2A. D.C. with a time constant greater than or equal to 20 milliseconds with a subsequent examination of mV drop/ visual defects/ temperature rise test.

b) Mechanical endurance test - A minimum of 5000 operations with a subsequent checking of contact pressure test/ visual examination

c) Heat run test on contacts

d) IR/HV test, etc.

8.12.00 **Type tests**

All equipment with their terminal connectors, control cabinets, main protective relays, etc. as well as insulators, insulator strings with hardwares, clamps and connectors, marshalling boxes, etc., shall conform to type tests and shall be subjected to routine and acceptance tests in accordance with the requirements stipulated under respective equipment sections.

ANNEXURE-I

Specification for Bay Kiosk

1. Construction:

The Bay Kiosk shall be made of "sandwich insulated panels" 80 mm thick with poly Urethane Foam (PUF) as filler material between polyester pre-coated cold rolled Steel. The insulation characteristics of PUF material shall conform to following requirement

Sl. No.	Particular	Parameters
1.	Thickness	78.6 mm
2.	Density	40 kg/m3
3.	Compressive Strength	1.2 kg.cm3
4.	Tensile Strength	3.6 kg/m2
5.	Bending Strength	4.0 Kg/m2
6	Adhesion Strength	2.9 Kg/m2
7.	Dimension Stability	At -25^{o} C : 0.1% and at 38^{o}C : 0.4%
8.	Temperature Range	-15^{o}C to 95^{o}C
9.	Thermal Conductivity	0.02 kcal/hr/m/^{o}C
10.	Fire Resistance	As per BS-4735 Horizontal Burn <125 mm
11.	Water absorption	0.2% @ 100% RH
12.	Vapour Permeability	0.08/0.12 g/hr/m2
13.	Self Extinguishing	Yes

The thickness of the inner-side and outer steel sheet except floor panel sheet shall be minimum 0.8 mm and 0.6 mm respectively. The outer bottom sheet shall be hot dip galvanised steel sheets of minimum 1.0 mm thickness to avoid rusting at bottom. The sandwich panels shall be manufactured by high pressure injection techniques. The floor of the kiosk shall be suitably designed for accommodating the control and relay IEDs in the panels. The adequate lighting shall be provided in the kiosk. The Kiosk shall have adequate space for working and maintain Clearances as per requirement of Indian Electricity Rules. The kiosk shall be provided with locking arrangement. The Kiosks shall have IP-55 degree of protection. The cable entries in the Kiosk shall be provided only from the side of the Kiosk. It shall be possible to lay additional cables in future for the panels without disturbing the existing facilities.

2. Air-Conditioning:

The air conditionings system shall be provided in the Kiosks to be used for housing panels having control and protection IEDs for performing sub-station

automation and protection functions. generally comply with relevant IS codes–. These kiosks shall be placed in the switchyard area generally unmanned; therefore, the air-conditioning system shall be rugged, reliable, maintenance free and designed for long life.

i. Operation:

The air conditioning is required for critical application i.e. for maintaining the temperature for critical sub-station control and protection equipment. To provide redundancy for such critical applications, each kiosk shall be installed with environment control system comprising of two units of air conditioners working in conjunction through a micro processor based controller for desired operation. The system shall be designed for 24 Hours, 365 Days of the year to maintain the inside kiosk temperature for proper operation of the critical equipment. One of the air-conditioner shall be running at a time and on failure of the same or as described hereunder, the other unit shall start automatically. To ensure longer life of the system, the redundant units shall also be running in cyclic operation through the controller. However, during running of one air-conditioner unit, if inside temperature of the shelter reaches to a predefined (i.e. 35ºC), the other unit shall start running to maintain the temperature to specified value (i.e.23+2ºC) and gives alarm for such situation. After achieving this temperature, the other unit shall again shut off.

ii. Sequence of Operation of the Unit:

Suitable arrangement shall be made to operate the unit in the following order. However, the actual operation arrangement shall be finalised during detailed engineering.

1. Evaporator Fan
2. Condenser Fan
3. Compressor

iii. Construction:

The air conditioning unit shall be completely self-contained. All components of the units shall be enclosed in a powder coated cabinet and colour of same shall be matched with kiosk colour. The unit shall be assembled, wired, piped, charged with refrigerant and fully factory tested as a system to ensure trouble free installation and start up. Suitable isolation or other by passing arrangement shall be provided such that any unit/component could be maintained/ repaired without affecting the running standby unit. The maintenance of unit shall be possible from outside the kiosk.

iv. Required Features of Various Components:

The compressor shall be very reliable, trouble free and long life i.e. hermitically sealed Scroll type of reputed make suitable for operation. Compressor should be

installed on vibration isolated mountings or manufacturer's recommended approved mounting. Valve shall be provided for charging/topping up of refrigerant. The bidder shall furnish details of their compressor indicating the MTBF, life of compressor and continuous run time of compressor without failure. The contractor shall also furnish details of all accessories i.e. refrigeration system, evaporator coil, condenser coil, evaporator blower filter, cabinet, indoor supply and return grill etc.

v. The kiosk shall be erected at least 300 mm above the finished ground level with suitable pedestal to avoid any entry of water.

3. Proto Testing:

One kiosk meeting the specified requirement as described above, shall be fabricated at the factory and offered for proto inspection at the factory. This proto shall be equipped with all required accessories like air-conditioning system, fire and smoke detector, lighting, various cut outs etc. The offered kiosk shall be inspected for finish, all fittings and accessories, opening including doors and locks. The kiosk shall be tested for dust and rain protection to check out any leakage and air tightness. The following main tests shall be carried out:

(a) Illumination inside the kiosk shall be switched off and it shall be checked that no light enters through panel joints, holes and other joints in the kiosk.

(b) Water Leakage Test (with a water pipe with suitable pressure from all sides for one hour.)

(c) Working and functional tests of all accessories like air-conditioning system, fire and smoke detector, lighting arrangements as per technical specification

(d) Start up test for air conditioner

(e) Satisfactory operation of air conditioner installed on Kiosk.

(f) The total heat load for panels and devices to be placed inside the kiosk including PLCC, all IEDs etc. shall be calculated and equivalent calculated heating load (maximum value from among the calculated values for various kiosk) shall be placed inside the kiosk and the kiosk shall be made operational for four hours with all accessories and inside & outside temperature of kiosk shall be recorded.

On successful completion of proto testing, all other system shall be manufactured after incorporation of all alteration/modifications observed/suggested during/after proto testing.

The detail test procedure shall be submitted by the contractor and get it approved from the owner before commencement of proto testing.

8.00.00 **INSTALLATION**

8.01.00 **EARTHING**

The earthing shall be done in accordance with requirements given in Annexure-I of this section and drawing enclosed with the specifications. Earthing of panels shall be done in line with the requirements given in respective equipment section of this specification. The cost of welding laying etc. of earth flats and rods is deemed to be included in the cost of respective item.

8.02.00 **CIVIL WORKS**

The civil works shall be done in accordance with requirements stipulated elsewhere in this specification.

8.03.00 **STRUCTURAL STEEL WORKS**

The structural steel works shall be done in accordance with requirements stipulated elsewhere in this specification.

8.04.00 **BAY EQUIPMENT**

8.04.01 The disposition of equipment to be supplied are shown in enclosed single line diagrams and layout drawings.

8.04.02 The Contractor shall prepare layout drawings and submit the same for approval of the Employer. The approval of drawing shall not absolve Contractor from his responsibility regarding designing & engineering of switchyard and Contractor shall be fully responsible for all works covered in the scope of this specification.

8.05.00 **LIGHTNING PROTECTION**

8.05.01 Direct stroke lightning protection (DSLP) shall be provided in the switchyard by lightning masts (at least 50 m high)/ shield wires.

8.05.02 Lightning protection System down conductors shall not be connected to other conductors above ground level. Also no intermediate earthing connection shall be made to Surge arrester, Voltage Transformer, earthing leads for which shall be directly connected to rod electrode.

8.05.03 Every down conductor shall be provided with a test joint at about 150mm above ground level. The test joint shall be directly connected to the earthing system.

8.05.04 The lightning protection system shall not be in direct contact with underground metallic service ducts and cables.

8.06.00 **EQUIPMENT ERECTION NOTES**

a) All support insulators, circuit breaker interrupters and other fragile equipment shall be handled with cranes with suitable booms and handling capacity.

b) Where, assemblies are supplied in more than one section, Contractor shall make all necessary mechanical and electrical connections between sections including the connection between buses. Contractor shall also do necessary adjustments/alignments necessary for proper operation of circuit breakers, isolators and their operating mechanisms. All components shall be protected against damage during unloading, transportation, storage, installation, testing and commissioning. Any equipment damaged due to negligence or carelessness or otherwise shall be replaced by the Contractor at his own expense. The contractor shall strictly follow manufacturer's recommendations for handling and erection of equipment.

c) The slings shall be of sufficient length to avoid any damage to insulator due to excessive swing, scratching by sling ropes etc. Handling equipment, sling ropes etc. should be tested before erection and periodically thereafter for strength.

d) Bending of piping should be done by a bending machine and through cold bending only. Bending shall be such that inner diameter of pipe is not reduced. The pipes shall be thoroughly cleaned before installation.

e) Cutting of the pipes wherever required shall be such as to avoid flaring of the ends. Hence only a proper pipe cutting tool shall be used. Hack saw shall not be used.

f) For cleaning the inside and outside of hollow insulators only Muslin or leather cloth shall be used.

g) The rigid busbars for equipment interconnections shall have rigid connections at one end and expansion / flexible at the other end. The tubular aluminium connections shall have not more than one joint per span. Since no wastages are permissible, the bidder shall work out the cut lengths of aluminum tube based on finalized layout and dispatch the same to site without requiring owner's approval. Corona bells shall be provided at the end of the rigid busbars.

8.07.00 **CABLING**

8.07.01 Cabling shall be on cable racks, in trenches, vertical shafts, excavated trenches for direct burial, pulled through pipes and conduits run clamped on steel structures etc.

8.07.02 Cables inside the switchyard shall be laid on bolted GI angle supports at 600mm spacing with separate tiers for control and power cables. The GI angles shall be bolted / welded to galvanized insert plates inside RCC trenches. Prefabricated GI

	angles welded / bolted to galvanized insert plates before embedment in RCC shall be preferred.
8.07.03	Cables shall be generally located adjoining the electrical equipment through the pipe insert embedded in the ground. In the case of equipment located away from cable trench either pipe inserts shall be embedded in the ground connecting the cable trench and the equipment or in case the distance is small, notch/opening shall be provided. In all these cases necessary bending radii as recommended by the cable supplier shall be maintained.
8.07.04	Cabling in the control room shall be done on ladder type cable trays.
8.07.05	All interpole cables (both power & control circuit) for equipments shall be laid in cable trenches/G.I. Conduit Pipe of NB 50/100mm which shall be buried in the ground at a depth of 300mm.

ANNEXURE-I

a) **EARTHING NOTES FOR SWITHCYARD**

GENERAL

i) Earthing of operating boxes, cubicles shall be done by 50 X 6 mm GS flat while cable trenches and structure by 75 X 12 mm GS flat.

ii) Neutral points of systems of different voltages, metallic enclosures and frame works associated with all current carrying equipments and extraneous metal works associated with electric system shall be connected to a single earthing systems unless stipulated otherwise.

iii) Earthing system installation shall be in strict accordance with the latest editions of Indian Electricity Rules, relevant Indian Standards and Codes of practice and Regulations existing in the locality where the system is installed.

b) **DETAILS OF EARTHING SYSTEM**

Item	Size	Material
Main Earthing conductor	40mm dia rod	Mild steel
Conductor above ground & earthing leads (for equipment)	75 x 12/ G.S. Flat 50 x 6 mm	Galvanized steel
Rod Electrode	40mm dia, 3000mm	Mild steel
G.I. Earthwire	7/8 SWG	GI

c) For Step and Touch potential the following parameters shall be considered
i) Current distribution factor – 1(One)
ii) Duration of fault current - 0.5 sec
iii) Human body weight - 50kg

d) Grid resistance shall be less than 1(one) ohm.

e) **EARTHING CONDUCTOR LAYOUT**

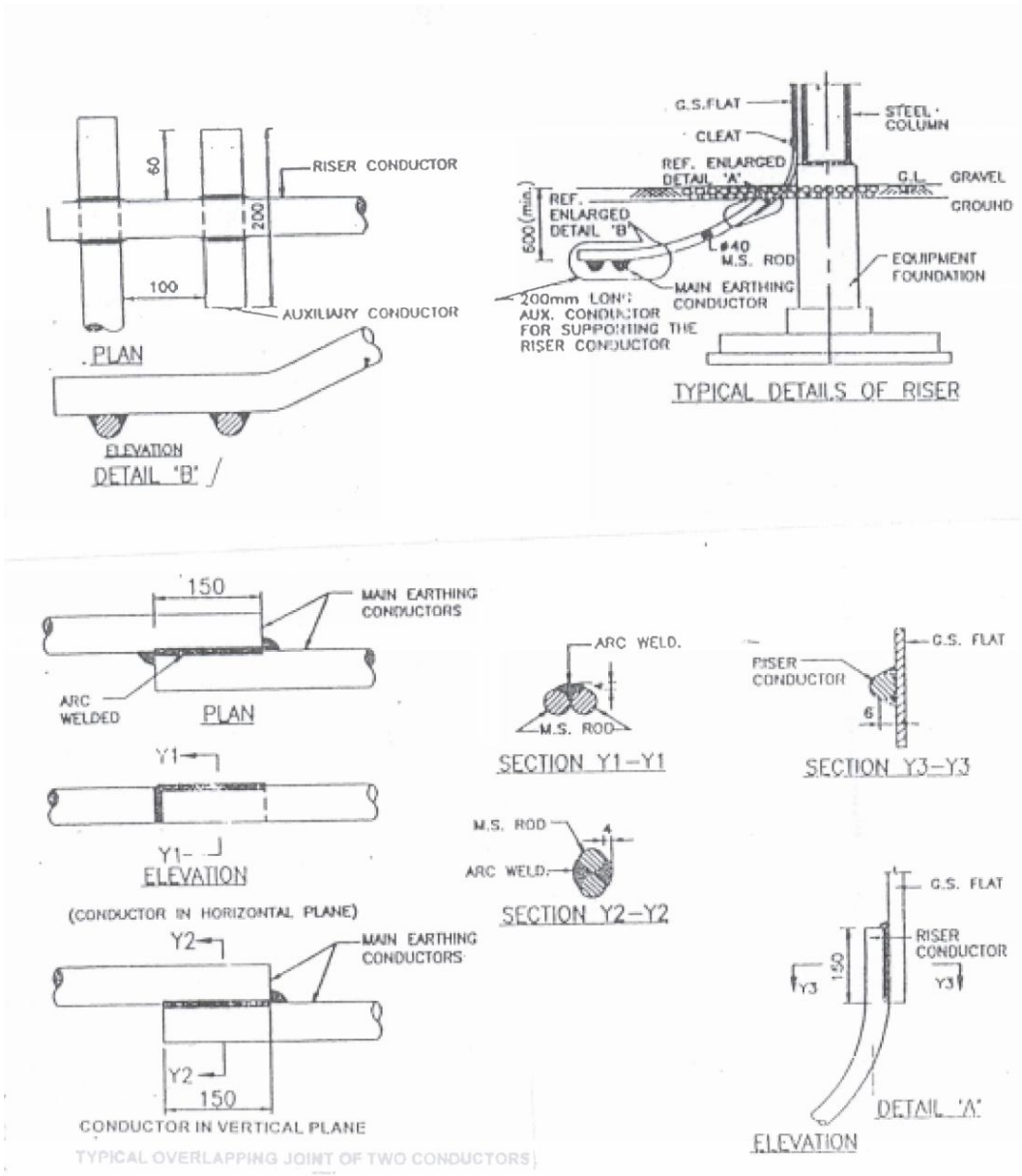
i) Earthing conductors in outdoor areas shall be buried atleast 600mm below finished grade level unless stated otherwise.

ii) Minimum 6000mm or higher spacing between rod electrodes shall be provided based on the earthmat design calculations.

iii)	Wherever earthing conductors cross cable trenches, underground service ducts, pipes, tunnels, railway tracks etc., it shall be laid atleast 300mm below them and shall be re-routed in case it fouls with equipment/structure foundations.
iv)	Tap connections from the earthing grid to the equipment/structure to be earthed, shall be terminated on the earthing terminals of the equipment/structure, if the equipment is available at the time of laying the grid. Otherwise, “earth insert” with temporary wooden cover or “earth riser” shall be provided near the equipment foundation/pedestal for future connections to the equipment earthing terminals.
v)	Earthing conductor along their run on cable trench ladder columns, beams, walls, etc. shall be supported by suitable welding/cleating at intervals of 750mm. Earthing conductors along cable trenches shall be on the wall nearer to the equipment. Wherever it passes through walls, floors etc. galvanized iron sleeves shall be provided for the passage of the conductor. Both ends of the sleeves shall be sealed to prevent the passage of water through the sleeves.
vi)	Earthing conductor around the building shall be buried in earth at a minimum distance of 1500mm from the outer boundary of the building. In case high temperature is encountered at some location, the earthing conductor shall be laid minimum 1500mm away from such location.
vii)	In outdoor areas, tap connections shall be brought 300mm above ground level for making connections in future, in case equipment is not available at the time of grid installations.
viii)	Earthing conductors crossing the road shall be either installed in hume pipes or laid at greater depth to suit the site conditions.
ix)	Earthing conductors embedded in the concrete fibre shall have approximately 50mm concrete cover.
f)	**EQUIPMENT AND STRUCTURE EARTHING**
i)	The connection between earthing pads and the earthing grid shall be made by short and direct earthing leads free from kinks and splices. In case earthing pads are not provided on the item to be earthed, same shall be provided in consultation with engineer.
ii)	Metallic pipes, conduits and cable tray sections for cable installation shall be bonded to ensure electrical continuity and connected to earthing conductors at regular interval. Apart from intermediate connections, beginning points shall also be connected to earthing system.
iii)	Metallic conduits shall not be used as earth continuity conductor.

iv)	A separate earthing conductor shall be provided for earthing lighting fixtures, lighting poles, receptacles, switches, junction boxes, lighting conduits, etc.
v)	Wherever earthing conductor crosses or runs along metallic structures such as gas, water, steam, conduits, etc. and steel reinforcement in concrete it shall be bonded to the same.
vi)	Cable and cable boxes/glands, lockout switches etc. shall be connected to the earthing conductor running alongwith the supply cable which, in turn, shall be connected to earthing grid conductor at minimum two points, whether specifically shown or not.
vii)	Railway tracks within switchyard area shall be bonded across fish plates and connected to earthing grid at several locations.
viii)	Earthing conductor shall be buried 2000mm outside the switchyard fence. Every post of the fence and gates shall be connected to earthing loop.
ix)	Flexible earthing connectors shall be provided where flexible conduits are connected to rigid conduits to ensure continuity.
x)	Equipment earthing (Riser & welding of two conductors) shall be done as per enclosed sketch.
g)	**JOINTING**
i)	Earthing connections with equipment earthing pads shall be of bolted type. Contact surfaces shall be free from scales, paint, enamel, grease, rust or dirt. Two bolts shall be provided for making each connection. Equipment bolted connections, after being checked and tested, shall be painted with anti-corrosive paint/compound.
ii)	Connection between equipment earthing lead and between main earthing conductors shall be welded/brazed type. For rust protections, the welds should be treated with red lead and afterwards thickly coated with bitumen compound to prevent corrosion.
iii)	Steel to copper connections shall be brazed type and shall be treated to prevent moisture ingression.
iv)	Resistance of the joint shall not be more than the resistance of the equivalent length of the conductor.
v)	All ground connections shall be made by electric arc welding. All welded joints shall be allowed to cool down gradually to atmospheric temperature before putting any load on it. Artificial cooling shall not be allowed.
vi	Bending of large diameter rod/thick conductor shall be done preferably by gas heating.

vii	All arc welding with large diameter conductors shall be done with low hydrogen content electrodes.
h)	**POWER CABLE EARTHING**
	Metallic sheaths and armour of all multi core power cables shall be earthed at both equipment and switchgear end. Sheath and armour of single core power cables shall be earthed at switchgear end only.
i)	**SPECIFIC REQUIREMENT FOR EARTHING SYSTEMS**
i)	Earthing terminal of each surge arrester, capacitor voltage transformer and lightning down conductors shall be directly connected to rod electrode which in turn, shall be connected to station earthing grid.
ii)	Auxilliary earthing mat of 1500mmX1500mm size comprising of closely spaced conductors at 300mm x 300mm spacing and at 300mm below ground shall be provided below the operating handles of the isolators. Operating handle shall be directly connected to earthing mat.
j)	**SPECIFIC REQUIREMENTS FOR LIGHTNING PROTECTION SYSTEM**
i)	Conductors of the lightning protection system shall not be connected with the conductors of the safety earthing system above ground level.
ii)	Down conductors shall be cleated on the structures at 2000mm interval.
iii)	Connection between each down conductor and rod electrodes shall be made via test joint located approximately 150mm above ground level.
iv)	Lightning conductors shall not pass through or run inside G.I. conduits.



NOTE : WELDING OF EARTHING CONDUCTOR SHALL BE CONDUCTED IN VERTICAL PLANE WHEREVER POSSIBLE

EQUIPMENT EARTHING DETAILS

STANDARD DRAWING

9.00.00 **SITE TESTING AND COMMISSIONING**

9.01.00 **INTRODUCTION**

An indicative list of tests is given below. Contractor shall perform any additional test based on specialties of the items as per the field QP/ instructions of the equipment supplier or Employer without any extra cost to the Employer. The Contractor shall arrange all instruments required for conducting these tests alongwith calibration certificates and shall furnish the list of instruments to the Employer for approval.

9.02.00 **GENERAL CHECKS**

a) Check for physical damage.
b) Visual examination of zinc coating/ plating
c) Check from name plate that all items are as per older/ specification.
d) Check tightness of all bolts, clamps and connecting terminals using toque wrenches.
e) For oil filled equipment check for oil leakage, if any. Also check oil level and top up.
f) Check ground connections for quality of weld and application of zinc rich paint over weld joint of galvanized surfaces.
g) Check cleanliness of insulator and bushings.
h) All checks and tests specified by the manufactures in their drawings and manuals as well as all tests specified in the relevant code of erection.
i) Check for surface finish of grading rings (corona control ring.)
j) Pressure test on all pneumatic lines at 1.5 times the rated pressure shall be conducted.

9.03.00 **CIRCUIT BREAKERS**

a) Insulation resistance of each pole.
b) Check adjustments, if any, suggested by manufacturer.
c) Breaker closing and tripping time.
d) Slow and power closing operation and opening
e) Trip free and anti pumping operation.
f) Minimum pick up volts of coils
g) Contact resistance
h) Functional checking of compressed air plant and all accessories
i) Functional checking of control circuits, interlocks, tripping through protective relays and auto-reclose operation.
j) Insulation resistance of control circuits, motor etc.
k) Resistance of closing and tripping coils.

9.04.00 **ISOLATORS**

a) Insulation resistance of each pole
b) Manual and electrical operation on interlocks
c) Insulation resistance of control circuits and motors.
d) Ground connections

e) Contact resistance
f) Proper alignment to minimise the vibration to the extreme possible during operation.
g) Measurement of operating torque for isolator and Earth switch
h) Resistance of operating and interlocking coils.

9.05.00 **CURRENT TRANSFORMERS**

a) Insulation Resistance Test
b) Polarity test.
c) Ratio identification test-checking of all ratios on all cores by primary injection of current.
d) Dielectric test of oil (wherever applicable)
e) Magnetizing characteristics test.

9.06.00 **VOLTAGE TRANSFORMERS/CAPACITOR VOLTAGE TRANSFOMERS**

a) Insulation resistance test
b) Polarity test
c) Ratio test
d) Dielectric test of oil (if applicable)

9.07.00 **SURGE ARRESTER**

a) Grading leakage current
b) Resistance of ground connection.

9.08.00 **PHASING OUT**

The phasing out of all supplies in the station system shall be carried out.

9.09.00 **STATION EARTHING**

a) Check soil resistivity
b) Check continuity of grid wires
c) Check earth resistance of the entire grid as well as various sections of the same.
d) Check for weld joint and application of zinc rich paint on galvanised surface.
e) Dip test on earth conductor prior to use.

9.10.00 **CONDUCTOR STRINGING AND POWER CONNECTORS**

a) Physical check for finish
b) Electrical clearance check
c) Testing of torque by torque by torque wrenches on all bus power connectors and other accessories.
d) Milli volt drop test on all power connectors.
e) Sag and tension check on conductors.

9.11.00	**INSULATORS** Visual examination for finish damage, creepage distance, etc.

SUB-SECTION-II-E19

CONTROL AND PROTECTION

Control and Protection

1.00.00 General Requirements

1.00.01 The specification covers the general description of design, manufacture, testing, supply, installation and commissioning of control and protection system.

1.00.02 Control and Protection for new 400/220kV (as applicable) Bays are envisaged at existing 400/220kV switchyard. The Busbar protection system for these new bays shall be integrated with existing Busbar protection scheme along with necessary modifications, if required.

2.00.00 **General Requirements of Numerical Relays and Auxiliary Relays**

i. All protection relays to be supplied under this package shall be Numerical type.

ii. All numerical relays, auxiliary relays and devices comprising the Bay Protection Units shall be of types, proven for the application, satisfying the requirements specified elsewhere and shall be subject to the Owner's approval.

iii. The necessary auxiliary relays, trip relays, etc. required for complete scheme, interlocking, alarm, logging, etc. shall be provided. No control relay, which shall trip the circuit breaker when the relay is de-energized, shall be employed in the circuits.

iv. Relays shall be provided with self-reset contacts except for the trip lockout, which shall have contacts with a manual reset feature.

v. Transients present in CT & VT connections due to extraneous sources in the EHV system shall not cause damage to the numerical and other relays. CT saturation/ transients shall not cause mal-operation of numerical relays.

vi. Only DC/DC converters shall be provided in the solid state devices / numerical relays wherever necessary to provide a stable auxiliary supply for relay operation. Except for event logging, alarm and annunciation type of non-trip functions, protective relay contact multiplication shall be done through high speed trip relay only.

vii. DC batteries inside protective relays necessary for relay operation shall not be acceptable. Equipment shall be protected against voltage spikes in the auxiliary DC supply.

viii. Each numerical relay shall have a serial interface on the front for local communication to a Personal Computer and Printer. Further, all the numerical relays being supplied under this package, shall be interconnected to each other through a rear communication port, forming an Engineering LAN, connected to engineering workstations located in the switchyard control room. Facilities shall be provided to access each discrete protection function including modification in relay settings and monitoring of the relay from a separate Protection / Disturbance Recorder Station provided and permanently wired to all the numerical relays comprising various Bay Protection Units. Necessary licensed software (latest version) and hardware including PC (latest configuration), printer, and fiber optic cabling (fiber optic cable to be used if the distance is more than 100 metres) for SCR, for the above purpose shall be in the Bidder's scope. A printout of all settings, scheme logic, event and disturbance records

	etc. shall be accessible through HMI and the engineering workstations. LEDs and a backlit LCD screen shall be provided for visual indication and display of messages related to major trips / alarms. Necessary multilevel password protection shall be provided. ix. The Bay Protection Units shall be arranged to provide two independent, high performance and reliable systems housed in different panels with separate DC supplies, separate CT/VT cores, separate cables and trip relays to obtain 100% redundancy. Associated trip relays of the two systems shall be separate, having a sufficient number of contacts for all the functions. x. The numerical relays shall be provided with built-in disturbance recording functionality. The data from DR function shall be available in IEEE/COMTRADE format and shall be compatible with the dynamic relay test system being supplied under this contract. x. The manufacturer of the numerical protection system offered shall carry out the complete engineering, testing and commissioning on site of the offered protection equipment including the associated relays and protection panels. The testing and commissioning protocols for the numerical protection systems offered shall be approved by the Owner before commissioning on site. xi. Pick up range of the Binary inputs shall be minimum 70 V DC/AC. xii. All the numerical relays shall have adequate processor capability to carry out programmable scheme logics (PSL) required for implementing approved protection and control schemes over and above its inbuilt protection functions algorithm. xiii. All numerical relays shall be supplied with all the protection function/features in disabled condition. Relevant features/protection function shall be enabled at the time of commissioning at site as per approved logic and relay settings. xiv. BPU offered shall have adequate I/Os for function realization. Use of auxiliary relays (contact multiplication) shall be permitted only when the entire product range does not support any further hardware augmentation for additional I/Os. xv. Configuration/ scheme logics /relay settings shall be submitted by the Contractor for approval during detailed engineering. xvi. The numerical protection shall have continuous self-monitoring & cyclical test facilities. The internal clock of all the numerical relays being supplied under this package shall be synchronised through the GPS Time synchronising system to be supplied under this contract. A timing accuracy of 1 ms shall be achieved for all the numerical relays.
3.00.00	**Remote Interface with RLDC**
3.01.00	The Engineering LAN shall have provision for sharing data related to bays under present scope with remote RLDC through existing RTU on IEC60870-5-101 or IEC60870-5-104. Typical data to be shared is indicated in the following paragraph. All hardware required for this data sharing such as modems, interconnecting communication cables etc. shall be under Bidder's scope. At least 64 digital inputs and 9 Analog inputs shall be provided for each bay.

3.02.00	Only selected information such as bus voltage, frequency, active / reactive power through various feeders, status of OLTC, open / close status of circuit breakers, isolators etc. is required to be shared with RLDC. However, actual list of information to be shared with RLDC shall be finalized during detailed engineering. The contractor shall have to demonstrate the availability of desired information at the output of modem at site.
3.03.00	Necessary hardware/software to ensure provision for Remote Interface with RLDC shall also be provided by the contractor.
4.00.00	**Provision for interfacing with owners PI (Plant Information) system on OPC (if applicable):**
4.00.01	**OPC Server requirement**: a) The OPC Server is envisaged for connectivity with owner's PI Server of OSI soft, USA. b) OPC Data Access Server with OPC version 2.05a shall be supplied. Any other higher version should be backward compatible with version 2.05a. c) Vendor shall ensure that data is accessible from the OPC Server to a PI Server of OSI Soft – version 3.4.375.38 and later (or any other 3rd party system) using PI-OPC client of OSI soft – version 2.3.7.0 and later (or any other 3rd party OPC Client). d) Timestamp when the measurement was made is to be used in the OPC Server. OPC Server should not use the time of the server as timestamp of the measured signal. e) Vendor to indicate the latency between measurement and availability in OPC server. f) All data like MW, MVAR, CB status, Metering Master Station Data etc. shall be communicated through this OPC Server. The number of tags to be licensed for the OPC Server as well as the maximum number of tags the OPC server can support shall be approved during detailed engineering. g) Vendor should inform the method of testing the OPC Compliance. Vendor should demonstrate that data is accessible from the OPC server using a standard 3rd party OPC client such as PI-OPC client of OSI soft, OPC client of Matricon.
4.01.00	**Main Plant DDC Interface (if applicable)** Suitable hardware and software, including adequate number of LAN switches / gateways, shall be provided to interface with Main Plant DDC. Also, necessary data such as Status of EHV Circuit Breakers, associated Isolator & Earth switch, Bus Voltage / frequency etc. can be provided to the Main Plant. The exact signals shall be finalized during detailed engineering. (Note: The I/O list for above shall be made available to the Bidder during detailed engineering). The cable and associated hardware required for connecting to the plant DDC terminal shall also be provided by the contractor**.**

4.02.00 Operator Workstations

i. Operator workstations shall be provided based on the latest state of the art workstations and technology suitable for industrial applications and switchyard environments.

ii. The main memory shall be sized sufficient to meet the functional and parametric requirements as specified. The bulk memory shall be at least 1.5 times the capacity required sufficient to meet the functional and parametric requirements However, both the main and the bulk memory shall be subject to minimum hardware specification (minimum 2X500GB RAID I, 8GB DDR RAM) . The exact system configuration and sizing shall be approved by the Owner during detailed engineering.

iii. The Workstation shall be based on industry standard hardware and software which will ensure easy connectivity and portability of all the software being provided for various IEDs under this contract.

iv. Power Fail Auto Restart (PFAR) facility, with automatic time synchronization to GPS time shall be provided. The only operation required will be the login of operators.

v. Workstations shall be powered from inverter supply connected to the station battery.

vi. Workstation shall work on Operating system Windows (latest version) (64bit) or higher. The Contractor shall state any other recommendations during Bidding. Latest anti-virus software shall be supplied.

4.03.00 Functional requirement of the HMI Software

i. The HMI shall have an intuitive graphical design.

ii. Single line diagram of the bays under scope, including the status of the equipment, shall be displayed. Different colours shall be used to differentiate voltage levels, earthed network components, selected object on screen, selected object for command, blocked/tagged equipment etc. on the graphical displays. A library of standard symbols shall be used to represent switchyard equipments on the graphical display. The graphic displays shall be subject to Owner's approval.

iii. Status of the bays in scope in terms of actual values of currents, voltages, frequency, active and reactive powers, positions of the circuit breakers, isolators and earth switches, tap positions, winding temperatures etc. shall be displayed.

iv. Highest degree of security shall be provided to prevent unwanted operation of any equipment through HMI. Simultaneous switching of more than one device from the same or different Control Levels shall not be possible. Once a device is "Selected" for operation, the operator shall be able to recognize the "Selected" device on all the graphical and other displays. All other devices shall be blocked as long as a device is selected for operation. The "execution" of a command shall be possible only if the device is not blocked and no interlocking condition is being violated. The interlocking scheme, implemented at the Bay Level, shall be checked before releasing the "execute" command. The operator shall receive suitable feedback about the successful or unsuccessful execution of the

command. In case of unsuccessful execution, the reason for non-execution of command shall be indicated to the operator, which shall include details of the blocking condition in the interlocking logic. In case of successful execution, the operator shall receive confirmation about the new switching position of the equipment depending on the command.

v. The following functionality shall be available at the Engineer and Fault Recording Workstation.

a) Formulation and Implementation of interlocking logic for various bay equipment into Bay Control Units.

b) Downloading or altering the protection relay settings in the Bay Protection Units.

c) Automatically upload, archive, review and analyse graphically the Digital Fault Data available from the BCU and Bay Protection Units.

d) Ability to export fault records in COMTRADE format.

5.00.00 **Bay Level Functionality**

i. All the Bay Level Functionality shall be built into Bay Control Units (BCUs) and Bay Protection Units (BPUs).

ii. BCUs and Bay Protection Units shall be provided at Control Level 1 i.e. Bay Level of Logical Architecture, to facilitate control, monitoring and protection of switchyard equipment. One Bay Control Unit shall provide complete functionality for one EHV bay. Each set of BCUs shall have sufficient analog and digital inputs to acquire the status of each and every circuit breaker, isolator, earth switch, Transformer gas parameters / tap position etc. of all the bays in Contractor's scope. A minimum of 64 Digital Inputs and 24 Digital Outputs per bay shall be provided in associated Bay Control Units. A minimum number of 16 Analogue input channels per bay shall also be provided in the associated BCU. Rating of the various analogue input channels (110 V /1 A /4-20 mA) shall be decided during detail engineering.

iii. All the Bay Control Units and Bay Protection Units shall be installed in Switchyard control room. BCU & BPU shall be mounted in different panels.

iv. All BCUs and Bay Protection Units shall be provided with self-diagnosis and supervision functions to ensure maximum availability. BCUs shall require no periodic routine maintenance and testing. An alarm contact shall be provided for hardware failures, failures of internal and external auxiliary supplies etc. Special algorithms shall be provided to check the microprocessor's memories. A watchdog function shall supervise the execution of program by the microprocessor.

v. The layout of equipments/panels in SWITCHYARD control Room/ shall be subject to Owner's approval.

5.01.00 **Bay Control Units (BCU)**

5.01.01 **Control and Protection Features of BCUs**

The Bay Control Units shall have following built-in functions:

i. **Mimic control panel** to display graphically the bay configuration, analogue measurands, alarms, and offer bay level control.

ii. **Switching of Switchyard Bay Equipment** depending on conditions such as interlocking, synch-check, control mode, or external status condition. Adequate safety features like prevention of double operation, command supervision, block/de-block, over-riding the interlocking etc. shall be provided. All such security features shall be finalized and approved by Owner during detailed engineering.

iii. **Status Supervision** of switchyard equipment.

iv. **Interlocking Function** to prevent unsafe operation of switchyard equipment such as circuit breakers, isolators, earth switches etc. Interlocking shall be implemented on bay level, by user-friendly, menu-driven configuration software within the BCU. Signalling of statuses between bays shall be performed by inter-bay communication (peer-to-peer) i.e. Goose messaging. The auxiliary contacts of each of the equipment shall be wired to the BCU for this purpose. However for those equipment, which are required for interlock of other bay equipment, two sets of their contacts shall be wired to BCUs of two different bays. Such interlocks involving more than one bay equipment shall be realized through goose messaging. An over-riding / bypass function for bay-level interlocking shall be provided at appropriate security level for maintenance or during emergency conditions. Failure of any one BCU shall not affect the interlocking at any other bay, only the bay with failed BCU shall not be able to operate. This shall be achieved by providing a backup mechanism in case of failure of one BCU which affects the interlocking in another BCU (e.g. a backup mechanism for monitoring the status of the bus bar earths), to allow the remainder BCUs to function **with full interlocking.** The interlocking logic shall be defined during the details engineering phase to prevent illegal operation.

v. **Analogue** Measurements for bay voltage (per phase), current (per phase), frequency, MW and MVAR, tap position / gas parameters / winding temperature of Transformers. These measurements shall not require the use of any intermediate transducers. The accuracy of measurement shall be 0.5% for voltage, current and frequency, and 1.0% for MW and MVAR. The measured and computed values shall be displayed locally on BCU and on operator's workstation located in central control room.

vi. **Event and Alarm Handling**: BCUs shall acquire all the bay level alarms and events from field inputs with a resolution and time tagging of 1 milli sec and shall transfer these to operator's workstation over substation LAN**.**

vii. **Synchronization Check Feature:** Synchronization Check feature shall determine the difference between the amplitudes, phase **angles and** frequencies of two voltage vectors. Checks shall be provided to detect a dead line or bus bar. The voltage difference and phase angle difference settings shall be adjustable.

5.00.00 **Protection and Metering for EHV System (EHV)**

i. The protection and control equipment and circuitry, shall be arranged to provide two independent, high performance and reliable protection systems with separate DC supplies, separate CT/VT cores and separate cables and hand reset (three phase) trip relays to obtain 100% reliability. The DC supplies to these protections shall be monitored.

ii. Associated trip relays of the two systems shall be separate having sufficient number of contacts for all the functions.

iii. Each protection system shall energize both trip coils of the circuit breaker.

iv. The general protection requirements for the EHV systems are indicated in the tender drawing for switchyard protection SLD.

v. Total critical fault clearing time including CB operating time from fault initiation in any part of the 400kV/220kV system under all conditions shall not be more than 80ms for faults within zone-I reach (i.e. up to 80% of line length) and 100ms for end zone faults including carrier transmission time of 20ms.

iii. The SIR values to be considered for the operating time of relays for the SWYD feeders shall be between 4 and 15. The rated break time for the EHV circuit-breaker, as offered, shall be considered for the purpose of circuit-breaker operating time. The Contractor shall furnish the operating time curves at various SIR values for all types of faults.

5.01.00 **Transformer Protection**

a) The Bay Protection Unit offered for each transformer should be such that it provides a comprehensive protection for the transformer for all types of faults and abnormal operating conditions.

b) The numerical relays, comprising the Bay Protection Unit, for each shall be configured into two protection groups operating on two separate DC supplies, such that one protection group shall always be available to detect and operate for any type of fault in the transformer, under condition of failure of other protection group or of associated DC supply of the other protection group.

c) Should the protection functions specified for a transformer be available as a single discrete numerical relay, two such relays shall be supplied to meet the requirements of relevant clause above. Differential, REF and Back-up protection of any transformer shall be realized in separate numerical relays with Differential , Back-up E/F in one channel and REF, Back-up O/C in another channel.

5.01.01 **Transformer differential protection shall:**

a) Be of numerical type and shall have continuous self-monitoring and diagnostic features

b) Be three-pole type, with faulty phase identification/indication. The operating time of the relay shall not be greater than 30ms at 5 times the setting.

c) Be stable for magnetizing inrush currents and shall be stable under normal over-fluxing conditions. Magnetizing inrush stability shall not be achieved through the use of an intentional time delay;

	d) Have an internal feature in the relay to take care of the angle and ratio correction; e) Have a disturbance recording feature to record the analogue form of instantaneous values of the current in all three windings (i.e. nine analog channels) during faults and disturbances for the pre-fault and post-fault periods. The disturbance recorder shall have the facility to record the following external digital channel signals in addition to the digital signals pertaining to the differential relay itself: HV breaker (main and tie) status LV breaker status Buchholtz/On-load tap-changer Buchholtz alarm/trip Winding temperature/Oil temperature/Pressure relief alarm/trip of transformer f) The necessary hardware and software for downloading the data captured by the disturbance recording function to a personal computer available in the substation shall be included in the scope. g) Be acceptable with built-in features of definite time overload protection (alarm) relay provided the technical requirements of these relays specified under the relevant clauses are met.
5.01.02	**Restricted Earth Fault Protection shall:** a) Be single-pole type; b) Be of current/voltage operated high impedance type; c) Have a suitable non-linear resistor to limit the peak voltage d) Shall have setting range from 5-80%
5.01.03	**Transformer over fluxing Protection shall** a) Operate on the principle of voltage to frequency ratio b) Have inverse time characteristics compatible to transformer over fluxing withstand capability and also a separate high set feature. c) Provide an independent alarm with continuously adjustable time delay. d) Tripping time shall be governed by V/ F Vs time characteristic of the relay e) Have a set of characteristics for various multiplier settings. f) Have a resetting ratio of 98% or better.
5.01.04	**Transformer Backup Over current Protection (51) shall** a) Be triple pole type b) Be of definite time over current type c) Have an adjustable setting range of 20-80% or 150-600% of rated current (as applicable) and 0.3 to 3.0 sec time delay. d) Be provided with operation indicator
5.01.05	**Transformer Backup Earth Fault Protection (51N) shall** a) Be single pole type

b) Be of definite time over current type

c) Have an adjustable setting range of 10-80% of rated current as applicable and 0.3 to 3.0 sec. Time delay

d) Be provided with operation indicator

5.02.00 **EHV Circuit-breaker Protection**

Each circuit breaker in the EHV switchyard shall be provided with following protection functions:

i. **Numerical Local Breaker Back up Protection Function**: Duplicated LBB protection function shall be provided for each EHV circuit breaker in the EHV switchyard. The LBB protection function for each main circuit-breaker shall be interfaced with the Bus bar protection by hard-wired signals between the Bay Protection Unit and the Bus bar protection panels. The intent of providing the hard-wired logic as a back up to the software logic is to ensure that in the event of failure of Substation LAN, the bay level functionality is not hampered. The LBB function as a built-in function of Bay Protection Unit is acceptable provided it meets all the requirements specified for the LBB function. However, Tie LBB of incomplete dia shall not be realized not be realized as in built function of BB protection. In addition, the LBB protection function shall meet following criteria:

a) Be three pole type having three single phase units

b) Shall operate for stuck breaker conditions

c) Have an operating/resetting time each of less than 15 ms.

d) The LBB function shall be initiated by external trip contacts from the Bay Protection Units and after a set time delay shall energize the trip bus in the bus bar protection scheme on which the stuck breaker is connected for tripping of all breakers connected to the particular bus. **For all EHV CBs, a repeat trip command from LBB shall be given to the primary breaker through two separate self-reset trip relay on different DC source.**

e) Have a setting range of 5 to 80% of rated current

f) Have a continuous thermal withstand of 2 times rated current irrespective of the setting.

g) Have time delay feature with a continuously adjustable setting range of 0.1 to 1s.

h) Shall be an individual phase comprehensive scheme.

i) Shall not operate during the single-phase auto-reclosing period.

j) Shall provide end-fault protection that initiates a direct transfer trip to the remote end.

ii. **Trip Coil Supervision:** A Trip Coil supervision function shall be provided for each lockout trip relay and each of the circuit-breaker trip coils. It shall incorporate both the pre-close and post-close supervision of trip coils and associated trip circuits. An audible alarm shall be given in the event of operation of trip coil supervision function. It shall have a time delay on drop-off of not less than 200ms. Trip coil supervision function as a built-in feature of the Bay Protection Units is also acceptable, provided it meets all other requirements specified here, including loss of DC supply.

iii. **High Speed Trip Relays** supplied under this package shall be:

a) With operating time of less than 10ms.

b) With reset time of less than 20ms.

c) Provided with operation indicator for each element/coil.

d) Have adequate contacts to meet the scheme requirements of trip, interlock, LBB, auto-reclose, DR, fault locator, etc.

e) Hand reset or self-reset, depending on the application. Further, the trip relays shall be provided with a feature to receive manual reset command from engineering workstation located in remote.

5.03.00 **Integration of Bus bar Protection with existing scheme**

a) The Busbar protection system for new bays shall be integrated with existing Busbar protection scheme along with necessary modifications, if required.

b) All necessary hardware components/trip relays/peripheral units/ accessories etc required for complete integration with existing bus bar system are in bidders scope

c) Bay units shall be mounted in respective BPU Panels.

d) Include individual high speed hand reset tripping relays for each bay/ feeder, as identified in single line diagram/ Tender SLD.

5.05.00 **Islanding Scheme (if applicable)**

a) New bays shall be integrated with existing islanding scheme. Also it shall have a separate dedicated islanding trip relay for each of the EHV breaker including all EHV bays as per tender SLD

5.06.00 **Energy Meters**

5.06.01 One no. class 0.2s accuracy energy meters suitable for ABT requirement as specified below in **clause 5.06.02** shall be provided at each location indicated in respective tender protection SLD. All ABT type meters shall be fed from accuracy class 0.2s CT and accuracy class 0.2 CVT/VT/PT.

This metering system shall have following features:

i. Meters shall be microprocessor-based MWH meters having an accuracy class of 0.2S or better. MVARH meters shall have accuracy class of 0.5 or better.

ii. These meters shall have provision for downloading of data through an optical port and /or through RS 232/485/ Ethernet port.

iii. Even under absence of VT input, energy meter display shall be available and it shall be possible to download data from the energy meters.

iv. All these meters shall be networked using Modbus protocol.

Dummy panels shall be supplied for mounting of owner's supplied energy meters. These energy meters shall be one (1) nos for each transformer bay**.** Terminal blocks (disconnecting type) shall also be provided with these panels.

Quantity and dimension of these panels shall be decided during detailed engineering.

5.06.02 **Technical Requirements of Energy Meters for ABT Requirement**

Contractor shall supply energy meters as per the technical specification given below:

i. Shall be microprocessor-based conforming to IEC 62052-11, IEC 62053-22, IS 14697

ii. Shall carry out measurement of active energy (both import and export) and reactive energy (both import and export) by 3-phase, 4 wire principle suitable for balanced/ unbalanced 3 phase load.

iii. Shall have an accuracy of energy measurement of at least Class 0.2S for active energy and at least Class 0.5 for reactive energy.

iv. The active and reactive energy shall be directly computed in CT & VT primary ratings.

v. The reactive energy shall be recorded for each metering interval in four different registers as MVARh (lag) when active export, MVARh (Lag) when active import, MVARh (lead) when active export, MVARh (Lead) when active import.

vi. Two separate registers shall be provided to record MVARH when system voltage is >103% and when system voltage is < 97%.

vii. Shall compute the net MWh and MVARh during each successive 15-minute block metering interval along with a plus/minus sign, instantaneous MWh, instantaneous MVARh, average frequency of each 15 minutes, net active energy at midnight, , net reactive energy for voltage low and high conditions at each midnight.

viii. Each energy meter shall have a display unit. It shall display the net MWh and MVARh with a plus/minus sign and average frequency during the previous metering interval; peak MW~~h~~ demand since the last demand reset; accumulated total (instantaneous) MWh and MVARh with a plus/minus sign, date and time; and instantaneous current and voltage on each-phases.

ix. All the registers shall be stored in a non-volatile memory. Meter registers for each metering interval, as well as accumulated totals, shall be downloadable. All the net active/reactive energy values displayed or stored shall be with a plus /minus sign for export/import.

x At least the following data shall be stored before being over-written for the following parameters:-

	Parameters	**Details**	**Min No. of days**
1	Net MWH	15 min block	40 days in meter
2	Aver Freq	15 min block	40 days in meter
3	Net MVARH for V>103%	15 min block	40 days in meter
4	Net MVARH for V<97%	15 min block	40 days in meter
5	Cumulative Net MWH at every midnight	15 min block	10 days in meter/ 40days in PC
6	Cumulative Net MVARH for V>103% at every midnight		10 days in meter/ 40days in PC
7	Cumulative Net MVARH for V<97% at every midnight		10 days in meter/ 40days in PC
8	Date and time blocks of VT failure on any phase		

xi. Shall have a built in clock and calendar with an accuracy of less than 15 seconds per month drift without assistance of external time synchronizing pulse.

xii. Date/time shall be displayed on demand. The clock shall be synchronized by GPS time synchronization equipment.

xiii. The voltage monitoring shall be inbuilt. The meter shall be suitable to operate with power drawn from the VT supplies.

xiv. The power supply to the meter shall be healthy even with a single-phase VT supply. An automatic backup, in the event of non-availability of voltage in all the phases, shall be provided by a built in long life battery and shall not need replacement for at least 10 years with a continuous VT interruption of at least

2 years. Even under absence of VT input, energy meter display shall be available and it shall be possible to download data from the energy meter. In case data downloading is not possible in absence of VT supply, meter with provision of 220V DC auxiliary supply shall be provided. Date and time of VT interruption and restoration shall be automatically stored in a non-volatile memory.

xv. Shall have an optical port on the front of the meter for data collection from either a hand held meter reading instrument (MRI) having a display for energy readings or from a notebook computer with suitable software . The contractor shall supply the MRI and/or notebook complete with all optical interface unit required.

xvii. The meter shall have means to test MWh and MVARh accuracy and calibration at site in-situ and test terminal blocks shall be provided for the same.

xviii. Each meter shall have a unique identification code provided by the Owner and shall be permanently marked on the front of the meter and stored in the non-volatile memory of the meter.

6.00.00 **Sequence-of-Event Recording system**

Sequence of event functionality pertaining to the main protection applications shall be provided as a part of the individual protection devices. Sequence of event recording pertaining to the monitoring of non-protection device status information, such as switchyard open and close status which are not catered by the main protection relays, shall be recorded by the bay controller.

The sequence of event recording shall:

a) Have a time resolution of 1 millisecond or better.

b) Be able to cope with up to 40 changes in any one 10 millisecond interval.

c) The date and time should be printed to the nearest 1 millisecond followed by a tag describing the point which has operated.

d) Events that occur while another event is in the process of being printed are to be stored for subsequent printing. Over 100 such events must be stored.

The event printouts shall contain at least the station identification, date and time (in hour, minutes, seconds and milliseconds), event number and event description (at least 40 characters).

7.00.00 **Time Synchronization Equipment**

i. Time Synchronization equipments shall be provided and shall be located in the switchyard Control Room. It shall receive Coordinated Universal Time (UTC) transmitted through Geo Positioning Satellite (GPS) for time synchronization of all components of the Engineering LAN.

ii. Shall be complete in all respects including antenna, all cables, processing equipment, etc.

iii. All auxiliary systems and special cables required for synchronization of the equipment shall be supplied and commissioned by the Contractor.

iv. Shall work from DC supplies only and the Contractor to clarify if any built-in battery backup is provided, in which case, same shall be of long life lithium batteries.

v. Shall be immune to hostile electrical environment. Suitable protections are to be provided against lightning surges and over-voltages in power supply systems and antenna feeders.

vi. The system shall be fully tested to the relevant international standards such as IEC: 801 and IEC: 255. One copy of all the test reports shall be enclosed with the bid.

vii. Bay Protection units (BPU) and all numeric protection relays shall be synchronized with an accuracy of 1ms.

viii. The system should be able to track more than 1 satellite at a time to ensure no interruptions of synchronization signals.

ix. The system shall have provisions for combination of any of the following output signals:

a) NTP (network time protocol) 100Mbits Ethernet port

b) IRIG-B00x (TTL, pulse width modulated signal)

c) 2 x Pulse per half-hour/ Pulse per minute/ Pulse per second outputs via potential free contacts

d) Any other output port as may be required for the offered system.

e) Alarm status contact indicating healthy status of system

x. These output ports shall be compatible with the requirement of the equipment to be synchronized i.e. BPUs. The master clock in control room shall also be synchronized with the time synchronization system. **The actual port requirements (no./type) in line with the system offered shall be finalized during detailed engineering.**

xi. The equipment should have a periodic time correction facility of one-sec. periodicity. The equipment shall also have real time display in hour, minute, second (24 hour mode) and have a separate time display unit to be mounted on top of the MIMIC panel, having display size of approx. 144mm height.

8.00.00 **Relay Test Equipment**

i. The required relay test equipment shall comprise the following:

a) Dynamic portable relay test system for allowing dynamic and steady state testing of IEC 61850 compatible IEDS also.

b) Any other auxiliary items like phantom loads, etc. required for testing all the protection relays supplied under this contract.

ii. It shall have the capability to replay the Disturbance / Fault records acquired by the numerical relays / stand-alone DR 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, energy meters and transducers, along with a laptop PC, shall also be supplied.

iii. All commissioning tests on protection relays, energy meters and transducers shall be carried out with this relay test equipment being supplied under this contract and test reports shall be maintained as per the agreed protocols.

10.00.00 **Constructional features**

10.01.00 **Panels**

i. All panels shall be free standing, floor mounting type and completely metal enclosed. Cable entries shall be from the bottom. Panels shall be of IP 31 class or better.

ii. Panels shall have removable gland plates with glands made of brass and shall be suitable for armoured cables.

iii. Thickness of panel sides shall be 2mm for Cold Rolled Sheet Steel, 2.5mm for Hot Rolled Sheet Steel.

iv. Panels shall be painted. The colour of paint for exterior of the panel shall be as follows:

I. Ends: Colour-Blue, Shade-RAL5012

II. Front and Rear: Colour-Grey, Shade-RAL9002

v. Panels shall have a lockable front toughened glass door and a swing frame/ fixed rack. Panels shall facilitate direct access to any component mounted inside and shall have at least 20% free space for future expansion.

vi. Shall be supplied complete with interconnecting wiring between all devices mounted therein.

vii. All equipment mounted on front and rear side of the panels shall have individual name plates with equipment designation engraved. Each panel shall also have circuit/feeder designation name plate.

viii. Each panel shall be provided with a 240V AC fluorescent lighting fixture controlled by door switch as well as a 5A, 240V AC switch-socket unit.

ix. Shall be provided with necessary arrangements for receiving, distributing, isolating and fusing of AC & DC supplies for various circuits for control, signalling, lighting, interlocking, etc. Selection of main and sub-circuit fuse rating shall ensure selective clearance of the sub-circuit faults.

x. Voltage circuits for protection and metering shall be protected by fuses. Suitable fuse failure relays shall be provided to give an alarm for voltage circuits of

protection/metering. Voltage selection scheme based on relays shall be provided for meters wherever applicable.

xi. The DC supplies at the individual relay and protection panels shall be monitored and failure of DC supplies shall be enunciated.

10.02.00 **Earthing**

i. The panels shall be equipped with an earth bus of at least 50x6mm^2 galvanized steel flat bar or equivalent copper.

ii. Earth buses of adjoining panels shall be connected for continuity. The continuous earth bus so formed shall be connected to the main earth grid at one end only.

iii. All metallic cases of the mounted equipment shall be separately connected to the earth bus by 2.5mm^2 copper wires. No loops in the earth wiring shall be permitted.

iv. CT/VT neutral secondary shall only be earthed at the terminal block of the panel through links, such that the earthing of one group may be removed without disturbing others.

v. An independent Electronic Earth System shall be provided as per contractor's standard. The electronic earth shall be connected to the substation earth mat through a dedicated riser.

10.03.00 **Wiring**

i. Internal wiring to be connected to external equipment shall terminate on terminal blocks.

ii. The terminal blocks for CTs and VTs shall be provided with test links and isolating facilities. The CT terminal blocks shall be provided with short circuiting and earthing facilities.

iii. Shall have 20% terminals as spare terminals in each panel.

iv. All equipment mounted on front and rear side of the panels shall have individual name-plates with equipment designation engraved. Each panel shall also have circuit/feeder designation name plate.

v. All wiring shall be with 660V grade, single core, PVC insulated stranded copper conductor. 660V grade Terminal Blocks shall be provided.

vi. Wires shall be vermin proof. Minimum size of conductor shall be 1.5 mm2 in general, but for CT & VT circuits it shall be 2.5 mm2. Minimum number of strands shall be three.

vii. Contractor shall be solely responsible for completeness and correctness of all the wiring, and for proper functioning of the connected equipment.

11.00.00 **Control Cabling Philosophy in Switchyard**

i. Each secondary core of all the phase CT/CVT shall be brought to the equipment marshalling box through independent cables.

ii. Each three phase secondary core of each CT/CVT shall be brought to the associated control/relay panel from the equipment marshalling box through independent cables.

iii. Minimum 2.5 sq mmc able shall be used for realising Control and protection scheme. Further, Duplicated cores with at least 2 x 2.5 sq.mm CU/equivalent core cross-sectional area per connection shall be used for connection of all CT/CVT circuits.

iii. VT leads used for tariff metering shall have an equivalent core cross-sectional area of at least 10 mm^2 CU/equivalent per phase/neutral connection.

iv. Duplicate channels of protection shall have independent cables for tripping, DC supply, etc. Duplicated cores shall be used for ALL closing/tripping commands and interlocking signals involving long (MORE THAN 500 m) cable lengths.

v. For the following applications multiple cores with at least 2 x 2.5 mm^2 CU / equivalent core cross - sectional area per connection shall be used:

a) DC supply to Bay Marshalling box

b) DC supply to circuit-breaker cubicle

c) DC looping for closing and tripping circuits of circuit-breaker

vi. All the interconnections (both AC/DC) within the switchyard and between switchyard and other systems required for the successful implementation of the control, interlocks and protection schemes under present package, as shown in the tender drawings for protection and control philosophy, shall be in the scope of the bidder.

vii. Spare cores shall be provided as per following norms:

a) Up to 3-core cable - Nil

b) 5 Core Cable - Min. 1 core

c) 7 to 14 core cables - Min. 2 cores

d) More than 14 core - Min. 3 cores

12.00.00 **Type Test Requirements**

12.01.00 Test reports for following type tests shall be submitted for all BPUs / DR / Energy Meter. Reports / Certificates of tests conducted in accredited Laboratories (accredited by the national accrediting body of the country where the lab is located) are also acceptable.

12.01.01 **BPU**

i. Insulation Tests

S.No.	Description	Standard

1.0	Dielectric Withstand Tests	IEC 60255-27 ed2.0 2kV rms for 1 minute between all case terminals connected together and the case earth. 2kV rms for 1 minute between all terminals of independent circuits with terminals on each independent circuit connected together. ANSI/ IEEE C37.90 1kV rms for 1 minute across the open contacts of the watchdog relays. 1kV rms for 1 minute across open contacts of changeover output relays. 1.5kV rms for 1 minute across open contacts of normally open output relays.
2.0	High Voltage Impulse Test, class III	IEC 60255-27 ed2.0 5 kV peak; 1.2/50 μsec; 0.5 J; 3 positive and 3 negative shots at intervals of 5 sec

ii. Electrical Environment Tests:

S.No.	Description	Standard
1.0	DC Supply Interruption	IEC 60255-26 ed3.0
2.0	AC Ripple on DC supply	IEC 60255-26 ed3.0
3.0	AC voltage dips and short Interruptions	IEC 61000-4-11 ed2.0
4.0	High Frequency Disturbance	IEC 60255–26 ed3.0, class III At 1MHz, for 2s with 200Ω source impedance: 2.5 kV peak; 1 MHz; T = 15 μsec; 400 shots/sec; duration 2 sec between independent circuits and independent circuits and case earth. 1.0kV peak across terminals of the same circuit.
5.0	Fast Transient	IEC 60255-26 ed3.0, class IV

	Disturbance	4kV, 2.5kHz applied directly to auxiliary supply 4kV, 2.5kHz applied to all inputs.
6.0	Surge Withstand Capability	IEEE/ANSI C37.90.1 4kV fast transient and 2.5kV oscillatory applied directly across each output contact, optically isolated input and power supply circuit.
7.0	Electrostatic Discharge	IEC 60255-26 ed3.0 Class 4 15kV discharge in air to user interface, display and exposed metal work.
8.0	Surge Immunity	IEC 61000-4-5 Level 4 4kV peak, 1.2/50ms between all groups and case earth. 2kV peak, 1.2/50ms between terminals of each group.

iii. EMC Tests:

S.No.	Description	Standard
1.0	Radiated Immunity	C37.90.2 25MHz to 1000MHz,
2.0	Radiated Electromagnetic Field Disturbance Test	IEC 60255-22-3 80-1000 MHz, Amplitude Modulated
3.0	Disturbances Induced by Radio Frequency fields, Amplitude Modulated (Conducted Immunity)	IEC 60255-22-6 150kHz – 80 MHz;
4.0	Power Frequency Magnetic Field	IEC 61000-4-8 ed2.0, class IV
5.0	Interference Voltage, Aux. Voltage (Conducted Emission)	EN 50081-2, 1994 or equivalent 150 kHz to 30 MHz
6.0	Interference Field Strength	EN 50081-2, 1994 or equivalent 30 MHz to 1000 MHz

	(Radiated Emission)	

iv. Atmospheric Environment Tests:

S.No.	Description	Standard
1.0	Humidity	IEC 60068-2-78 ed1.0
2.0	Temperature	IEC 60255-1 IEC 60068-2-1 ed6.0 for Cold IEC 60068-2-2 ed5.0 for Dry heat

v. Mechanical Stress Tests:

S.No.	Description	Standard
1.0	Vibration (during Operation and Transportation)	IEC 255-21-1; IEC 68-2-6
2.0	Shock (during Operation and Transportation)	IEC 255-21-2, IEC 68-2-27
3.0	Seismic Vibration (during Operation)	IEC 60255-21-3

12.01.02 **ENERGY METER**

All type test reports as per IEC 62052-11/IEC 62053-22

12.02.00 **Functional Tests**

All the numerical relays shall be tested for the functions specified in this technical specifications. In case of Numerical Distance Relays, test reports for dynamic tests clearly indicating the operating time under different system / fault conditions shall be submitted.

13.00.00 **Settings**

Fault levels will be provided to the Contractor by the Owner. The Contractor shall, based on this information, compile a complete and detailed report for the setting of the protection elements on all the protection equipment, to the approval of the Owner. Any additional information required to complete this exercise shall be timely requested by the Contractor.

The contractor shall provide the Owner with a philosophy document clearly setting out the philosophy the contractor will use in determining setting levels. Each setting will have a brief description of the specific function or element. The setting calculation and formula will also be shown on the document. All relevant system parameters, line data, transformer data additionally used for calculating the setting will appear in the setting document. The contractor will conduct system studies in determining fault levels on different locations. These study results will also form part of the setting document. Any additional information required to complete this exercise shall be timely requested by the Contractor.

The setting document will be presented and discussed with the Owner prior to final issue of the document. The final accepted setting document should be made available to the Owner in PDF format.

It is the Contractor's responsibility to configure each protection relay to provide the protection and control facilities required. A full set of relay configuration and setting files shall be included in the design and documentation submissions. The contractor will issue three sets of setting documents once accepted by the client and consultant.

SUB-SECTION-II-E20

ELECTRICAL WORKS FOR CHIMNEY

ELECTRICAL WORKS FOR CHIMNEY

1.00.00 INTENT OF SPECIFICATION

The following specification shall be applicable to all the electrical equipment furnished and erected under this specification. Items of work not specifically stated in this specification but which are necessary for meeting the requirements of this specification shall be included in the scope.

2.00.00 SCOPE OF WORK

2.01.00 The Contractor shall include in his scope of work the design, engineering, manufacture, supply, erection, testing and commissioning of the following equipment / system complete with all materials and accessories for each chimney:

i) Main distribution board, emergency distribution board, elevator board, power, lighting panels and DBs.

ii) All lighting fixtures and socket outlets with complete wiring.

iii) Aviation Obstruction lighting system.

iv) Power and control cables.

v) Cabling system.

vi) Lightning protection system.

vii) Earthing system.

viii) Communication system.

2.02.00 The Contractor shall provide 1 No., 415 volt, 3 phase, 4 wire feeder for power supply connection to main distribution board located at chimney base for further distribution of power.

2.03.00 In addition to the above the Contractor shall also provide one No. 415 volt, 3 phase, 3 wire emergency power supply for emergency distribution board located at chimney base. This board shall also receive one feeder from main distribution board described above. Contractor shall provide auto-change over supply to healthy source on failure of any source.

2.04.00 The details of the power supply are given below. The Contractor shall furnish the equipment to suit the same.

a) **415 volt System (normal)**

i)	System voltage	415 ±10% V, three phase and 4 wire neutral solidly earthed
ii)	System frequency	50 ± 5% Hz
iii)	Combined voltage and Frequency variation	10%
iv)	Fault Level	50 KArms(105 KA peak)/1 sec

b) **415 volt System (emergency)**

i)	System voltage	415 ±10% V three phase and three wire system.
ii)	System frequency	50 ± 5% Hz
iii)	Combined voltage and frequency variation	10%
iv)	Fault Level	50 kA

c) In case any power supply other than 415 V, 3 phase indicated above is required, the transformation for same shall be included in the Contractor's scope of work.

2.05.00 Not used.

2.06.00 All bought out electrical equipment like cables, distribution boards/panels, conduits, lighting fixtures, power receptacles, aviation lighting etc. shall be from reputed manufacturers who have manufactured and supplied equipment of the type and rating specified and this equipment should have been in successful operation in chimneys and other structures under similar service conditions. The sub vendors list and makes of all equipment/devices shall be subjected to Owner's approval.

3.00.00 STANDARDS AND REGULATIONS

3.01.00 The equipment supplied shall comply with the relevant IS Standards. All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revision as on date of opening of bid.

3.02.00 The electrical equipment/installations shall comply with the requirements of the following Rules/ Regulations as amended up to date:

i) The Indian Electricity Rules/Acts.

ii) National Electrical codes and Indian standards.

iii) International Civil Aviation organisation Regulations.

iv) National Airport Authority/DARA Regulations.

4.00.00 GENERAL REQUIREMENTS

4.01.00 **Ambient Conditions**

The equipment shall be suitable for installation and render trouble free operation at higher ambient temperature and rigorous weather conditions prevailing at chimney. Ambient temperature for design of all equipment shall be considered as 55 degrees C which is likely to be encountered during service when the chimney is in full operation.

4.02.00 The successful Bidder shall be required to carry out the detailed engineering such as:

a) Preparation of detailed wiring/schematic diagrams for distribution boards and lighting panels/DBs.

b) Preparation of conduit/cable layouts and conduit/ cable schedule.

c) Preparation of detailed lighting layout drawings.

d) Preparation of detailed wiring / layout drawings for aviation obstruction lighting system.

e) Preparation of detailed earthing and lightning protection system drawing.

f) Preparation of mounting detail drawings for various equipments.

g) Preparation and submission of all approved drawings duly marked up, to reflect the 'as built' status, along with reproduceables.

4.03.00 The successful bidder shall submit the following documents for all the equipments/items being supplied:

a) Technical particulars and catalogues

b) Routine & Type Test reports

c) Instruction manual for storage, unpacking, handling at site, erection, pre-commissioning etc.

d) Operation & Maintenance Manual

5.00.00 TECHNICAL REQUIREMENTS

5.01.00 **Distribution boards/Elevator board/Power panels**

5.01.01 Distribution Board shall be of metal enclosed, single front, indoor, floor mounted, free standing, fixed type conforming to IS 13947-PART-I. The Elevator board & Power panels shall be of floor/wall mounted type. The equipment shall be supplied fully assembled and wired, complete with base frame and anchoring arrangement, gland plates, internal wiring, terminal blocks and suitable for termination of external power and control cables. Overall height of Board shall not exceed 2450 mm. All board frames and load bearing members shall be fabricated using suitable mild steel structural sections or pressed and shaped cold-rolled sheet steel of thickness not less than 2.0 mm. Frames shall be enclosed in cold-rolled sheet steel of thickness not less than 1.6 mm. Doors and covers shall also be of cold rolled sheet steel of thickness not less than 1.6 mm. Stiffeners shall be provided wherever necessary. The gland plates thickness shall be 3.0 mm (minimum) for hot/cold-rolled sheet steel and 4.0 mm (minimum) for non-magnetic material. All panels shall be dust and vermin proof.

5.01.02 The Board shall be divided into distinct vertical sections, each comprising of:

i) A completely enclosed busbar compartment for running horizontal and vertical busbars.

ii) Completely enclosed switchgear compartment(s) one for each circuit of outgoing feeder.

iii) A cable alley for power and control cables of 250 mm width. Cable alley shall have no exposed live parts and shall have no communication with busbar compartment. Cable terminations in cable alley shall be designed to meet Form IVb Type & (as per IEC 60439) for safety.

The front of the compartment shall be provided with hinged single leaf door with locking facility.

5.01.03	Boards shall be provided with phase & neutral busbars along entire length of board. The minimum air clearance between live parts shall be 25mm for busbars and 10mm elsewhere both for phase to phase and phase to earth. Wherever such clearance is not available, the live parts shall be fully insulated/shrouded. However for busbars minimum 25mm air clearance shall be maintained irrespective of insulated/shrouded busbars are provided.
5.01.04	All busbars shall be adequately supported by non-hygroscopic, non combustible, track-resistance and high strength sheet moulded compound or equivalent type polyester fiber glass moulded insulators. Temperature rise of busbars & contacts when carrying rated current along the full run shall not exceed 55 deg.C with silver plated joints and 40 deg.C with all other type of joints over an outside ambient of 50 deg.C. Busbars and jumper connections shall be of high conductivity aluminium alloy / copper.
5.01.05	Paint shade for DBs & panels excluding end covers shall be RAL 9002 & shall be RAL 5012 for extreme end covers.
5.01.06	Boards shall be designed for IP 52 degree of protection.
5.01.07	Air break switches shall be of heavy duty, single throw, group operated, load break, fault make type, complying with IS 13947 PART-3. Incoming switches shall have door interlocks and pad locking facility. Fixed contacts shall be of shrouded type. Switches shall be of AC 22 utilisation category.
5.01.08	All fuses shall be of HRC type with operation indicator, and shall be of suitable rating conforming to IS 9224. They shall be mounted on fuse carriers. Isolating switches shall be of AC 23A category when used in motor circuit & AC 22A category for other applications. Fuse switch combination shall be provided wherever possible.
5.01.09	Contactors shall be of air break, electromagnetic type suitable for DOL starting of motors and shall be of utilization category AC-3 for ordinary & AC-4 for reversing starters. Nominal coil voltages of contactors shall be as required. AC contactors shall operate satisfactorily between 85% to 110% of the voltage. DC contactors shall be of DC-3 category.
5.01.10	Current transformers shall be completely encapsulated, cast resin insulated type, having accuracy class of 1.0 conforming to IS 2705.
5.01.11	Selector switches shall be of rotary type with escutcheon plates clearly marked to show the function and positions. Ammeter and voltmeter selector switches shall have four stay-put positions with adequate number of contacts for three phase 4-wire system.
5.01.12	Indicating lamps shall be cluster LED type. Bulbs and lamp covers shall be easily replaceable from front of the panel.

5.01.13	All indicating meters shall be flush mounted on panel front. The instruments shall be of at least 96 mm square size with 90 degree scales and shall have an accuracy class of 2.0 or better.
5.01.14	Miniature circuit breakers (MCB's) shall be current limiting type with magnetic and thermal release suitable for manual closing and automatic tripping under fault condition. MCB's shall have interrupting capacity of 9 KA rms. MCB 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 terminal shall be shrouded to avoid accidental contact. It shall conform to IS 8828.
5.01.15	Each panel shall be provided with prominent, engraved identification plates for all front mounted equipment. Panel identification name plates shall be provided at front and rear. All name plates shall be of non-rusting metal or 3-ply Lamicoid, with white engraved lettering on black back ground. Inscription and lettering sizes shall be subject to Owner's approval. Labels for fuses shall also clearly indicate current ratings of the respective fuses. These labels shall be positioned so as to be clearly visible and shall give the device number, as mentioned in the wiring drawings.
5.01.16	All internal control wiring shall be carried out with 1100 V grade, single core, 1.5 square mm or larger, stranded copper wires having color - coded, PVC insulation. Space heater / power circuits shall have wires having adequate current carrying capacity, but not less than 2.5 sq.mm Copper. Internal terminals of stranded conductors shall be made with solderless crimping type tinned copper lugs. Insulating sleeves shall be provided over the exposed part of lugs. Engraved core identification ferrules marked to correspond with panel wiring diagrams shall be fitted at both ends of each wire. Jumper wires between two terminal blocks shall also be ferruled at both ends.
5.01.17	A continuous galvanised steel grounding bus of 50 mm x 6 mm size shall be provided along the bottom of the panel structure. It shall run continuously through out the length of the panel and shall have provision at both ends for connection to the grounding grid. Metallic parts of all components shall be effectively earthed using green colored insulated copper wire or other approved means. Electrical continuity of the whole enclosure/frame work shall be maintained even after paint-ing. All hinged doors shall be earthed through flexible earthing braids of copper.
5.01.18	The space heaters shall be suitable for continuous operation on 240 V AC, 50 Hz, single phase supply and shall be automatically controlled by thermostat. Each free standing panel section shall have a 240 V AC, plug point and a light operated by door switch. Necessary isolating MCBs shall also be provided for protection.
5.01.19	All sheet steel work shall be pretreated in tanks in accordance with IS 6005. The phosphated surfaces shall be rinsed and passivated, given a stoved lead oxide primer coating, followed by two coats of finishing synthetic enamel paint. Each coat of primary and finishing paint shall be of slightly different shade to enable

	inspection of painting. Finishing paint on panels exterior shall be shade RAL-9002 unless required otherwise by the Owner. The inside of the panels shall be glossy white.
5.01.20	Terminal blocks shall be of 1100V grade, rated for cable ampacity, in one piece moulding, complete with insulating carriers, terminals and identification strips. For control circuits it shall be of Klippon type and for power circuits it shall be of stud type.
5.01.21	Typical details of Feeders of Main distribution board, Emergency distribution board, Elevator board & Power panels etc. are shown in the enclosed drawings. However, No. and size of Distribution boards/panels/feeders shall be as per actual requirement.
5.01.22	Lighting transformers shall be dry type, natural air cooled epoxy insulated. Impedance of lighting transformer shall be so selected that the fault level of lighting system shall be reduced to 3 to 5 kA. Lighting 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 DB, the same shall be housed in a separate 2 mm thick CR sheet steel enclosure with IP-42 degree of protection as per IS:2147. However, the transformer terminal box shall have IP-52 degree of protection.
5.02.00	**Lighting Panels (LP) / Distribution Boards (DB)**
5.02.01	Lighting panel / DBs shall be constructed out of 2 mm thick CRCA sheet steel. The door shall be hinged and the panel / DB shall be gasketted to achieve IP:55 degree of protection. The panel / DB shall be provided with terminal blocks for incoming and outgoing circuits, earthing terminals, M.S. mounting brackets suitable for surface mounting on wall/column/structure, allen keys with bolts as locking arrangements, circuit directory plate & circuit diagram fitted on the inside of the door etc. Removable gland plates shall be provided for top/bottom entry of cables/conduits.
5.02.02	Wiring inside the panel / DB shall be carried out with 1100 V grade PVC insulated stranded copper conductors of adequate size. On both ends of each wire engraved identification ferrules shall be provided.
5.02.03	Busbar shall be of Aluminium alloy / copper conforming to clauses 5.01.03 & 5.01.04.
5.02.04	All MCB's/Isolators etc. shall be mounted inside the panel / DB and an inner bakelite sheet/fibre glass sheet shall be provided inside such that operating knobs of MCBs etc. project out of it for safe operation against accidental contact. Operating handle of Incoming Isolator shall project out of door.
5.02.05	Equipment mounted inside the panel / DB shall be provided with individual labels with equipment designation/rating. Front of the panel / DB shall be provided with

label engraved with designation of the panel / DB as furnished by the owner. Labels shall be made of 3 ply lamicoid/engraved PVC having white letters on black background.

5.02.06 Terminal blocks shall be 1100 V grade, stud type, moulded in melamine, suitable for terminating incoming cable and outgoing circuit of specified size. All the terminals shall be shrouded, numbered and provided with identification strip for the feeders.

5.02.07 Miniature Circuit Breaker and isolator shall of same type as specified under cl. 5.01.14. Other features of the panel / DB shall be same as that of distribution board.

5.03.00 **Lighting System**

5.03.01 The lighting system shall provide adequate illumination at various platforms, stairways, landing and other areas of the chimney.

5.03.02 The following average illumination levels shall be achieved and guaranteed by the contractor after considering maintenance factor of not more than 0.6 :

a)	On equipment	150 Lux
b)	General platform area	70 Lux
c)	Stairways and landings	100 Lux [minimum one (1) light fixture at each landing].

Any additional fixtures to take care of dark patches/shadows shall also be provided.

5.03.03 Power supply for normal lighting system shall be obtained through main distribution board. 80% lighting at various platforms and 50% lighting in staircases shall be fed from normal A.C. source. 20% lighting at various platforms and 50% lighting on staircases shall be fed from emergency AC supply. Emergency AC supply shall be obtained from emergency distribution board.

5.03.04 Lighting fixtures shall be suitable for continuous operation under atmospheric condition prevailing at chimney. Lighting fixtures shall be suitable for operation on 240V, AC, 50 Hz. supply with voltage variation of ± 10% and frequency variation of ± 5% and combined voltage and frequency variation of 10%.

5.03.05 Lighting fixtures shall be dust tight LED, well glass fixtures.

5.03.06 Lighting fixtures shall be designed for IP:55 degree of protection. Power factor shall not be less than 0.85. Ballast shall be of copper wire wound type. Ballast shall include radio interference suppressors. LED lamps shall have screwed cap. All lighting fixtures shall be adequately earthed with galvansied steel wire.

5.03.07 3 Pin Receptacles designed for IP:55 degree of protection shall be provided at every platform level, rated for 20A, 240 V,AC. The Receptacles shall be complete with 20A, 240V, AC switch and 3 pin plug.

5.03.08 Heavy duty welding Receptacle with ELCB rated for 415V, AC, 63A shall be provided at each internal platform level. They shall be metal clad, shrouded die-cast aluminum designed for IP:55 degree of protection. The Receptacle unit shall be complete with 63 A, AC 23 category switch unit, plug and safety lid cover.

5.03.09 The Receptacle shall be wall mounted type with bolted front cover and removable gland plate. The Receptacle shall be interlocked such that,

a) Switch can be put ON only when the plug is fully engaged.

b) Plug can be with drawn only when the switch is in OFF position.

c) Covers can be opened only when the switch is in OFF position.

5.03.10 Conduits/pipes shall be complete with fittings and accessories. The size of conduit pipe shall be selected on the basis of maximum 40% fill criteria. Minimum size of the conduit shall not be less than 19mm.Conduits shall be of rigid steel type suitable for heavy mechanical stresses conforming to IS 9537, threaded on both sides and shall be hot dip galvanised. All conduit accessories shall also be hot dip galvanised.

5.03.11 Flexible steel conduits shall be water proof and rust proof made of heat resistant lead coated steel.

5.03.12 Junction boxes and pull boxes shall be made of CRCA sheet steel of 1.60 mm thickness and shall be hot dip galvanised. It shall be designed for IP:55 degree of protection. Junction boxes shall incorporate terminal blocks for termination of incoming and outgoing cables.

5.03.13 Lighting wires shall be of 1100V grade, PVC insulated, stranded copper/Aluminium conductor conforming to IS 694. Lighting wires shall be terminated using solderless crimping type copper lug. Minimum size of wire shall not be less than 1.5 sq.mm in case of copper and 4 sq.mm in case of aluminium. The size of the lighting wire/cables shall be selected such that total voltage drop from LDB to lighting fixture/receptacle does not exceed 3%.

5.04.00 **Cables**

5.04.01 Power cables shall be 1100 volt grade, multicore FRLS-HRPVC/XLPE insulated, PVC inner sheathed, armoured PVC outer sheathed, stranded copper/Aluminium conductor conforming to IS-1554-I.

5.04.02	Control cables shall be of 1100 volt grade, multicore, FRLS-HRPVC/XLPE insulated, PVC inner sheathed, armoured, PVC outer sheathed, stranded copper conductor conforming to IS-1554-I.
5.04.03	FRLS properties for power and control cables shall be as follows: a) Oxygen index Min. 29 (As per ASTM D - 2863) b) Acid gas generation: Max 20% (As per 2863) c) Smoke density rating: 60% (As per ASTM D - 2843)
5.04.04	Following factors shall be considered in sizing the cables: a) Continuous current carrying capacity b) Voltage drop c) Short circuit capacity d) Ambient temperature condition prevailing in chimney e) Cable grouping factors
5.04.05	Minimum size of the power cable shall not be less than 2.5 sq.mm copper or 4 sq.mm aluminium. Maximum voltage drop between main distribution board and final equipment shall be limited to 3% when carrying full load current. Cable sizing calculations shall be submitted for approval. Minimum size of control cable shall not be less than 1.5 sq.mm.
5.04.06	Cables shall meet the testing requirements as per IS.
5.04.07	Cables shall be terminated using double compression type cable gland and tinned copper solderless crimping type lug. Cable glands shall be heavy duty, brass machine finished conforming to BS:6121.
5.04.08	Cable trays and accessories shall be of ladder type, hot dip galvanized, made of minimum 2.0 mm thick sheet steel.
5.05.00	**Aviation obstruction lighting system**
5.05.01	Aviation obstruction lighting system shall conform to the requirements of the latest applicable rules of International civil aviation organization (ICAO) and NAA/DARA regulations.
5.05.02	The aviation obstruction lighting system shall be of high intensity type.
5.05.03	The system shall be suitable for operation on 240V ± 10% single phase, 50 Hz, AC supply.

5.05.04 Photo electric controller shall be housed in rugged weather tight, IP 65 enclosure. LED's shall be provided to indicate the operation status of the unit.

5.05.05 System controller shall be suitable for operation at specified ambient temperature and shall be wall mounted type. The enclosure shall have IP:55 degree of protection.

5.05.06 Aviation obstruction light unit shall provide easy access to lamp and components.

5.05.07 Four nos. of obstruction lights shall be installed at each specified elevation. The system controller is proposed to be located at 1.2 metre elevation and photo electric controller at about 40 metre elevation. Necessary cables for wiring between photocell & system controller and between system controller & obstacle lights shall be provided. Typical aviation obstruction lighting system arrangement is shown in the enclosed tender drawing.

5.05.08 Each item shall be preassembled, routine tested optically and electrically before shipment.

5.05.09 Bidder shall furnish the complete routine test report of the fixtures, controllers, photocells etc. Testing of aviation lights as per ICAO regulations to be carried out and routine test report to be submitted.

5.05.10 High intensity obstacle lights shall meet the following requirements.

(a) It shall be flashing white light. The effective intensity of obstacle light shall be variable and dependent on background luminance as follows.

	Background luminance	Effective Intensity
(i)	Above 500 cd/m2	200000 cd minimum
(ii)	50 to 500 cd/m2	20000 ± 25% cd
(iii)	Less than 50 cd/m2	4000 ± 25% cd

(b) The obstacle lights shall flash simultaneously at a rate between 40 to 60 per minute.

(c) Obstacle lights shall have a day time effective intensity of minimum 200000 cd. The intensity of lights shall reduce automatically to 20000 cd ± 25% at twilight through the use of photocell and again automatically to a night time intensity of 4000 cd ± 25% through the use of photo- cell.

(d) The system shall also provide automatic sensing and display of system status and aviation lamp failure detection.

5.05.11	The distance between lighting elevations shall not be more than 105 Metre and lowest lighting elevation shall not be less than 70 metre.
5.05.12	The light unit shall have adjustable bracket with level indicator to ensure accurate vertical placement of the light flash.
5.05.13	Temporary obstruction lighting shall be provided during construction. Obstruction lights shall be provided on the uppermost part of the chimney, or the surrounding scaffolding. As construction progresses each completed level shall be provided with temporary lighting. Temporary obstruction lights shall have four fixtures located in a horizontal plane on the chimney structure to ensure unobstructed visi-bility of at least one obstruction light from aircraft at any normal angle of approach. Power for operation of the temporary obstruction lights shall be obtained from the construction power system. Supply circuit for these lights shall be furnished, installed and maintained by the Contractor. Temporary obstruction lights shall be operated from sunset to sunrise during each day of the contract period until such time as the Engineer issues instructions in writing to discontinue.
5.06.00	**Earthing**
5.06.01	Earthing system shall conform to IEEE 665 and IS 3043. Earth grid system for chimney shall consist of horizontal conductors and vertical conductors. Horizontal conductor shall be of 40mm dia mild steel rod buried at a depth of 1 metre all around the chimney. Vertical rods shall be of 40 mm dia, 3 metre long mild steel driven deep in to the ground and also connecting to horizontal conductor at 20 metre interval. The chimney earth grid system shall be interconnected with main plant earth grid at minimum 2 points, through bolted removable link and earth pits.
5.06.02	Metallic enclosures of all electrical equipments shall be earthed by two separate and distinct connections to earth grid system. The earth connections shall consist of galvanised steel strip/rod/wire, sized adequately to carry the earth fault current of the system. Two nos. main earthing conductor shall be run inside all along chimney height. Electrical equipments at every platform shall be earthed with this conductor. Cable armour shall be bonded to earthing system at both ends of the circuit. The earthing conductors and accessories located at top 12m level shall have lead cover of minimum 2mm thickness. The accessories like nuts, bolts, dash fasteners, round clamps, washers etc. to be used for top 12m level shall be made of stainless steel.
5.06.03	Steel structures, metallic pipes etc. shall also be connected to earthing system. Connections between earthing conductor and equipments shall be of bolted type only. Earthing conductors along their run on walls shall be supported by cleating at 1 metre interval. Clamps and hardwares shall be of compatible material. Minimum size of earthing conductor shall not be less than 14 SWG G.S wire. Earthing conductor shall also be run along with cable ways / each conduit run.

5.06.04	The contractor shall provide and maintain a temporary earthing system as per attached tender drawing until permanent earthing system is installed.
5.07.00	**Lightning Protection System**
5.07.01	Lightning protection system shall conform to IEC 62305. It shall comprise vertical air termination, horizontal air termination, down conductor, test links, earth connections and earth electrodes.
5.07.02	Vertical air termination shall extend 3 metre above the top of the chimney. For each flue duct, 3 nos. vertical air terminations shall be provided. Vertical air termination shall be of 20mm dia copper rod with lead cover of 2 mm thickness.
5.07.03	Horizontal air terminations(coronal bond) shall be of minimum 50x6 mm galvanised steel strips provided at following levels. a) Top level of each flue b) Roof top level around outer concrete shell c) Mid height around concrete shell
5.07.04	Horizontal air terminations and vertical air terminations shall be inter connected by down conductors. No. of down conductors shall be minimum 4, equally spaced around and on exterior surface of concrete shell. Down conductors shall be of minimum 50x6 mm galvanised steel strip. Down conductors shall additionally be connected to vertical reinforcement rods at top and bottom of chimney at minimum four locations. Suitable precaution shall be taken at these joint connections to prevent any galvanic action. Reinforcement bars shall be made electrically continuous throughout their height.
5.07.05	Each down conductor shall be provided with a test link at 1 metre above ground level. Each test link shall be enclosed in a galvanised sheet steel enclosure.
5.07.06	Below the test link, direct connection with 40 mm dia mild steel rod shall be made to the earth grid system. Adequate no. of vertical electrodes of 40mm dia mild steel shall be provided to obtain required earth resistance.
5.07.07	Down conductors shall not be connected to other earthing conductors above ground level. To avoid side flashing, metallic structures like hand rails, stairs etc.in the vicinity of down conductor shall be bonded to lightning protection system.
5.07.08	Air terminations, down conductors, coronal band and accessories located at top 12 m level shall have lead cover of 2mm thickness. Suitable bimetallic washers shall be used while connecting conductors of different materials.

	The accessories like nuts, bolts, dash fasteners, round clamps, washers etc., to be used for top 12 metre level shall be made of stainless steel.
5.07.09	Down conductors and horizontal air terminations shall be cleated to concrete structure at 750 mm interval.
5.07.10	The contractor shall provide and maintain a temporary lightning protection system as per attached tender drawing until permanent lightning protection system is installed.
5.08.00	**Communication system**
5.08.01	Contractor shall provide telephone cable installed in independent G.I. conduits and wired up to junction boxes with telephone socket at 0.0 M and at every internal platform for connection of telephone handset.
5.08.02	Telephone cables shall be of minimum 0.6 mm dia annealed high conductivity electro copper conductor, PVC insulated, twisted, PVC tape wrapped, screened, rip corded, PVC sheathed, conforming to relevant ITD (Indian Telephones Department) specifications.
6.00.00	**INSTALLATION**
6.01.00	Equipments/items shall be installed in a neat work manner so that it is leveled, plumbed, squared and properly aligned and oriented.
6.02.00	The Contractor shall furnish all supervision, labour, tools, equipment, rigging materials, incidental items such as bolts, wedges, anchors/angles, frames, studs, rawl plugs, concrete inserts etc. required to completely install, test, adjust and fix the equipment.
6.03.00	Manufacturer's drawings, instructions and recommendations shall be correctly followed in handling, erecting, testing and commissioning of all items/equipments and care shall be exercised in handling to avoid distortion to stationary structures, the marring of finish, or damaging of delicate instruments or other electrical parts. All care should be taken to avoid damage of galvanised/painted surfaces during installation. All damaged surfaces of galvanised or ungalvanised faces of steel structures, conduits, junction boxes, trays etc. shall be brushed up and shall be painted with red primer paint followed by two coats of aluminium paint/enamel paint to the satisfaction of Engineer.
6.04.00	Connections between distribution boards, between distribution board and Elevator board/lighting & power panels and between distribution board/power panels & receptacles shall be carried out with FRLS-HRPVC insulated armoured copper / aluminium cables. Connections between lighting panel and lighting fixture/receptacles and for aviation lighting system shall be carried out with PVC insulated copper / aluminium wires laid in galvanised steel conduit.

6.05.00	After installation of lighting fixtures/ receptacles/switch boxes, the panel number and circuit number shall be painted on them at a suitable place.
6.06.00	Wherever non-galvanised steel members/structures are erected, they shall be brushed before giving one coat of lead primer followed by two coats of epoxy paint. All nuts, bolts and washers required for complete installation shall be hot dipped galvanised.
6.07.00	Wooden plugs in walls and ceilings for fixing of lighting fixtures and accessories are not acceptable. A suitable fool-proof method (preferably using dash fasteners) for fixing these shall be offered and this shall be subject to Owner's approval.
6.08.00	To distinguish emergency AC fixtures from normal AC fixtures, red painted circular mark of 1 cm. dia. shall be provided on emergency fixtures.
6.09.00	Exposed conduits shall run in straight lines. Conduits shall be fixed by using metallic saddles/clamp secured to suitable nylon rawl plugs with screws or secured to the wall/structure at an interval of not more than 1 metre. Notwithstanding the above in case of couplers or similar fittings, saddles/clamps shall be fixed at a distance of 30 cm from the center of such fittings.
6.10.00	All openings in the floor/wall/ceiling etc, made for conduit installation shall be sealed and made water proof.
6.11.00	For long conduit runs pull out boxes shall be provided at suitable intervals (not exceeding 4 m to facilitate wiring. However pull out boxes need not be provided wherever junction boxes exists in circuit.
6.12.00	The entire metallic conduit system whether embedded or exposed shall be electrically continuous and thoroughly grounded. Where slip joints are used, suitable bonding shall be provided among the joint to ensure a continuous ground circuit. G.I. Pull wire of adequate size shall be laid in all conduits before installation.
6.13.00	Each conduit run shall be marked with its designation as indicated on the drawings. Identifications shall be marked by means of painting so that each run of conduit is readily identified at each end. Where conduits terminate at panels, switch boxes, junction boxes, or other enclosures, the designations shall also be painted on the inside of the enclosure adjacent to the conduits.
6.14.00	Wires shall not be pulled through more than two equivalent 90^{o} bends in a single circuit run. Wherever required, suitable conduit junction boxes/pull boxes shall be provided. All types of wiring, concealed or unconcealed shall be capable of easy inspection.
6.15.00	Receptacles and lighting circuits shall be fed from different circuits. The switch controlling these circuits shall be on the live side (phase wire) of the circuits.

6.16.00	A.C. normal & AC emergency wiring shall run throughout, in separate conduits. Wires of different phases shall run in different conduits
6.17.00	Wiring shall be spliced only at junction boxes. Maximum two wires shall be connected at each terminal. In vertical run of wires, in conduit the wires shall be suitably supported by means of hard rubber plugs, at each pull/junction box.
6.18.00	Cables shall be installed on trays/troughs or cleated to steel work. Cable trays/troughs and supports shall be prefabricated and hot dip galvanised. Cable trays/troughs shall be of ladder/ perforated type constructed of minimum 2mm thick mild steel.
6.19.00	Cable tray/trough supports shall be fixed by bolting in case of concrete structures and by welding in case of steel structures. Cable trays shall be adequately fastened to supports. Cables shall be cleated/clamped with cable tray/trough on vertical runs at every 1 metre interval. Cables laid on horizontal runs shall be secured to trays with nylon cable ties at every 5 metre interval.
6.20.00	Wherever cable passes through floor/wall, pipe sleeves shall be provided and shall be properly sealed after laying cable. No joints shall be allowed in any cable run. Power and control cables shall not be laid together. Cable tags shall be provided on all cables at each end, on both sides of floor/wall crossings and at every 20 metre interval in cable tray runs.
7.00.00	**TESTS**
7.01.00	All equipment to be supplied shall be of type tested quality. The Contractor shall submit for Owner's approval the reports of all type tests as listed below: (A) Distribution boards/panels-Degree of protection tests (B) Aviation lights: (1)Intensity Test (2)Degree of protection test (3)Dust Ingress test The tests must be carried out within last 10 years from date of bid opening on equipment similar to those proposed to be supplied under this contract. The test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client. In case the test report(s) are not found to be meeting HPGCL requirements, the Contractor shall conduct all such tests under this contract at no additional cost either at third party laboratory or in presence of Owner's/Client's representative & submit the reports for approval.
7.02.00	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.
8.00.00	**MANDATORY SPARES**

8.01.00 A list of Mandatory Spares parts for Aviation Obstruction Lighting System is described below:

(1)	Power Supply Card	-	6 nos.
(2)	Electronic Flasher Card	-	3 nos.
(3)	Photocell Control Unit	-	3 sets
(4)	Spare lamp/tube with holder for Aviation Obstruction Lighting fixture	-	12 nos.