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**

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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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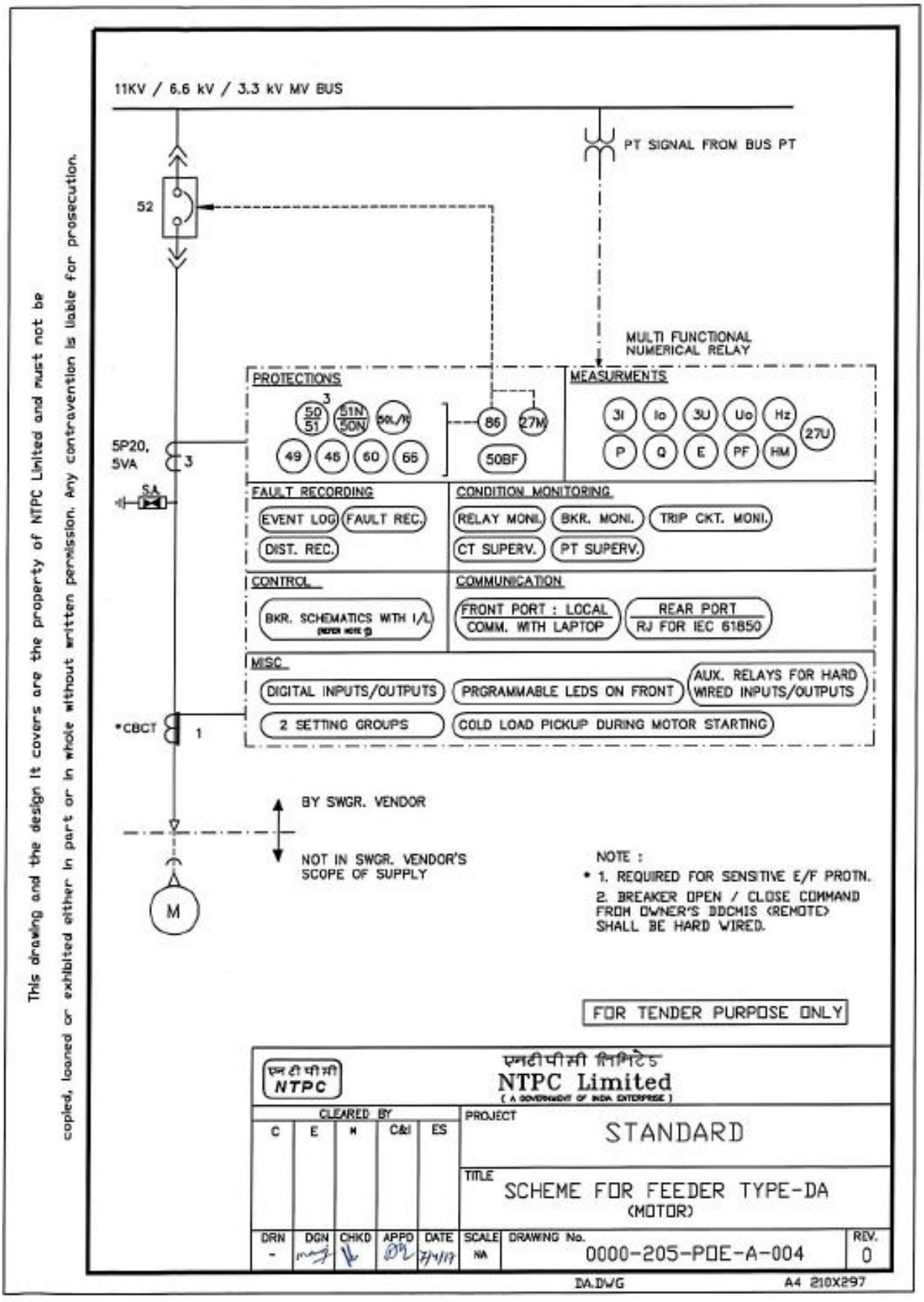
NTPC Limited
(A GOVERNMENT OF INDIA ENTERPRISE)

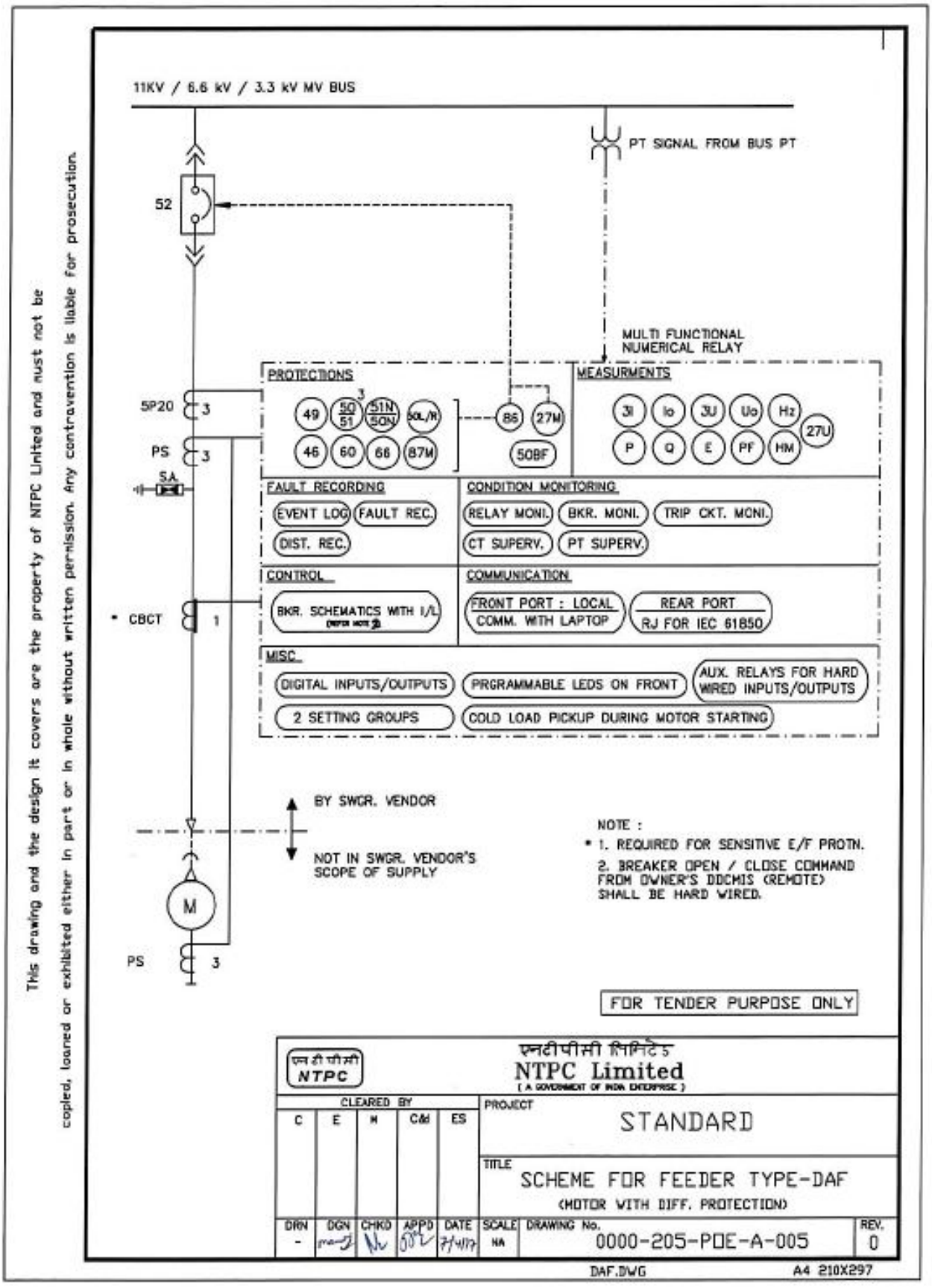
CLEARED BY					PROJECT
C	E	M	C&I	ES	STANDARD

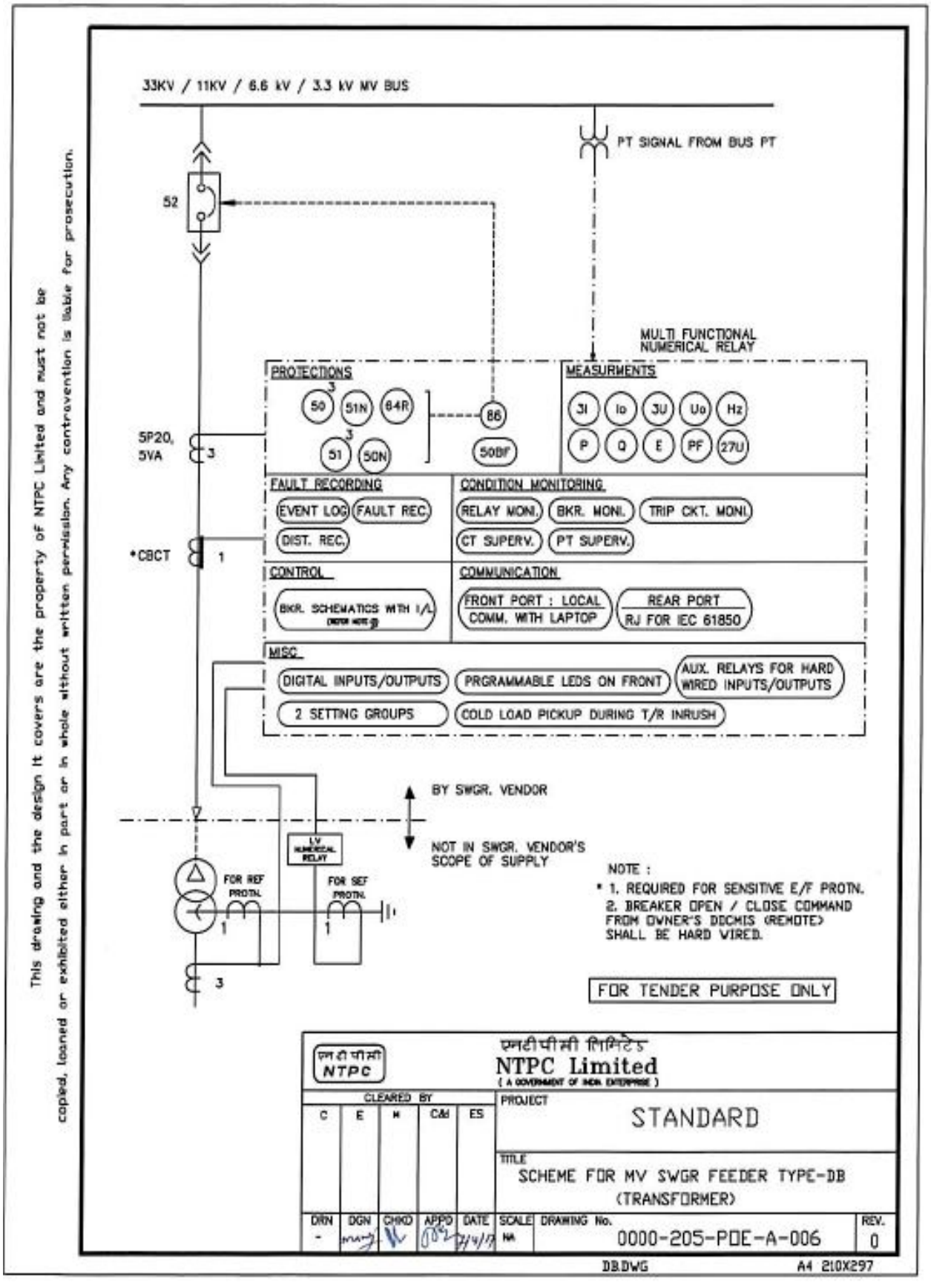
TITLE: LEGEND DETAILS

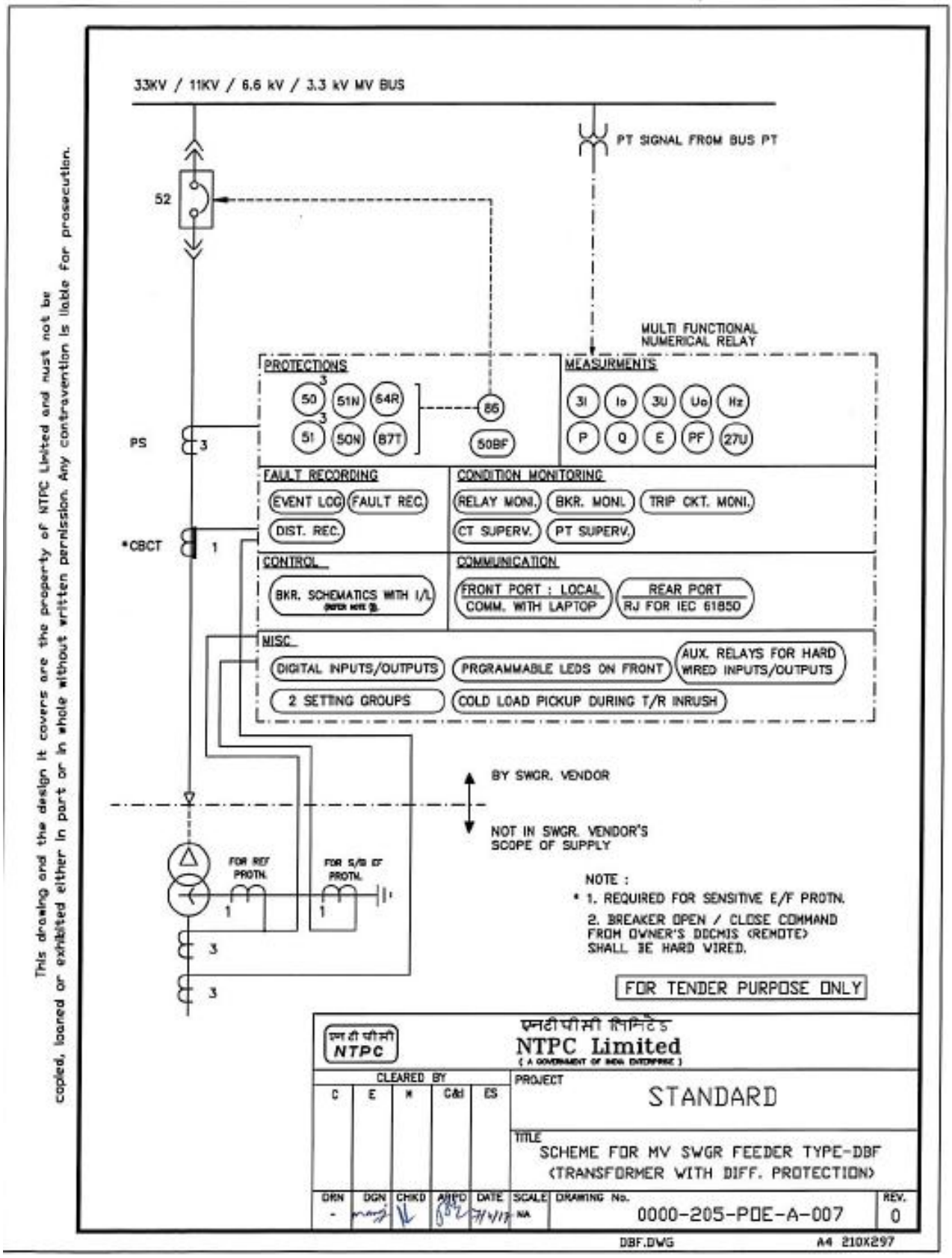
DRN	DGN	CHKD	APPD	DATE	SCALE	DRAWING No.	REV.
-				10/01/07	NA	0000-205-POE-A-003	0

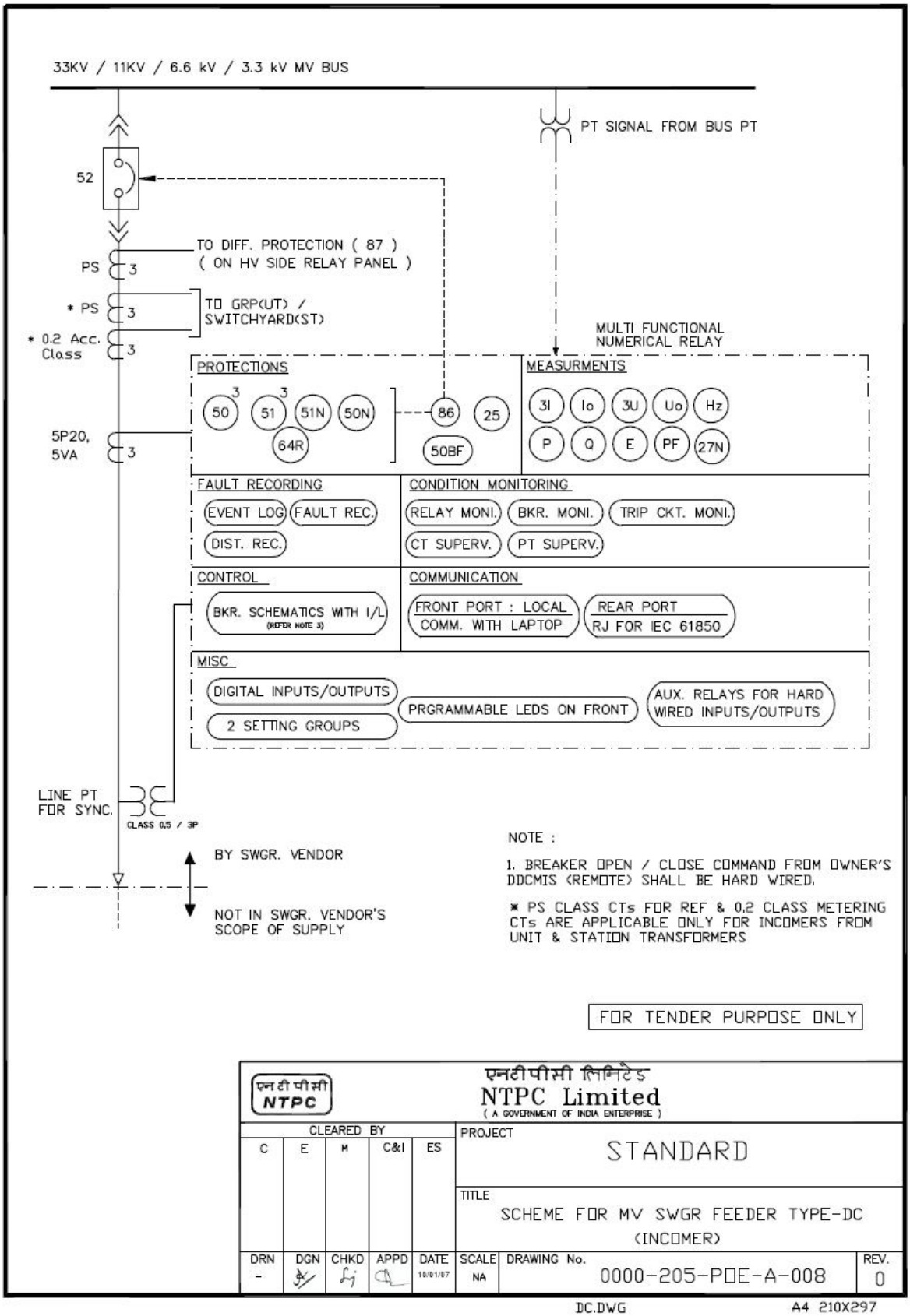
LEGEND.DWG A4 210X297

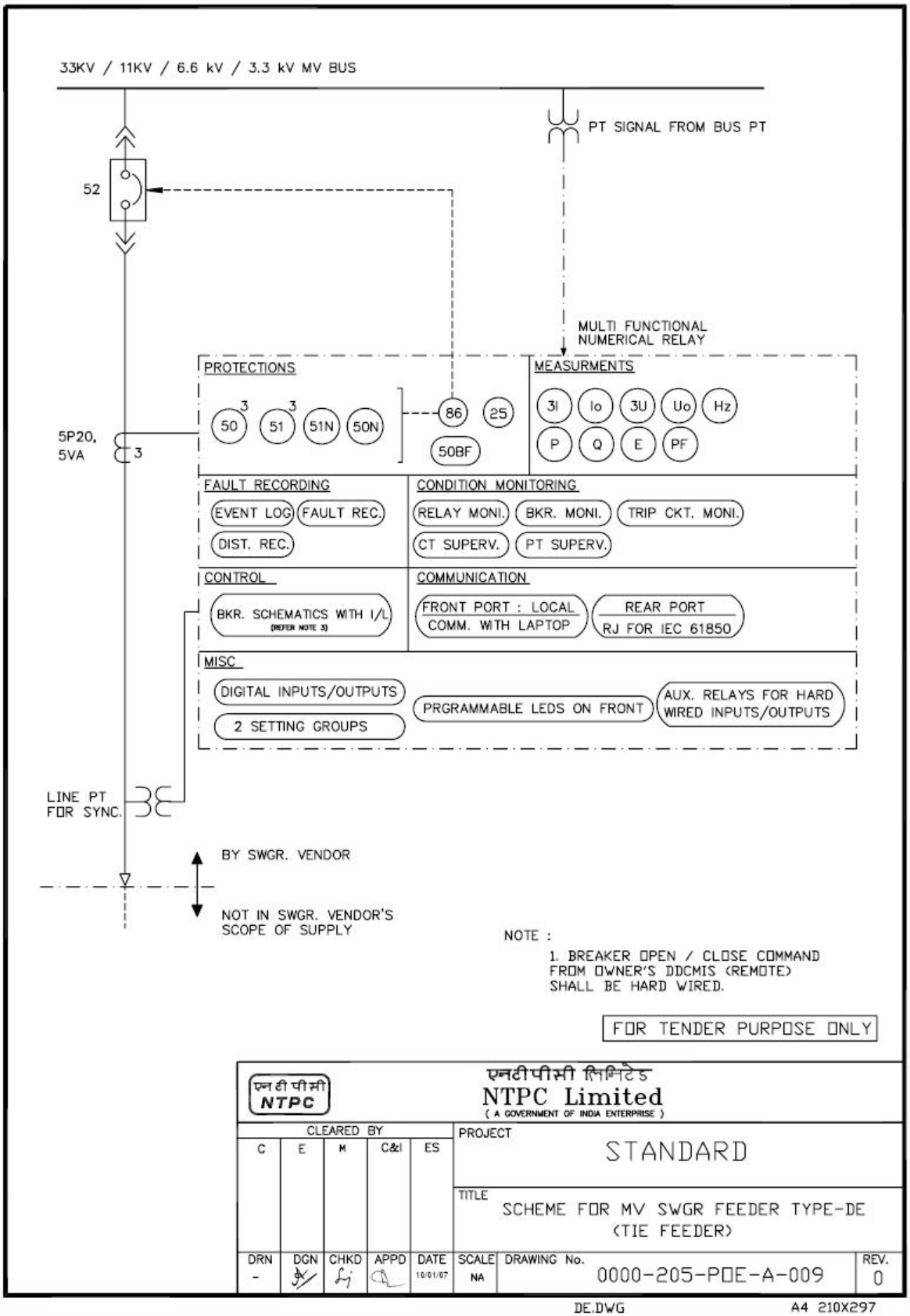


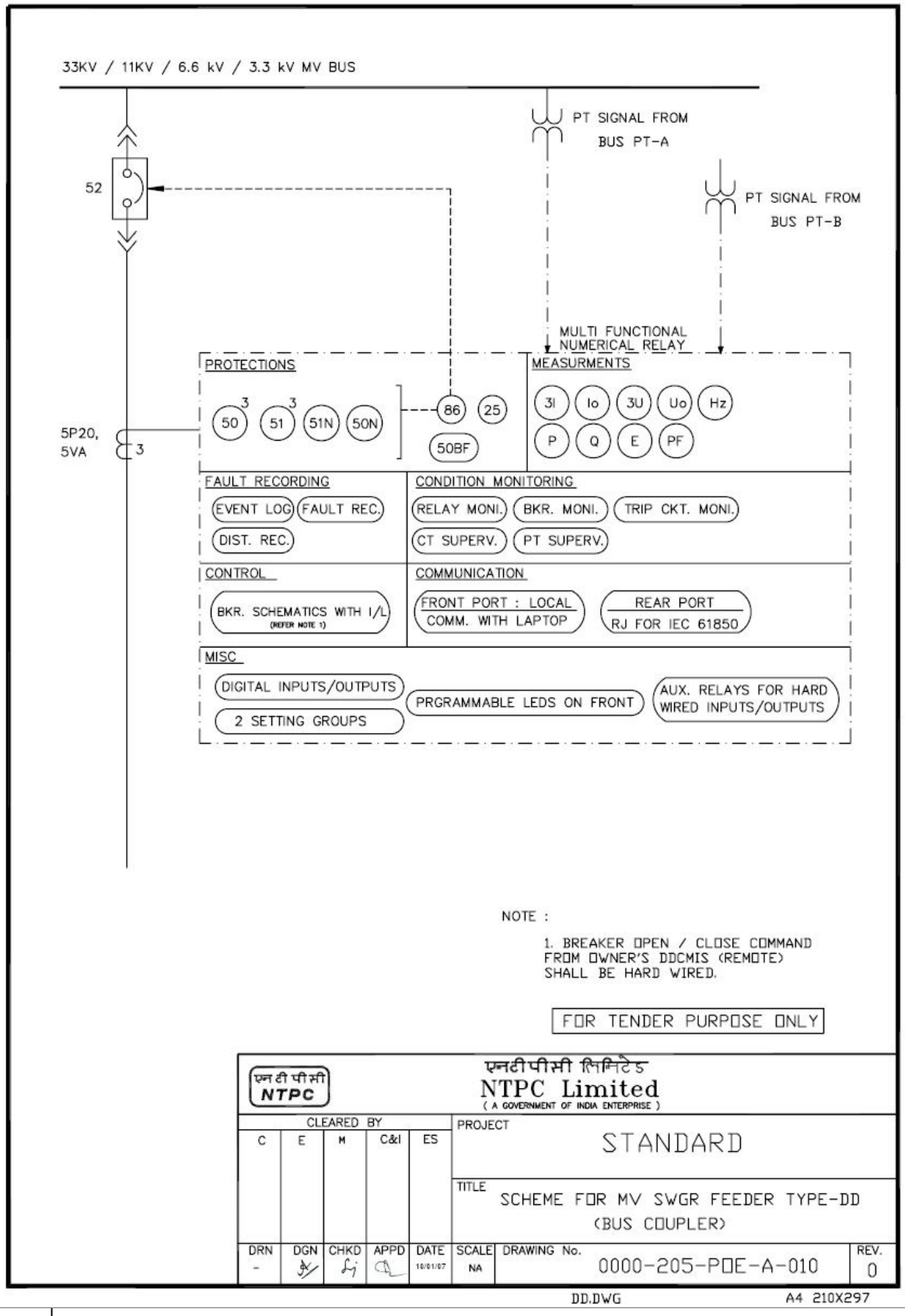


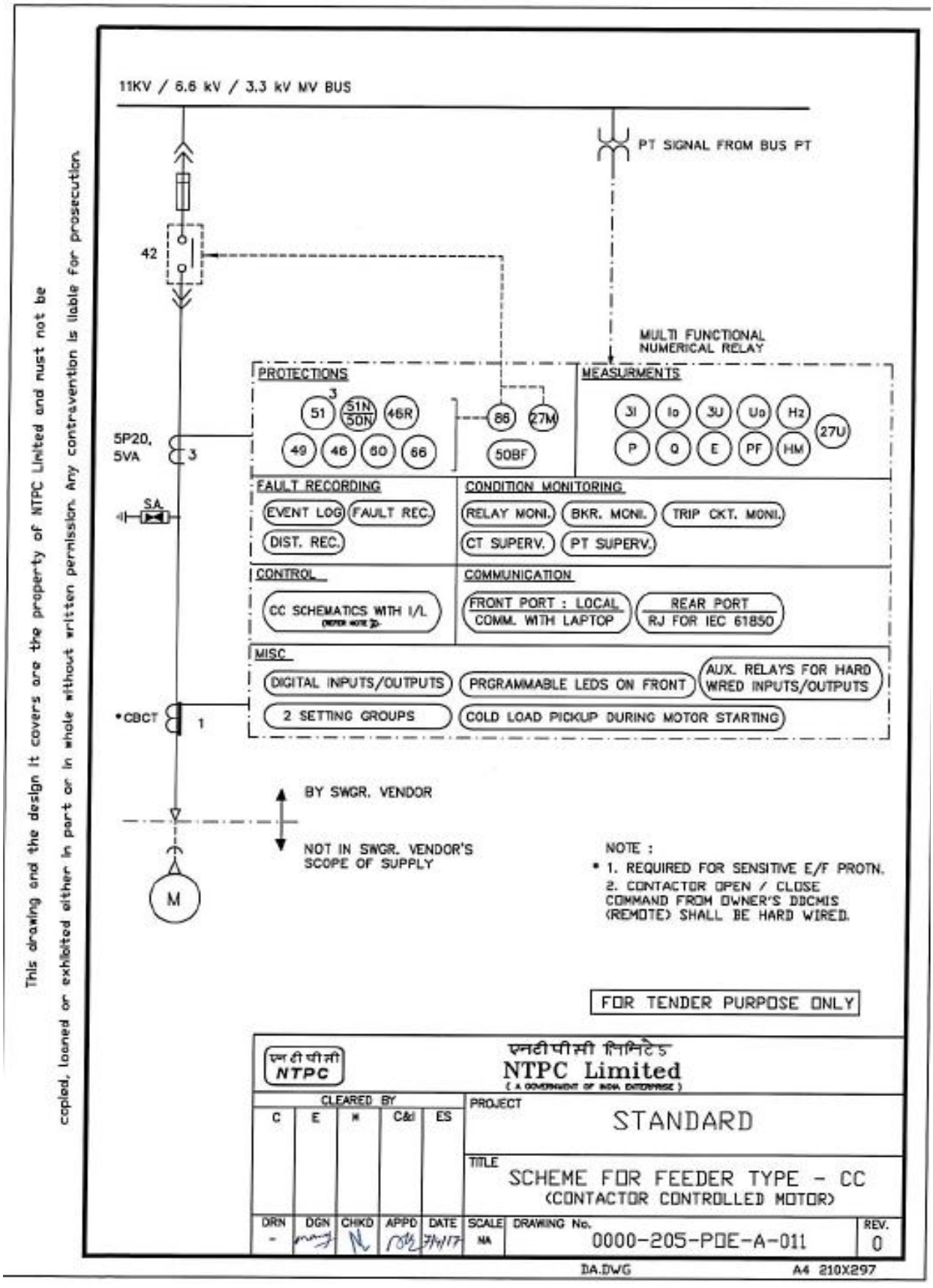


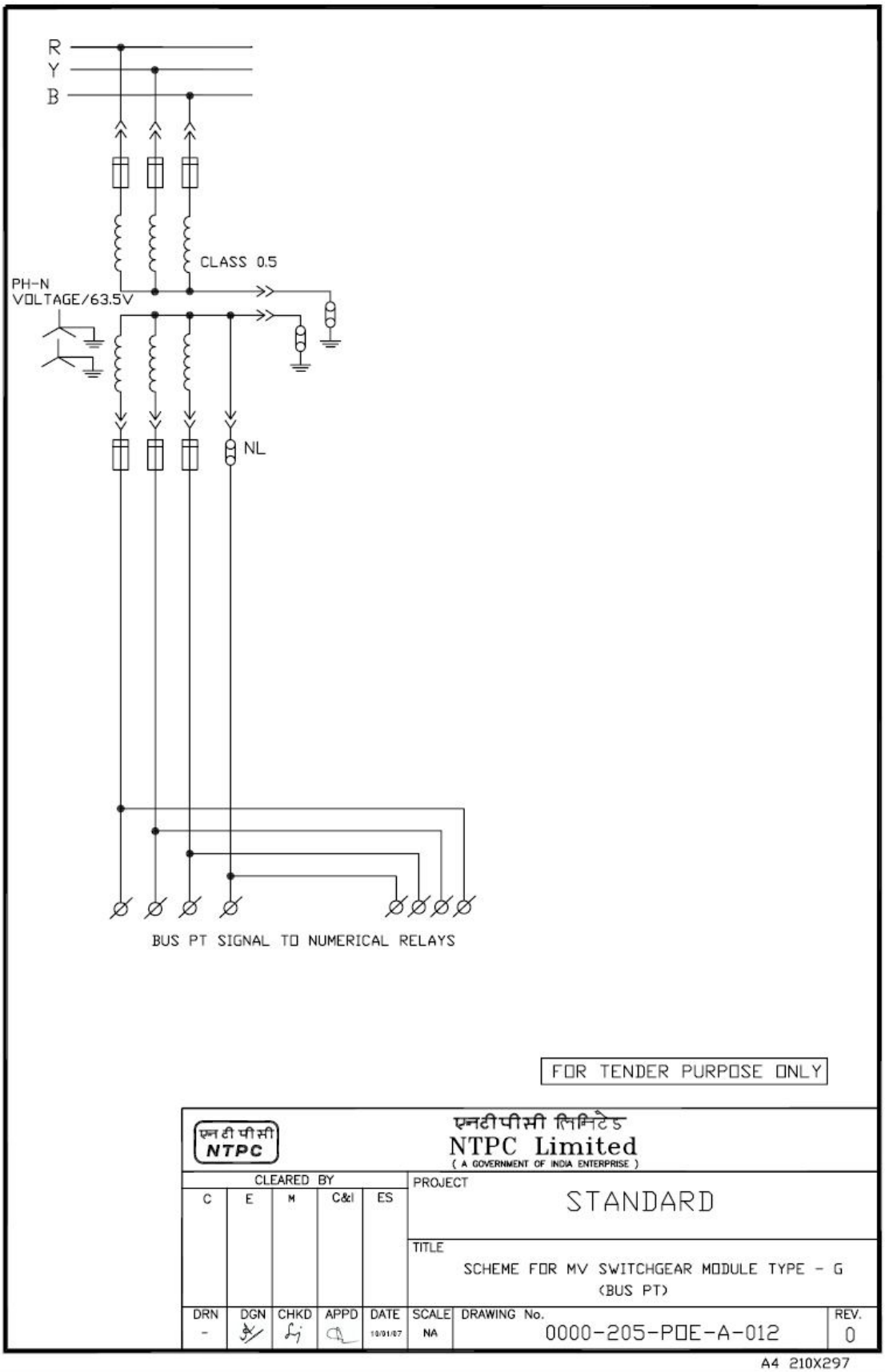


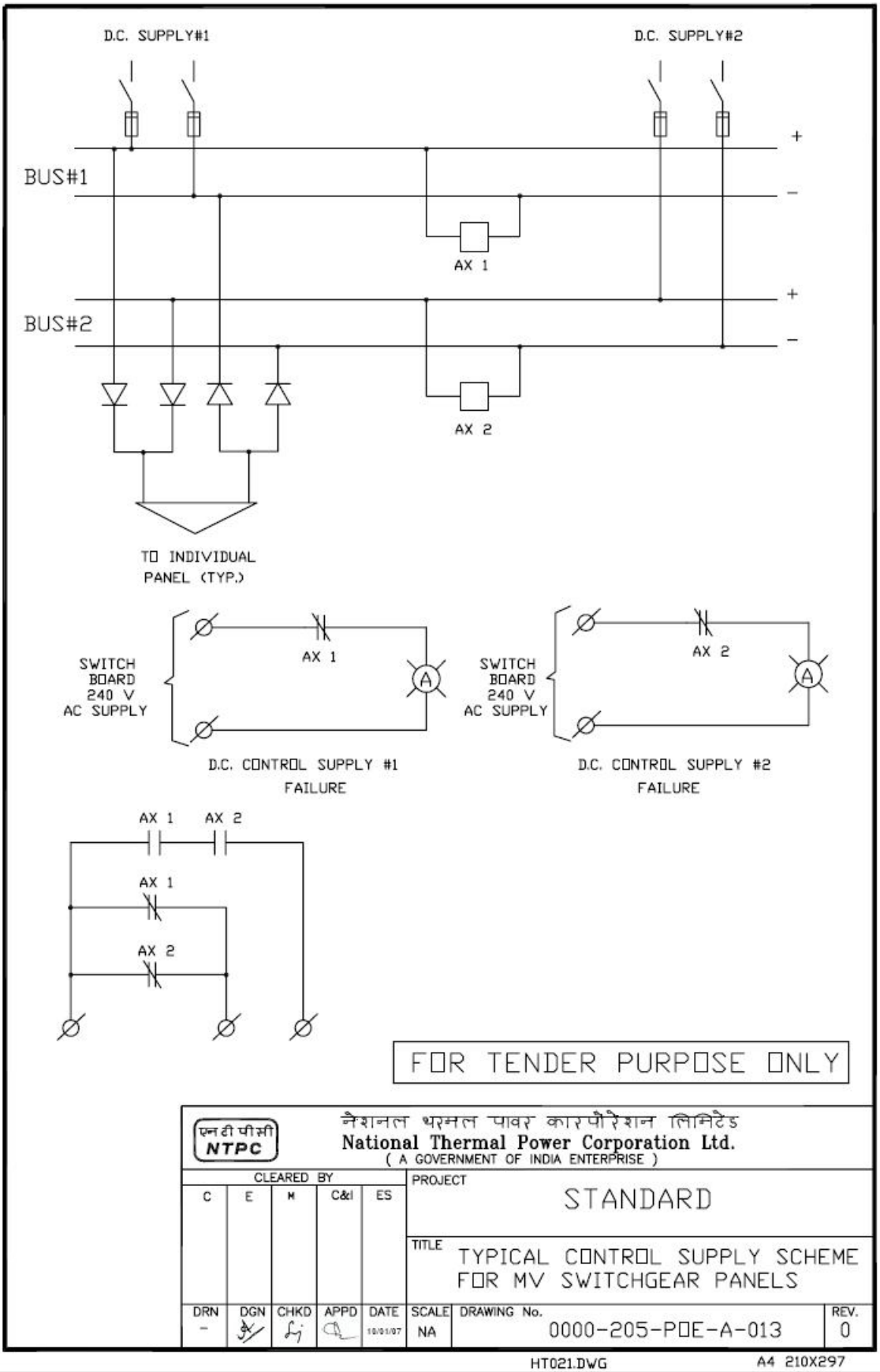












SUB-SECTION-II-E9

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 single line.

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 ± 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.
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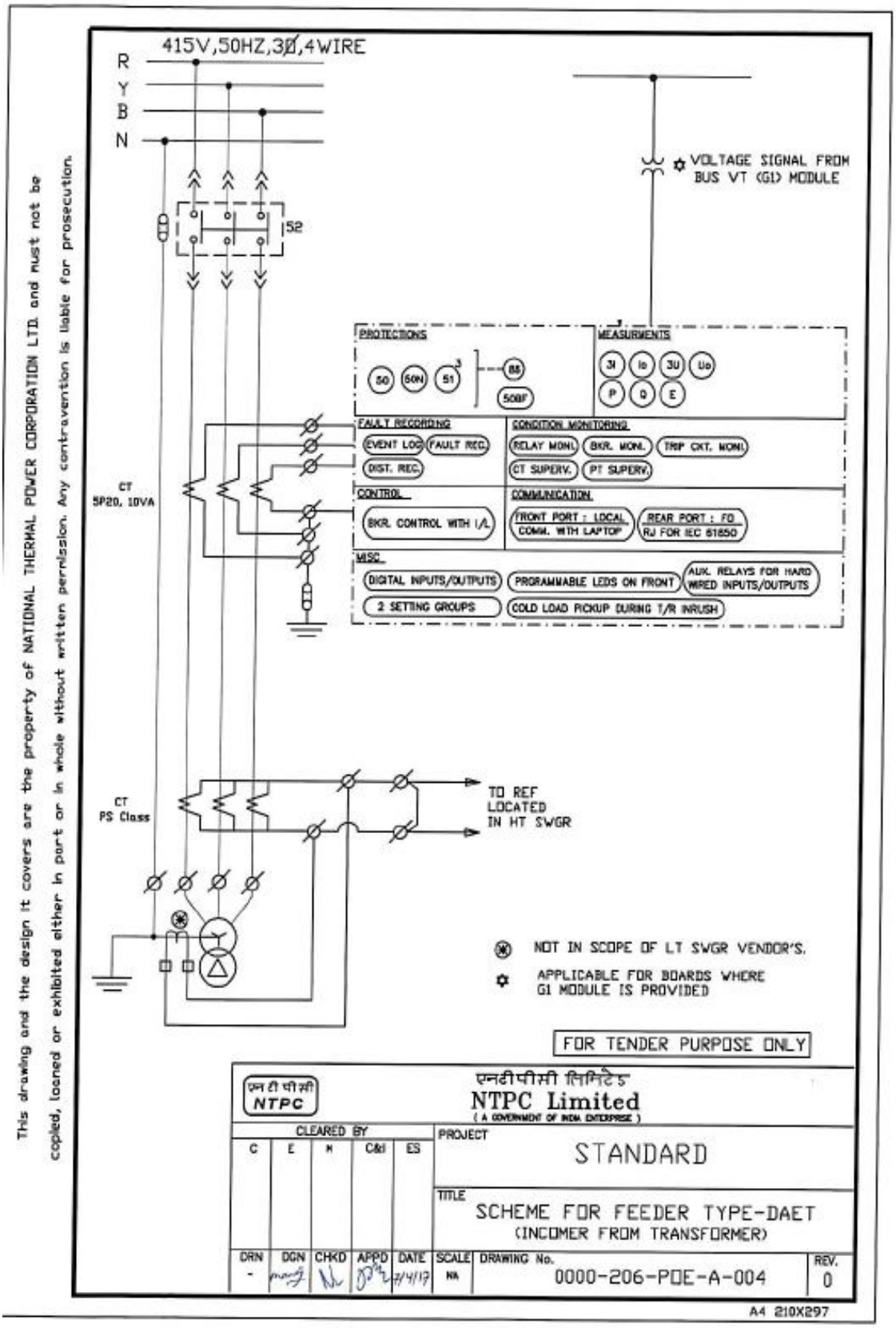
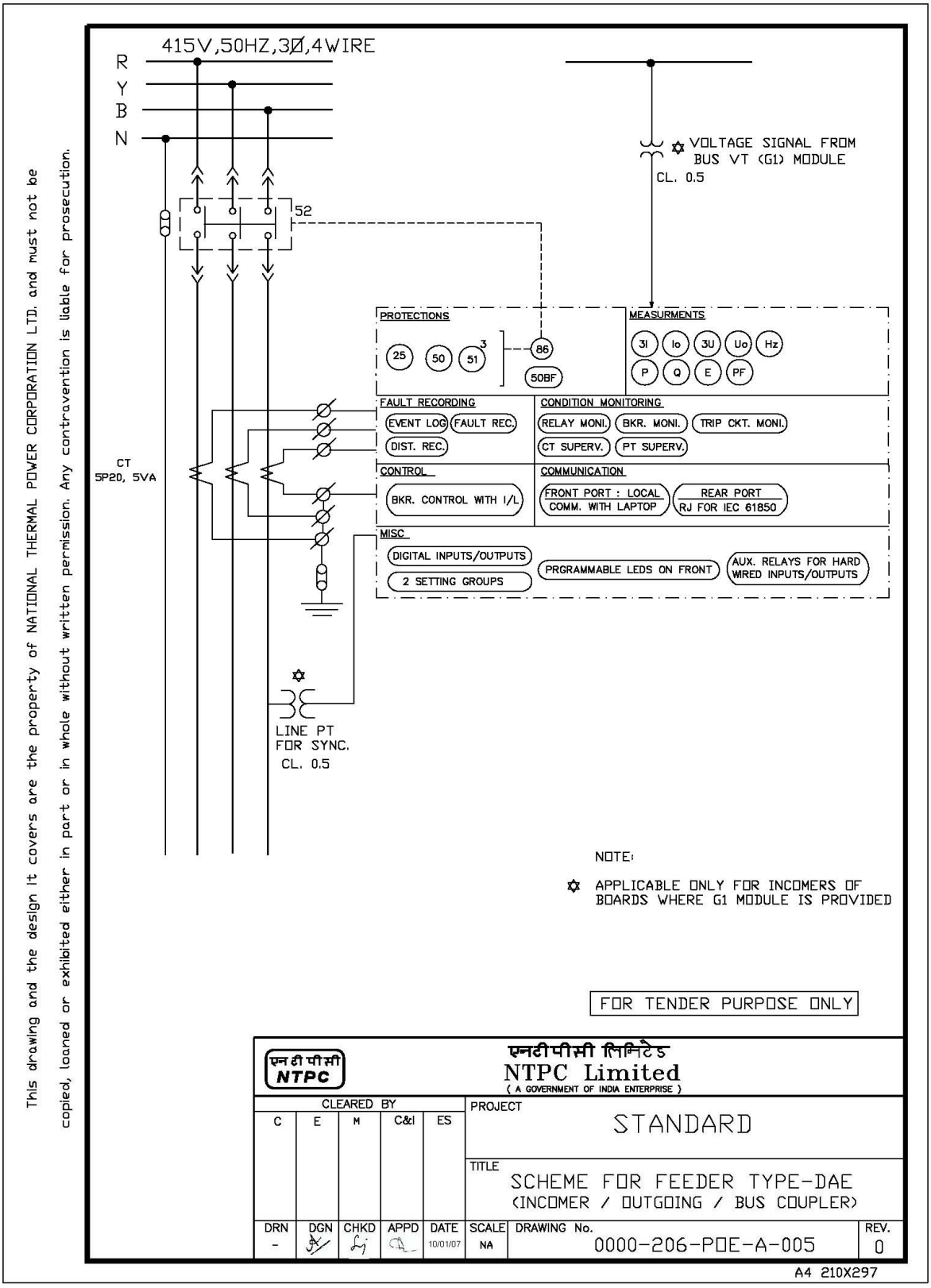
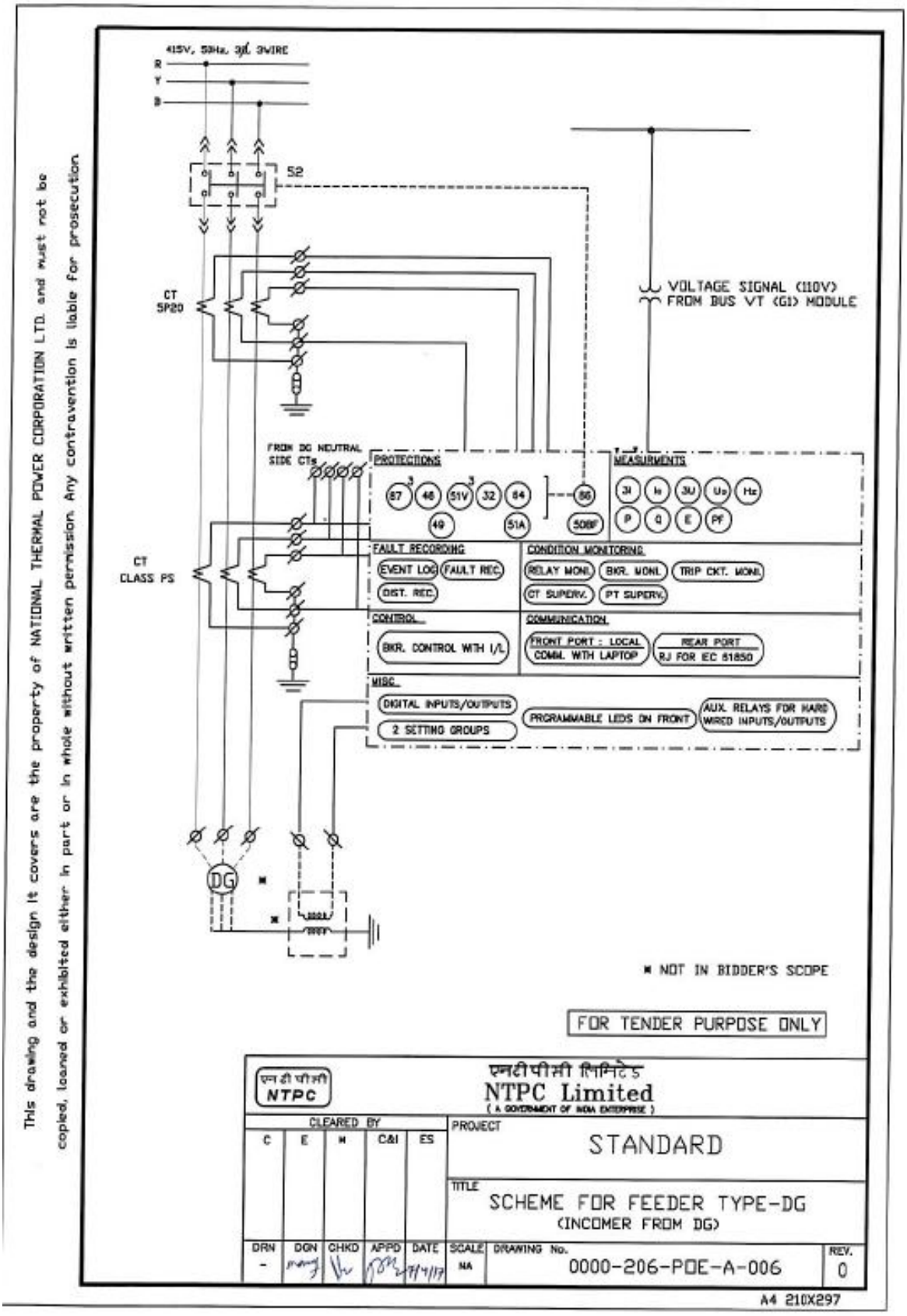
LEGEND.DWG A4 210X297






415V, 50Hz, 3ϕ, 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
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SCHEME FOR FEEDER TYPE-DG
(INCOMER FROM DG)
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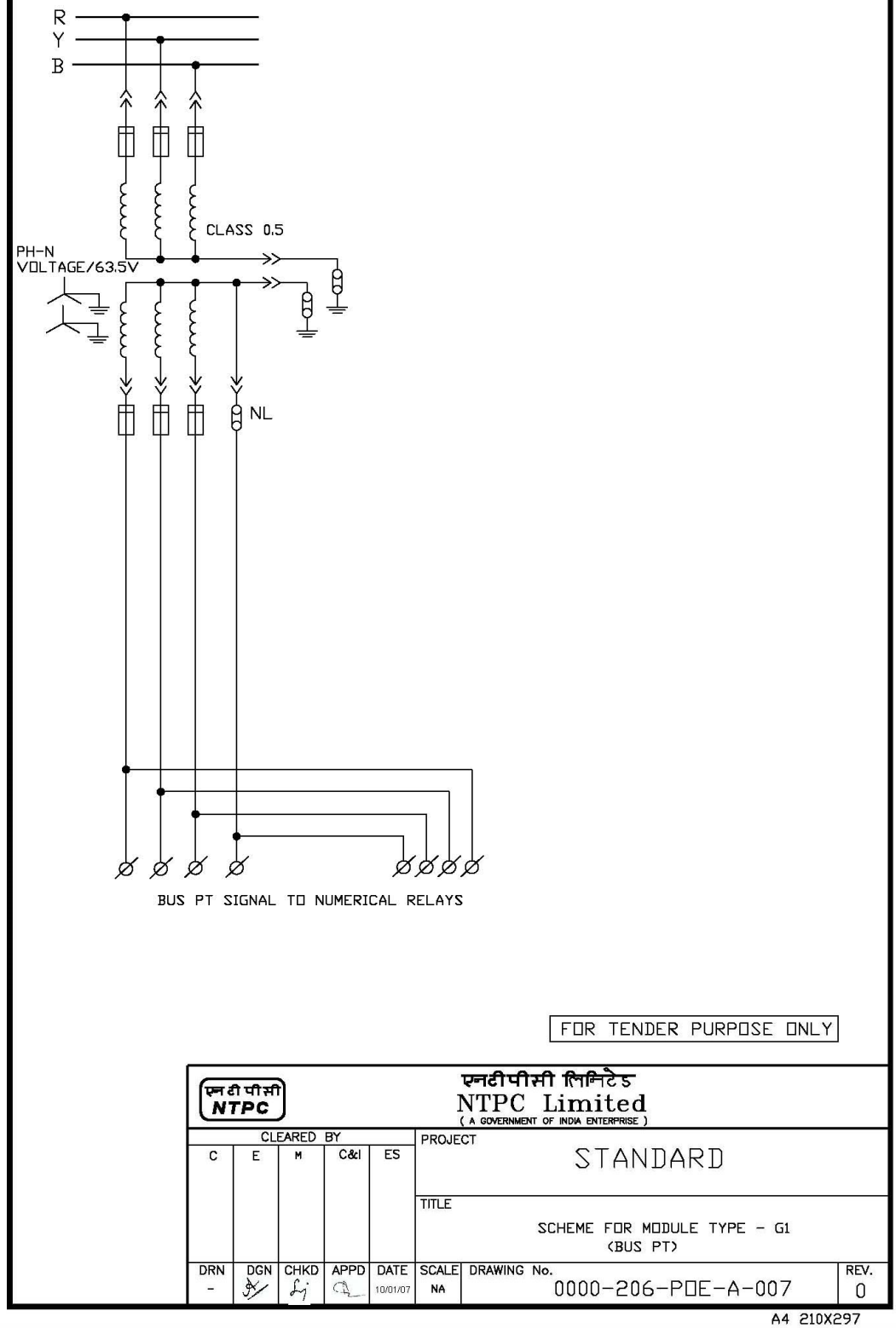
R
Y
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CLASS 0.5
PH-N
VOLTAGE/63.5V
NL
BUS PT SIGNAL TO NUMERICAL RELAYS
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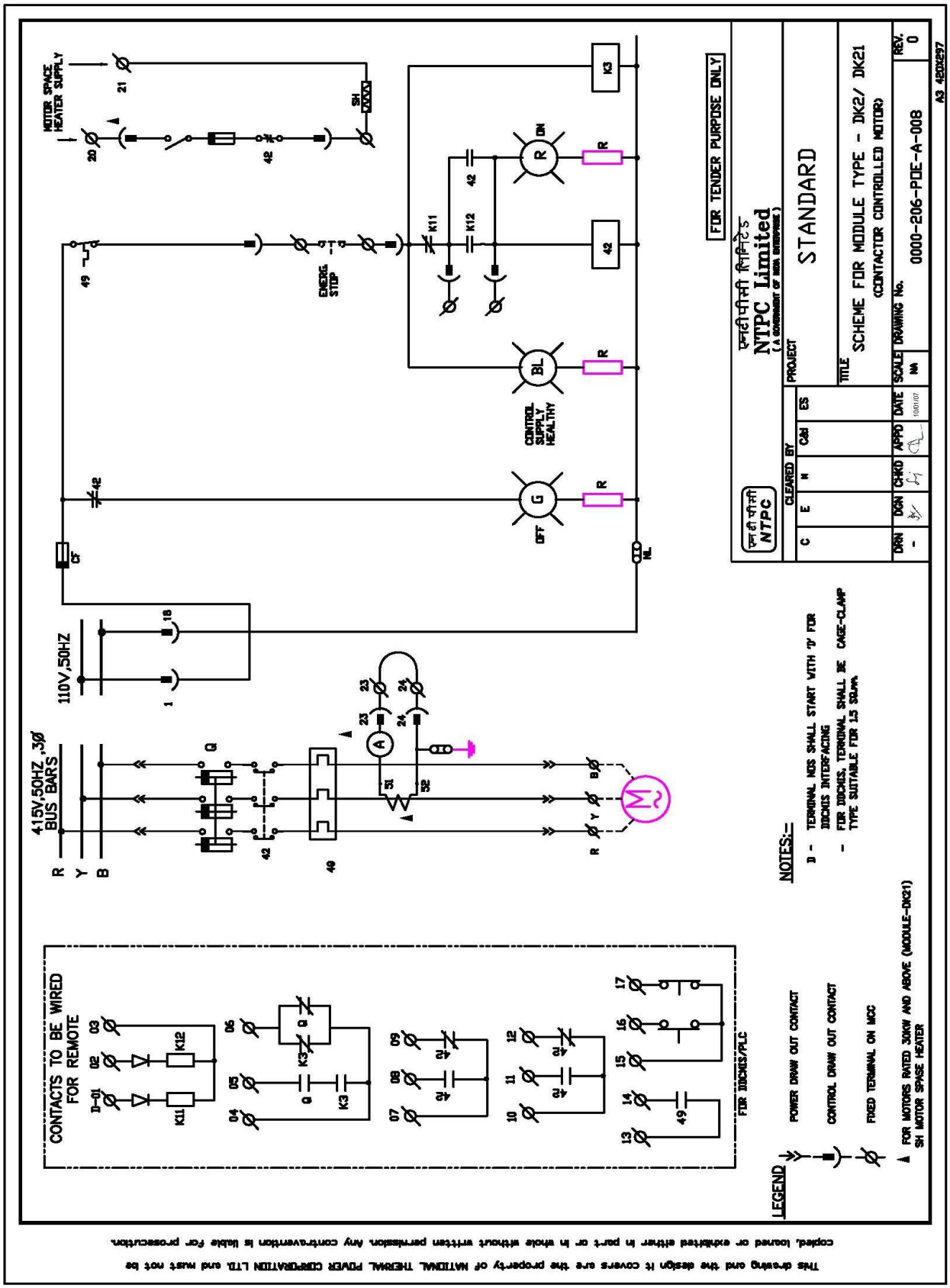

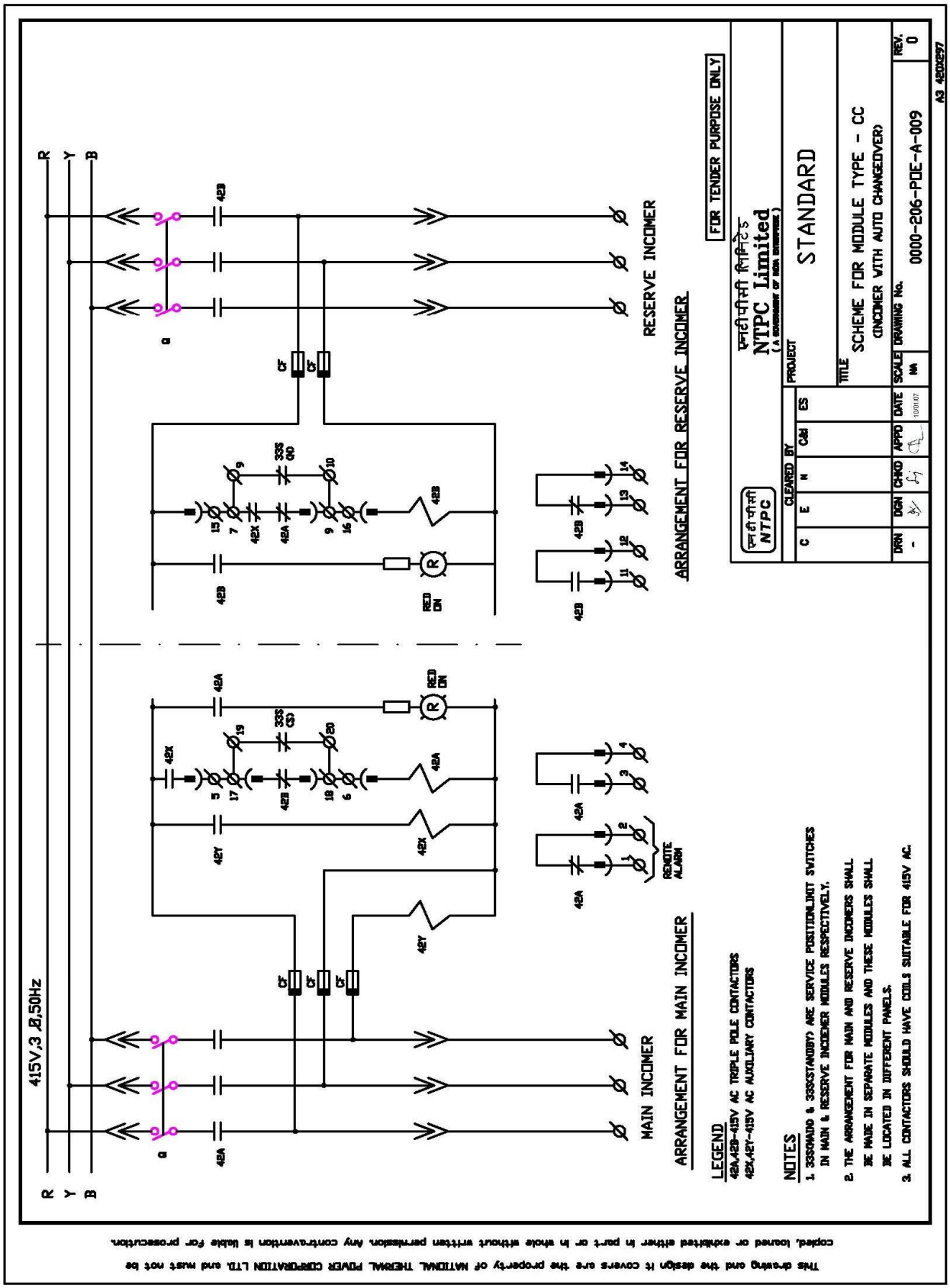

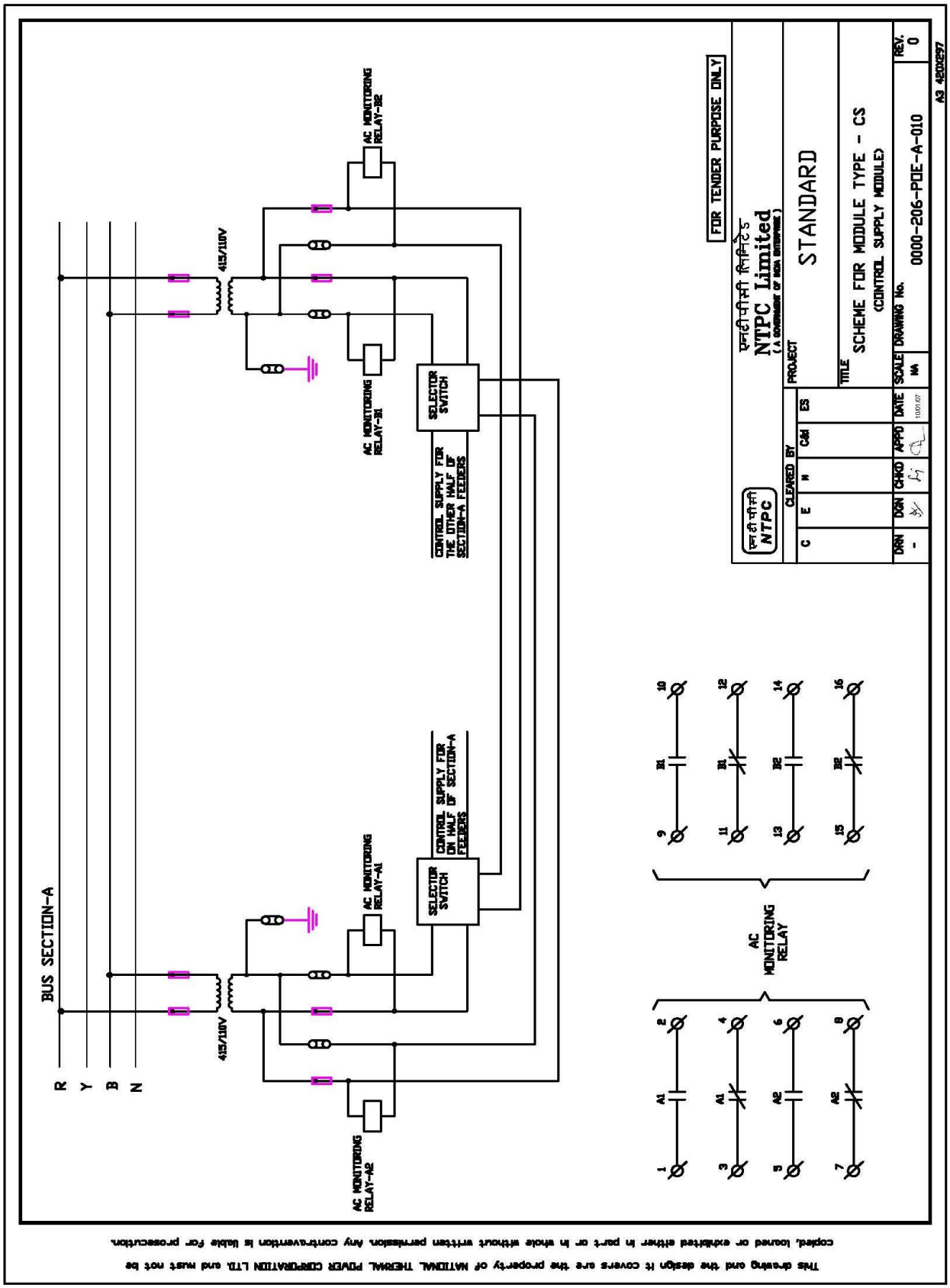

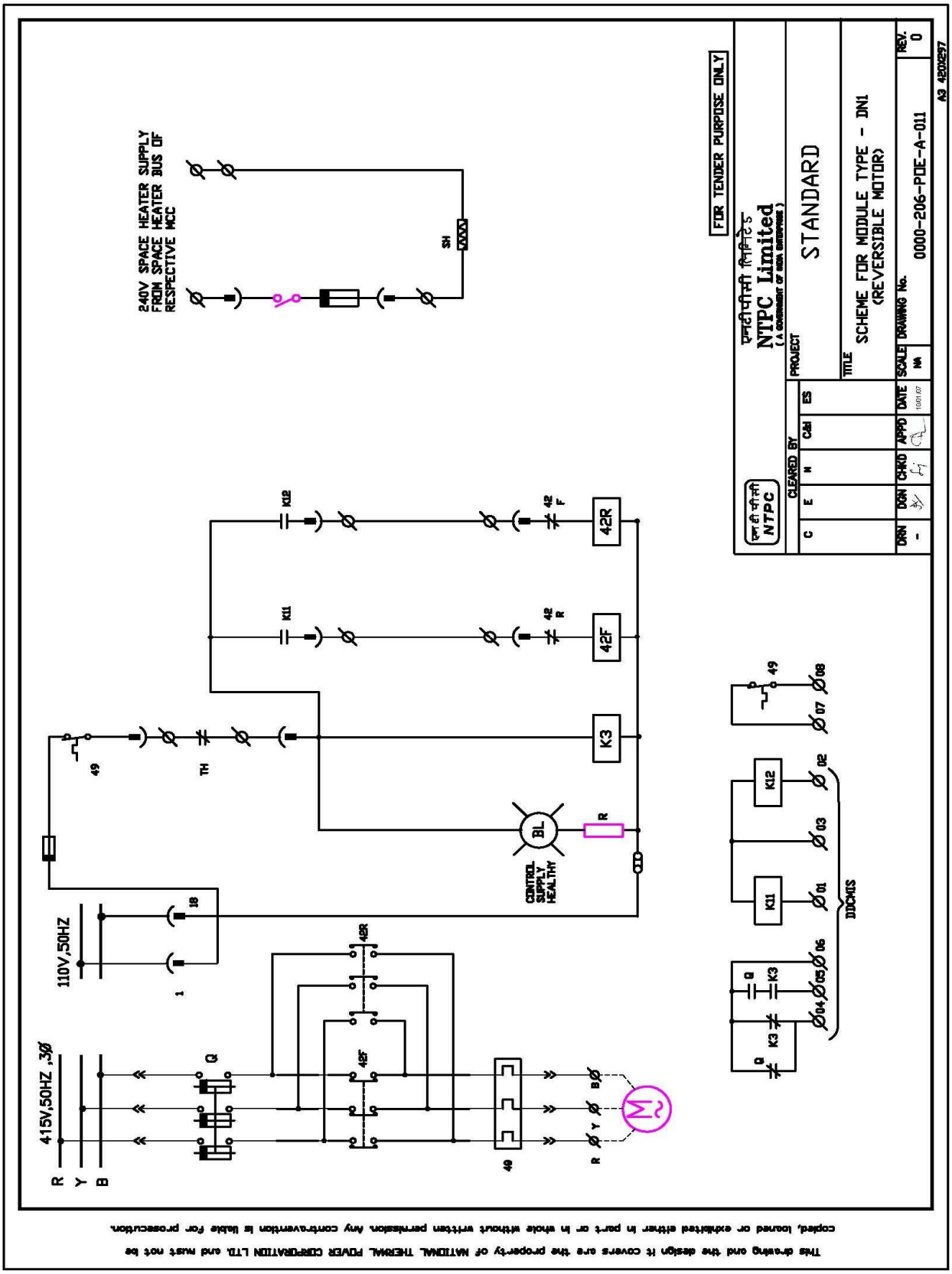

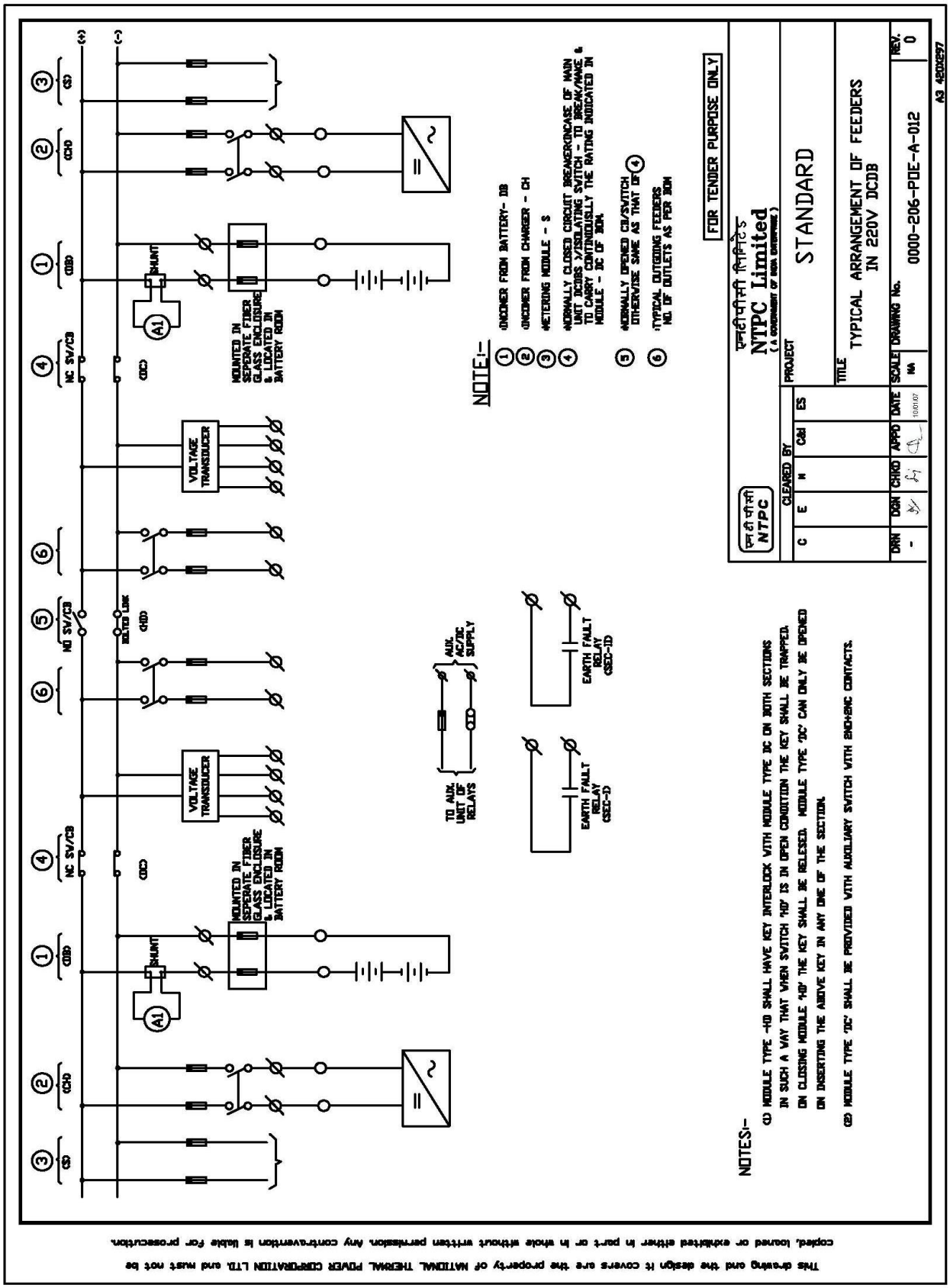

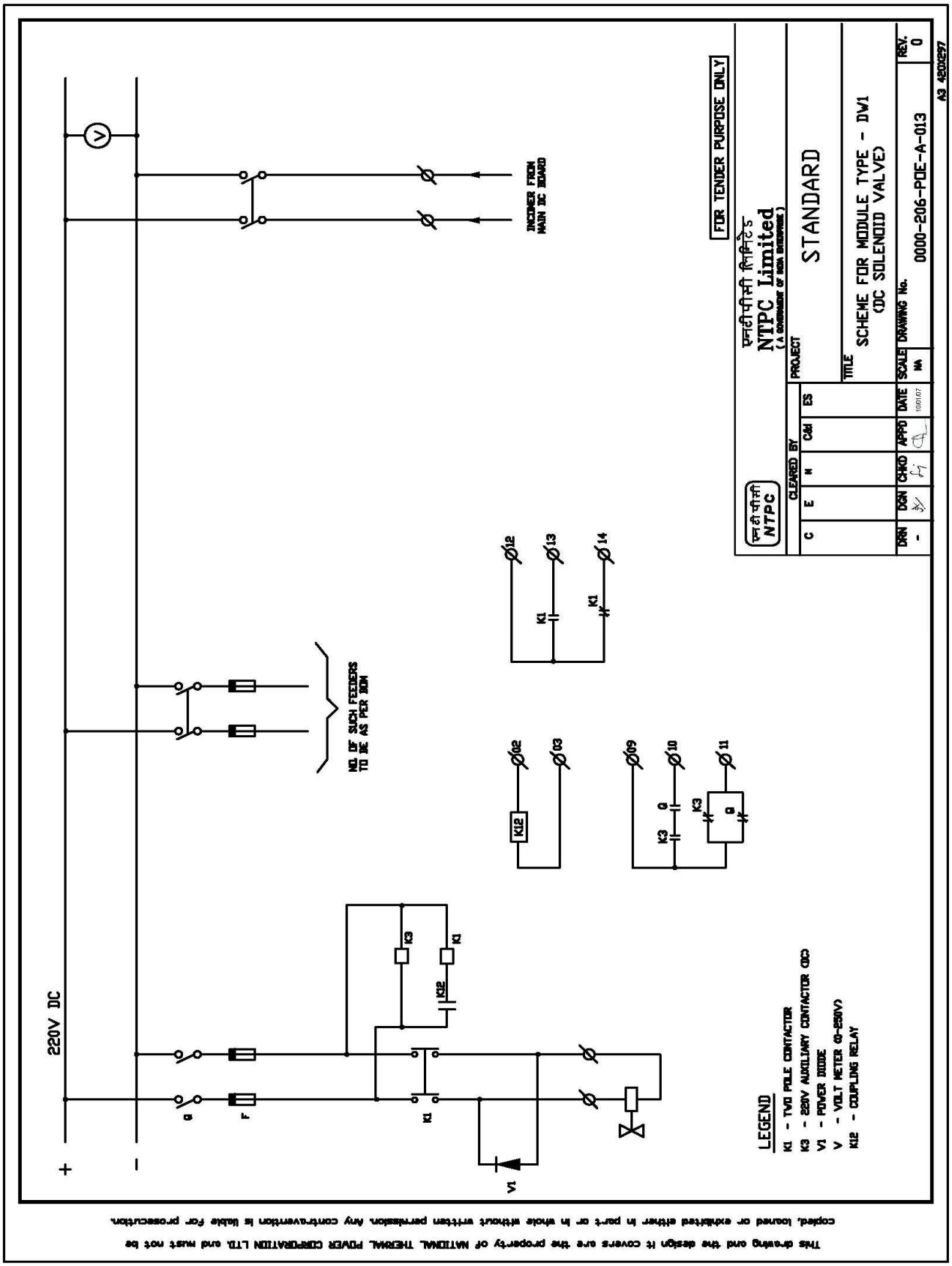

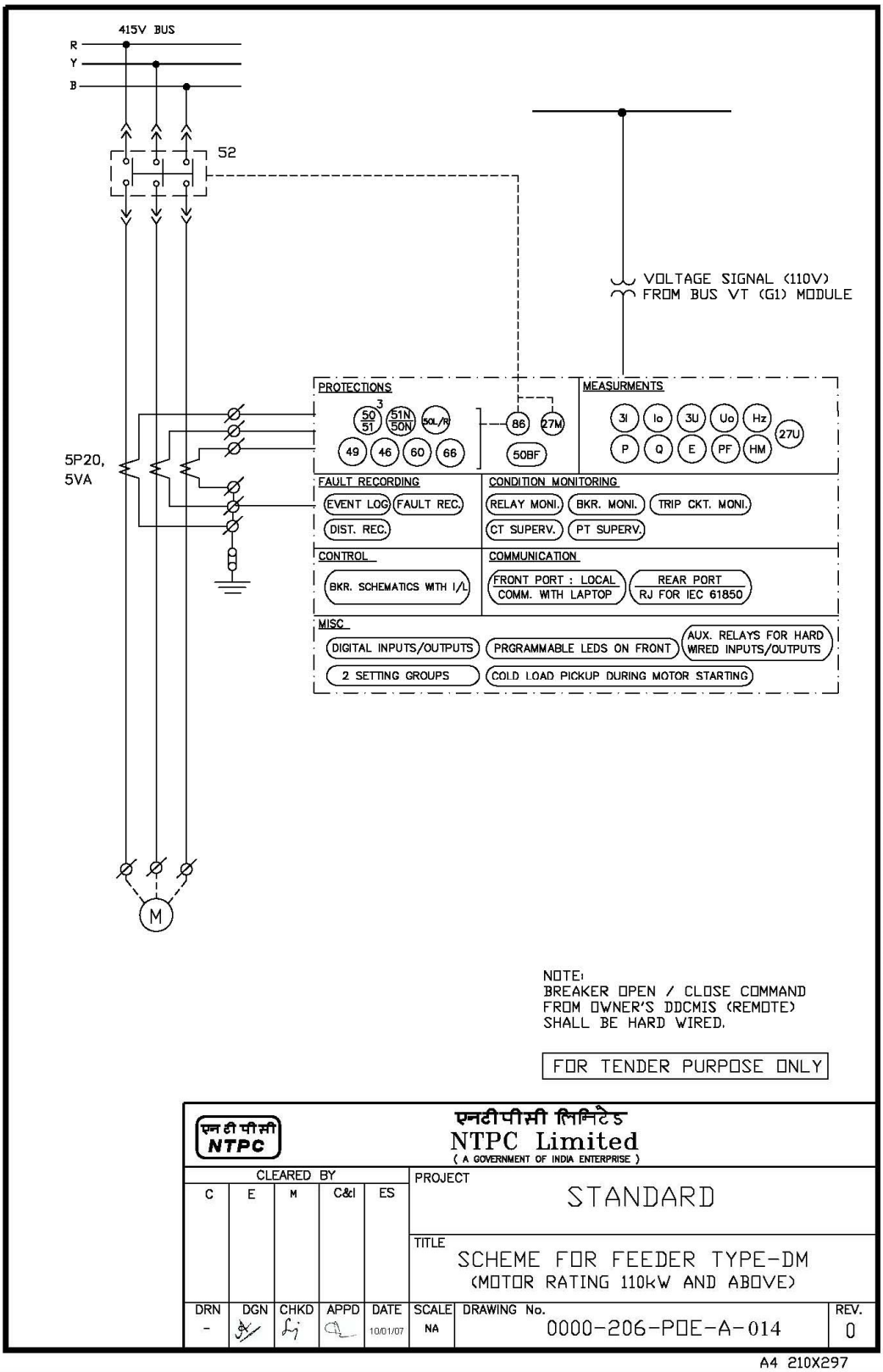

NOTE:
BREAKER OPEN / CLOSE COMMAND FROM OWNER'S DDCMIS (REMOTE) SHALL BE HARD WIRED.

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					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

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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.
	Indian Electricity Act
IS:5	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

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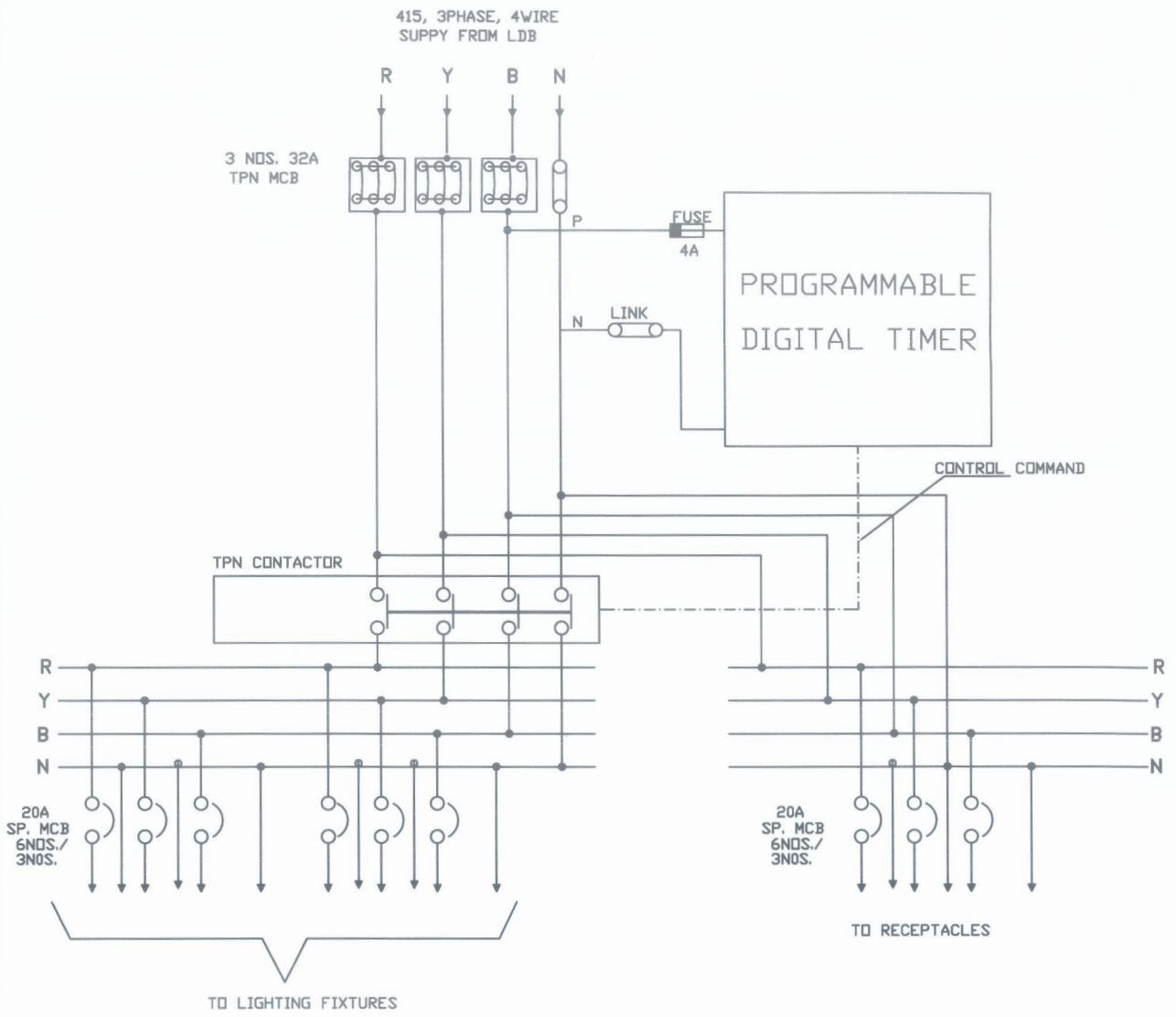

S.NO.	LP TYPE	INCOM ISOLATER	OUTGOING 20A MCB'
1	LP-1	3 NOS 32A TPN MCB + 63A CONT + SYNC. TIMER + INDICATING LAMPS	12 NOS. SP+ 6NO. SP
2	LP-2	3 NOS 32A TPN MCB + 63A CONT + SYNC. TIMER + INDICATING LAMPS	6 NOS. SP+ 3NOS. SP

REV. NO.	DESCRIPTION	DRAWN	DESIGN	CHKD	M	E	C	C&I	ARCH	APPD	DATE
					CLEARED BY						
RC	FOR TENDER PURPOSE	√C	√C		–		–	–	–		
RB	FOR TENDER PURPOSE	–	–	–	–	–	–	–	–	–	27.04.2009
RA	FOR TENDER PURPOSE	–	–	–	–	–	–	–	–	–	17.01.2009

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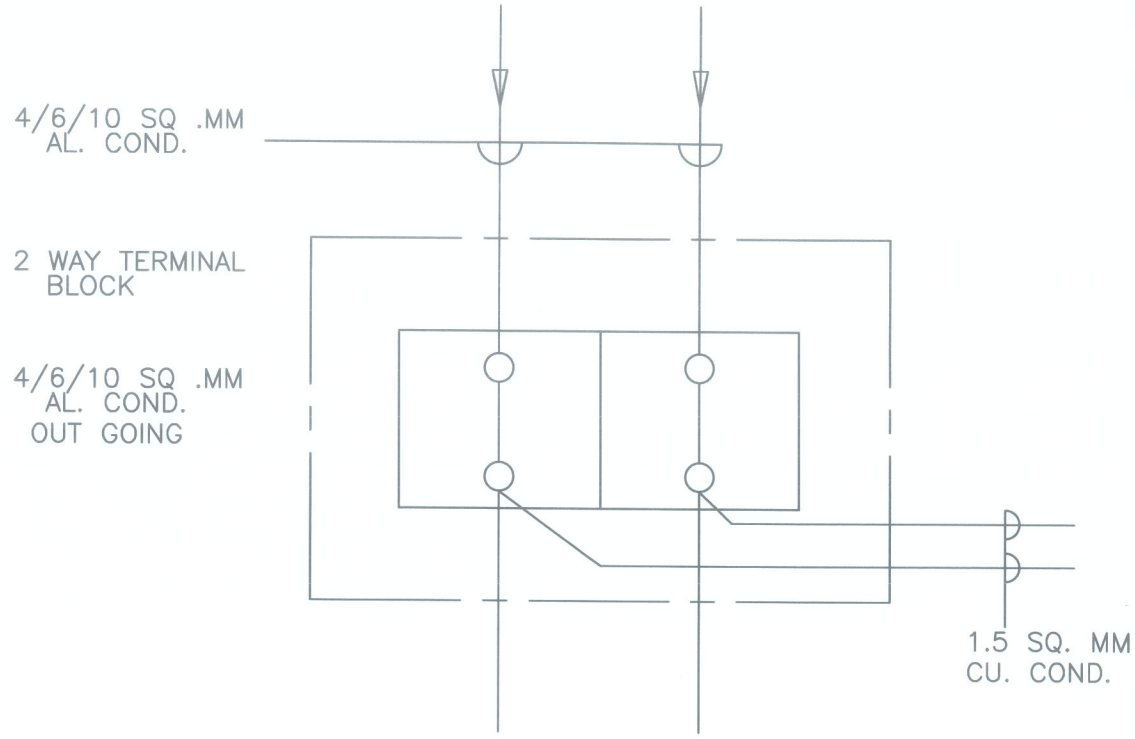
NTPC LTD.
(A GOVERNMENT OF INDIA ENTERPRISE)
ENGINEERING DIVISION

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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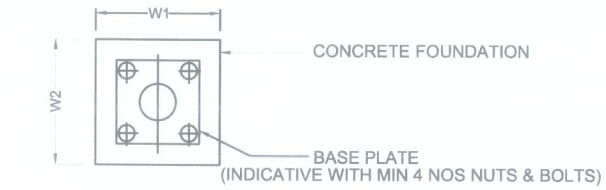
NTPC LTD.
(A GOVERNMENT OF INDIA ENTERPRISE)
ENGINEERING DIVISION

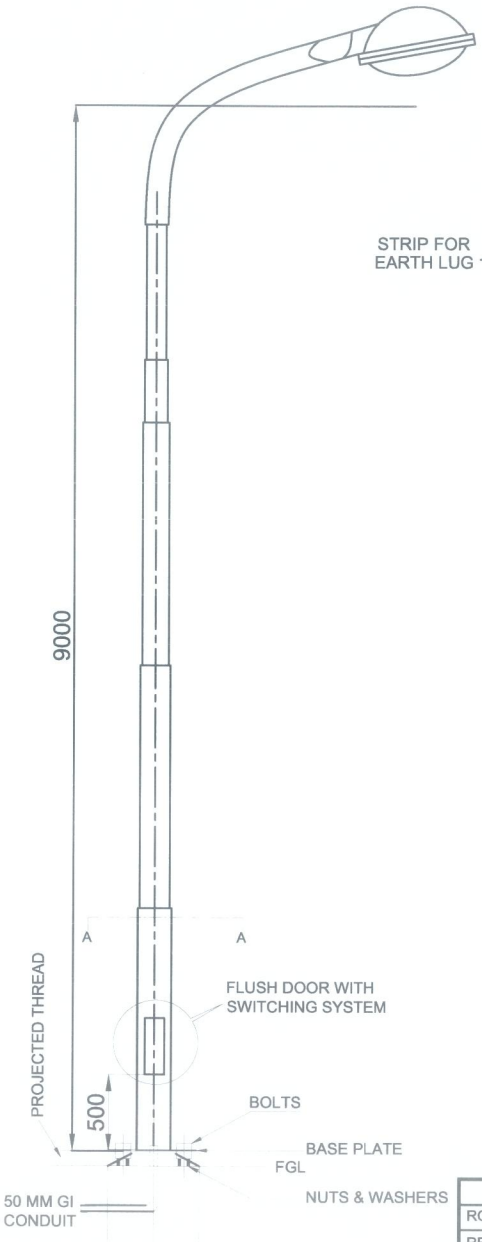
PROJECT: STANDARD

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



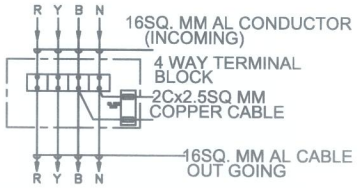
SECTION A–A



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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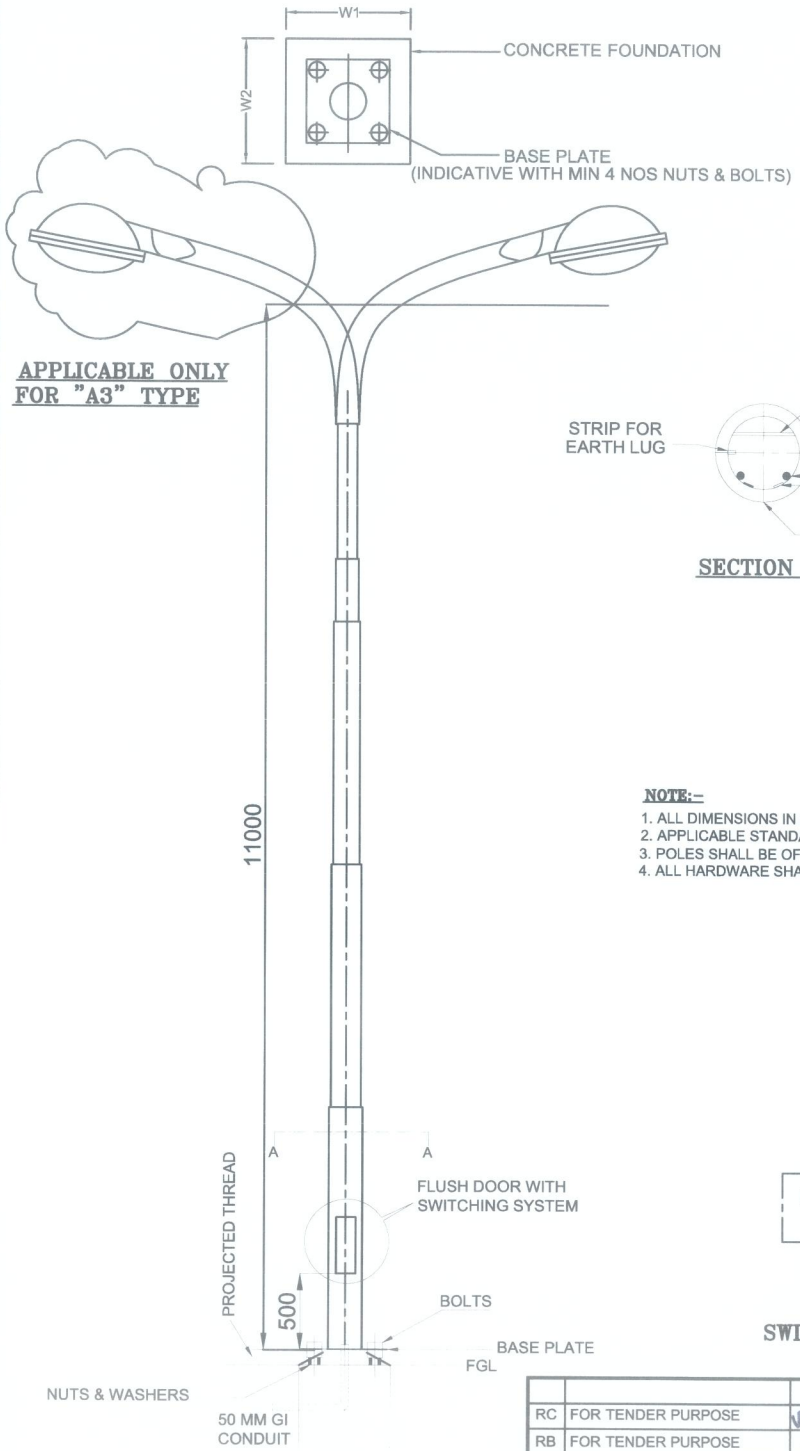
NTPC LTD.
(A GOVERNMENT OF INDIA ENTERPRISE)
ENGINEERING DIVISION

PROJECT: STANDARD

TITLE: GENERAL ARRANGEMENT FOR STREET LIGHTING POLES

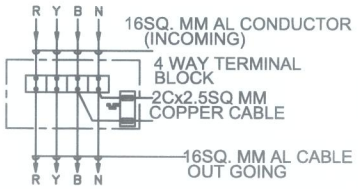
SIZE	SCALE	DRG. NO.	REV. NO.
A4	NTS	0000-217-POE-A-001 SH. 4 OF 20	RC



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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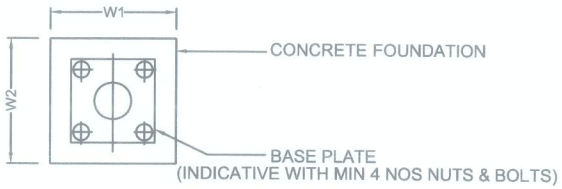
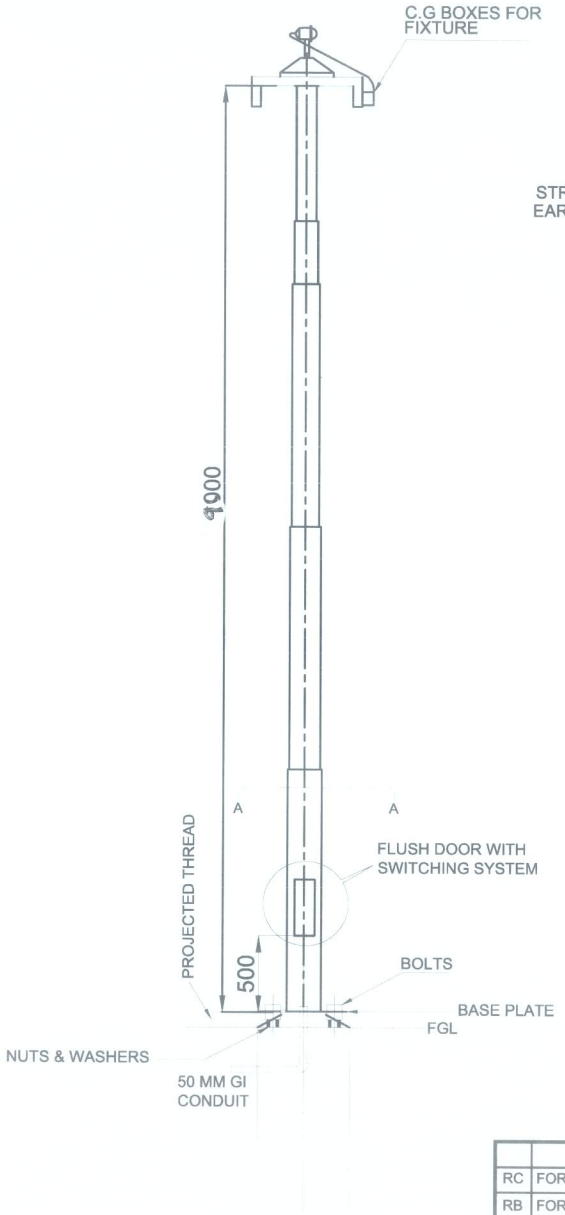
ENGINEERING DIVISION

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



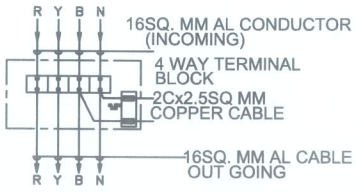


TYPE–C1

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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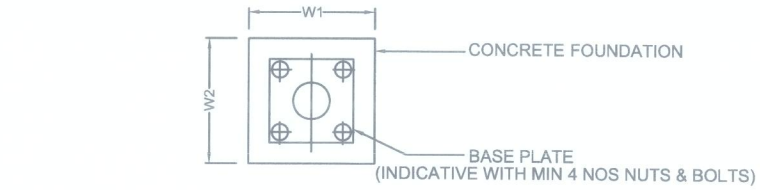
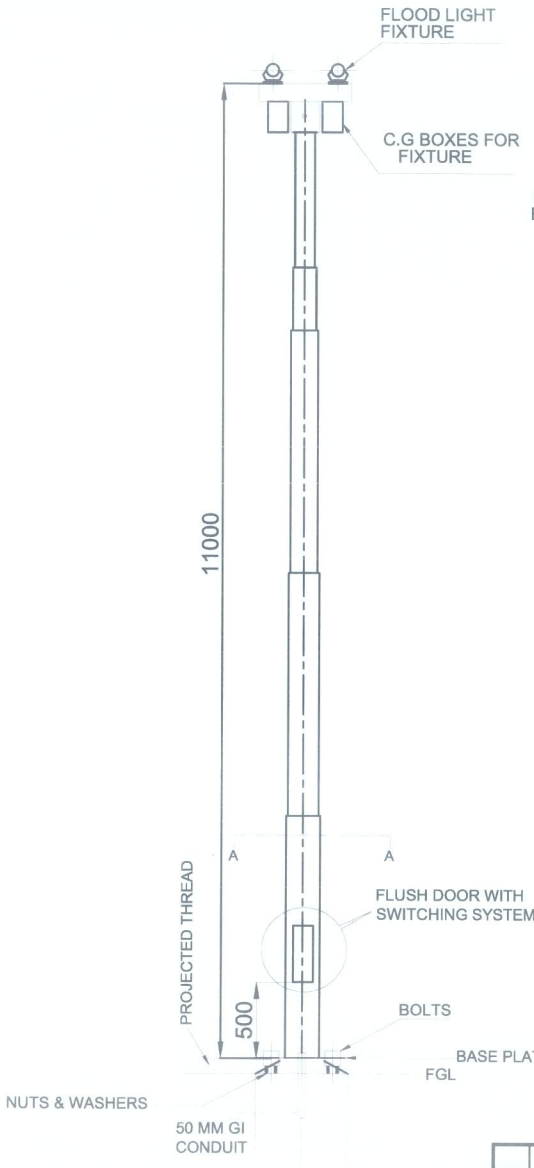
NTPC LTD.
(A GOVERNMENT OF INDIA ENTERPRISE)
ENGINEERING DIVISION

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



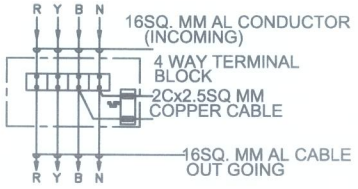


TYPE–C2

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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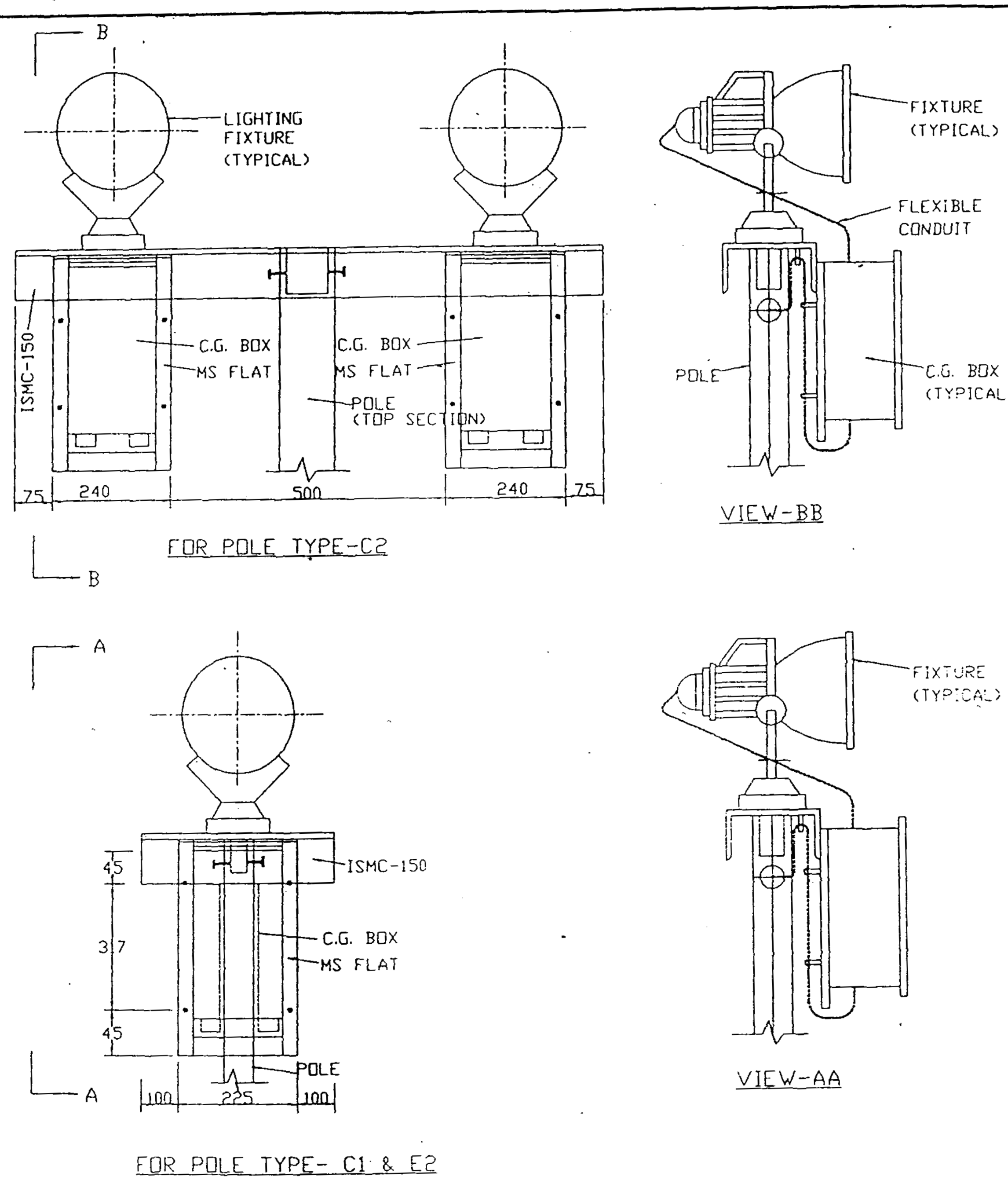
NTPC LTD.
(A GOVERNMENT OF INDIA ENTERPRISE)
ENGINEERING DIVISION

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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NTPC Limited
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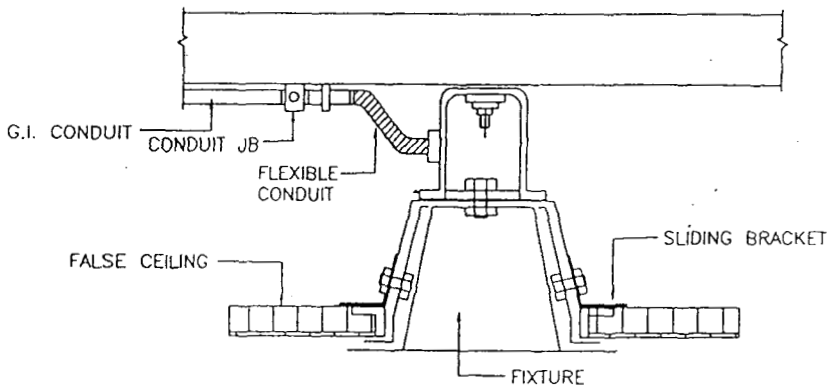
ENGINEERING DIVISION

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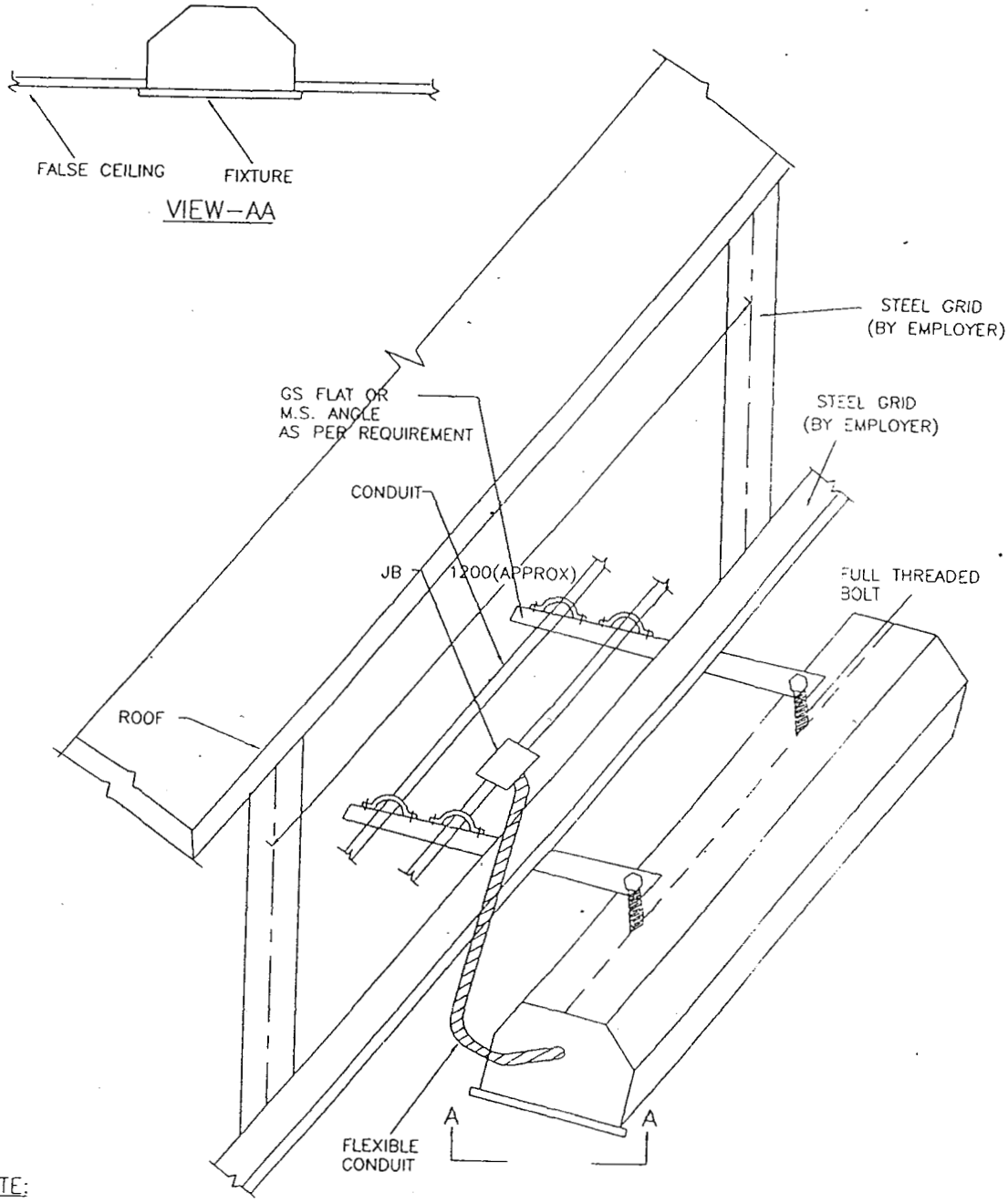
PROJECT	STANDARD		
TITLE	TYPICAL MOUNTING DETAIL OF FIXTURES IN FALSE CEILING AREA		
SIZE A4	SCALE NTS	DRG. NO. 0000-217-POE-A-001 SH. 10 OF 20	REV. NO. RB

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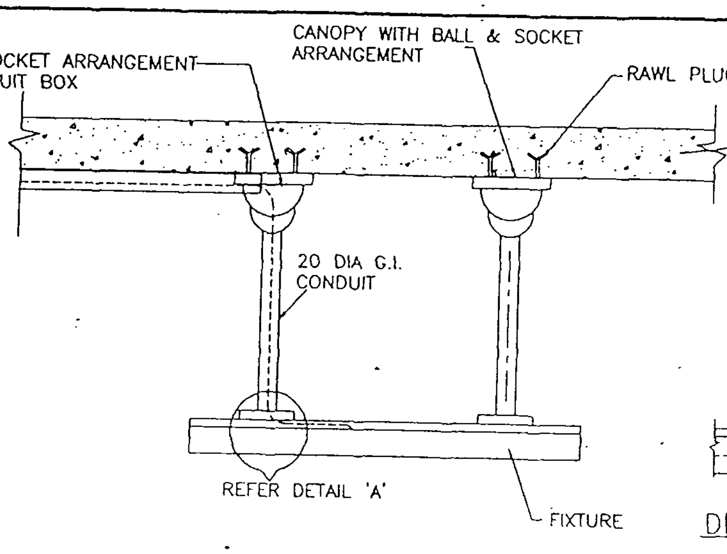
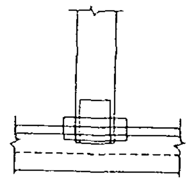
PROJECT	STANDARD		
TITLE	TYPICAL MOUNTING DETAIL OF FIXTURES IN FALSE CEILING AREA		
SIZE A4	SCALE NTS	DRG. NO. 0000–217–POE–A–001 SH. 11 OF 20	REV. NO. RB

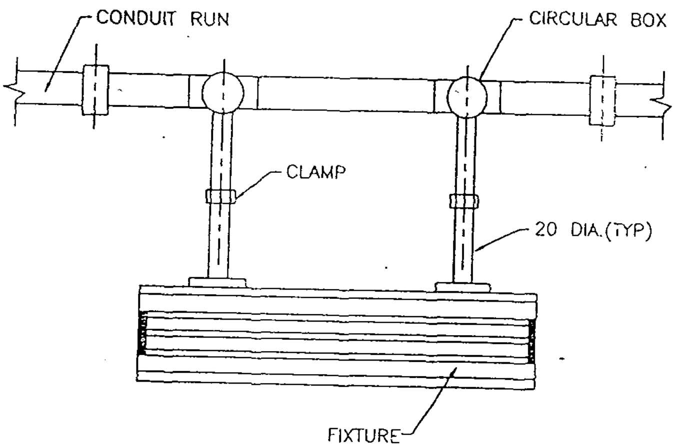
L21.DWG



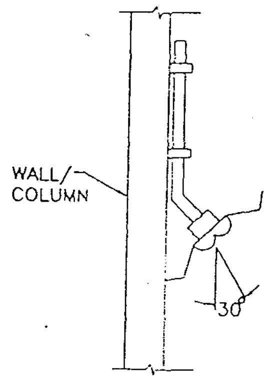


DETAIL-'A'

TYPE-C



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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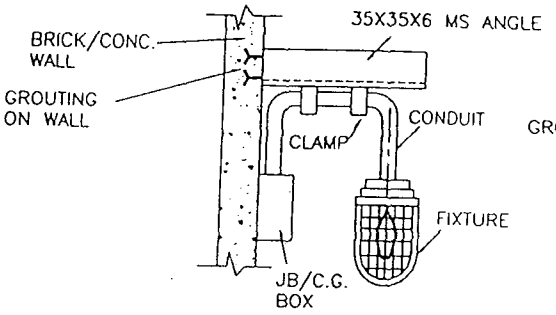
ENGINEERING DIVISION

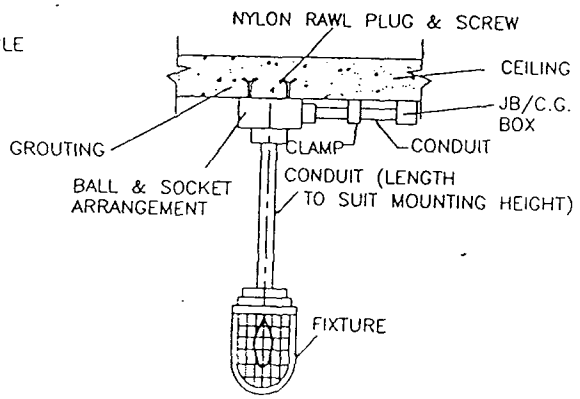
PROJECT	STANDARD
TITLE	TYPICAL MOUNTING DETAIL OF FLUORESCENT FIXTURE

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

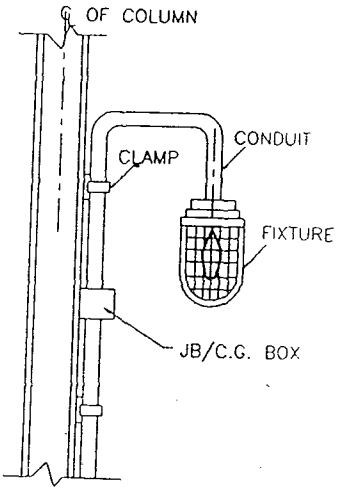
L11.DWG



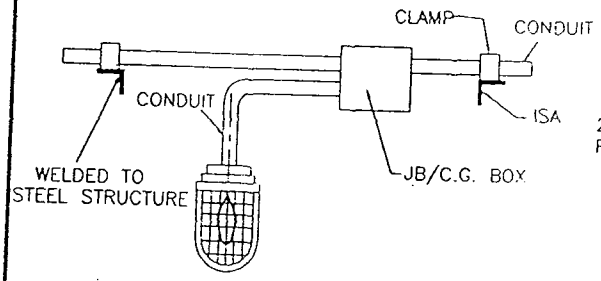
WALL MOUNTING (TYPE-E)



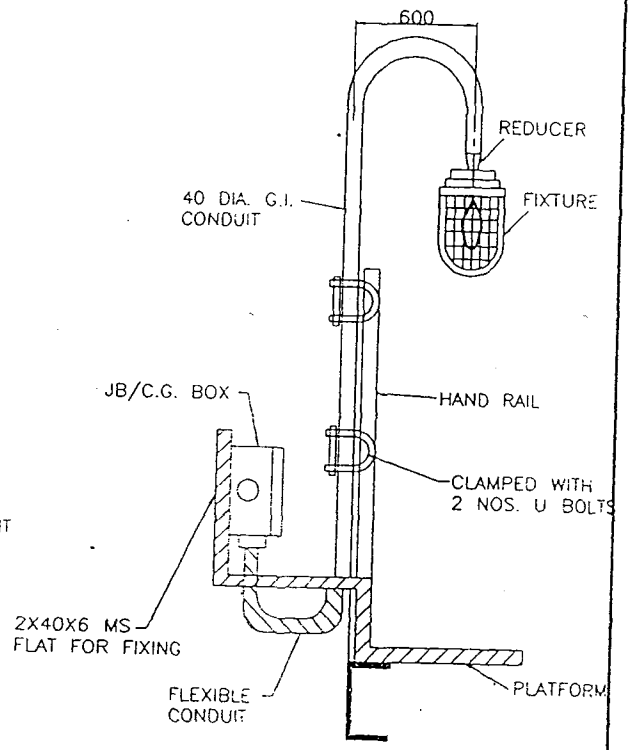
CEILING MOUNTING (TYPE-F)



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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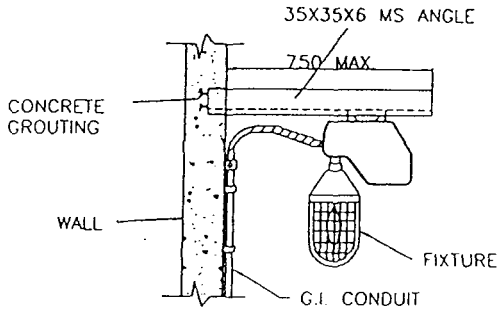
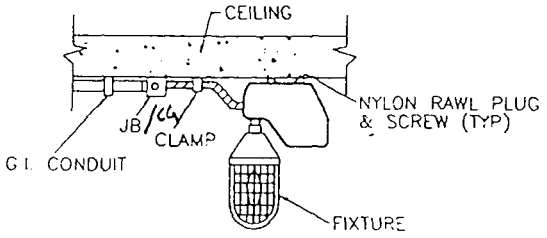
ENGINEERING DIVISION

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

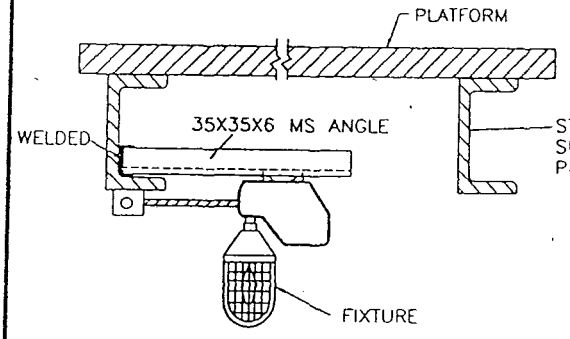
L12.DWG



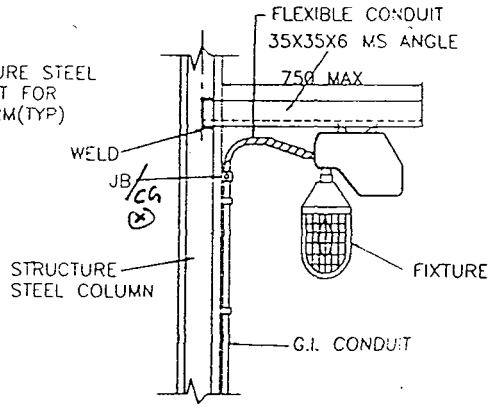
WALL MOUNTING (TYPE-J)



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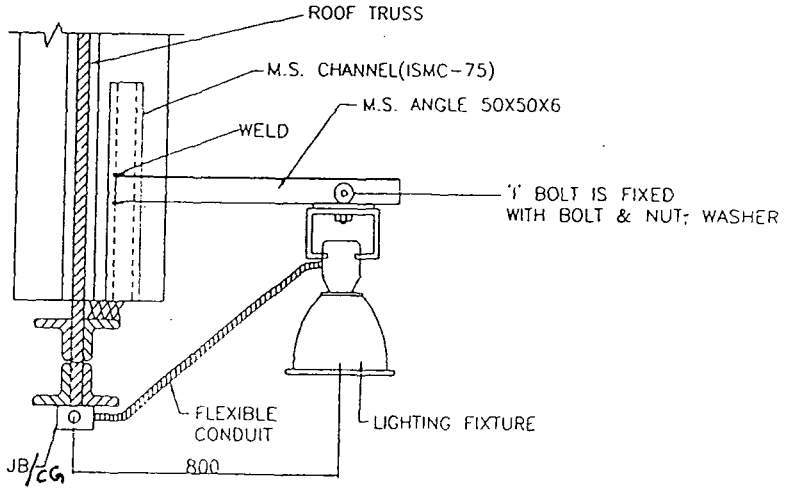
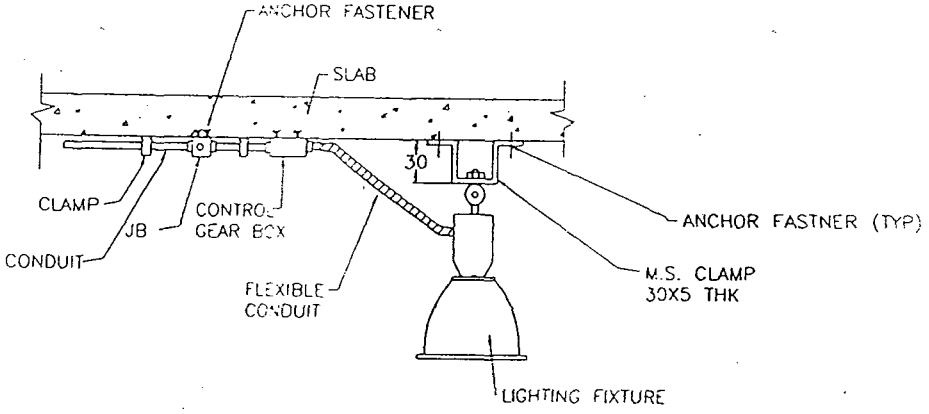
PROJECT	STANDARD		
TITLE	TYPICAL MOUNTING DETAIL OF INTEGRAL TYPE WELL GLASS FIXTURE		
SIZE A4	SCALE NTS	DRG. NO. 0000-217-POE-A-001 SH. 14 OF 20	REV. NO. RB

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			-		-	-	-		

CLEARED BY

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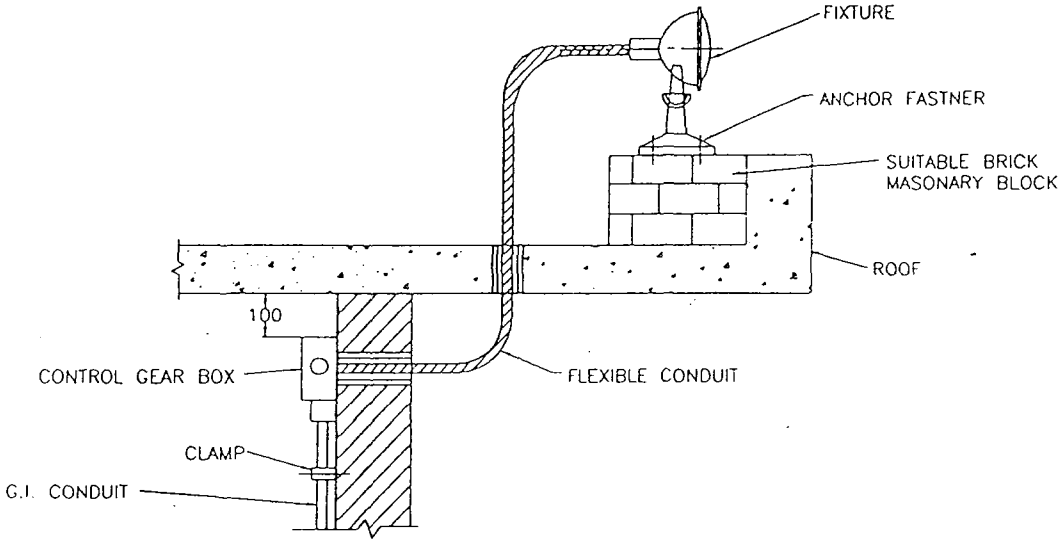
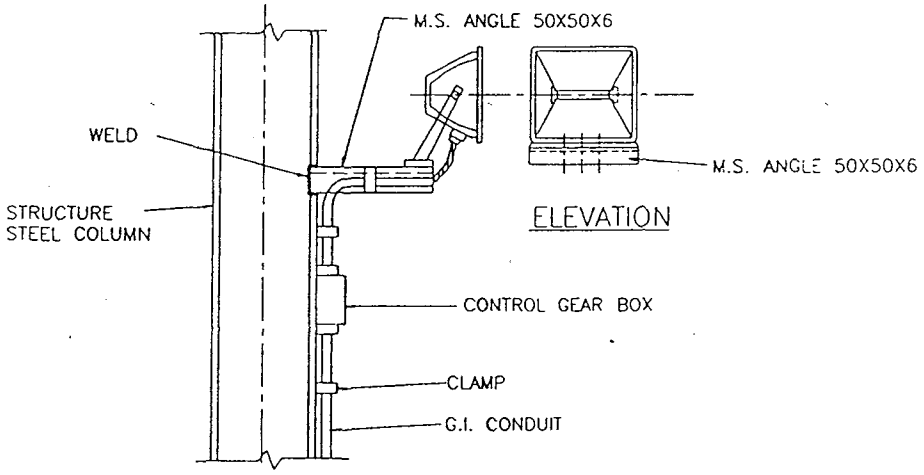
ENGINEERING DIVISION

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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NTPC Limited
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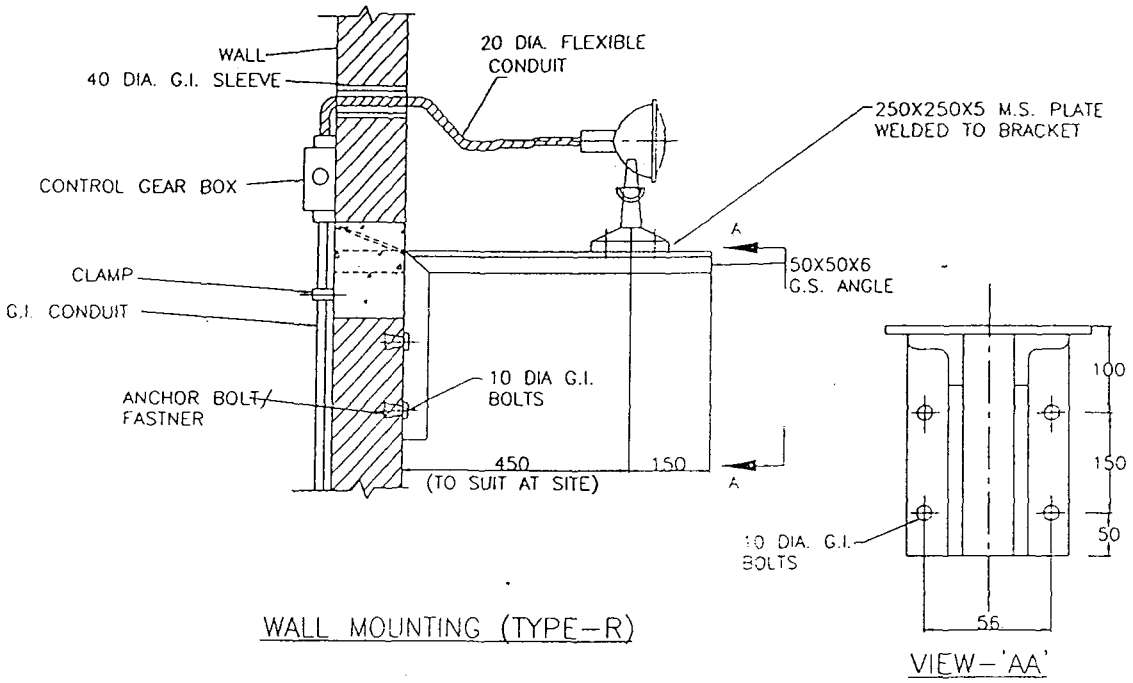
ENGINEERING DIVISION

PROJECT: STANDARD

TITLE: TYPICAL MOUNTING DETAIL OF AREA LIGHTING FIXTURES

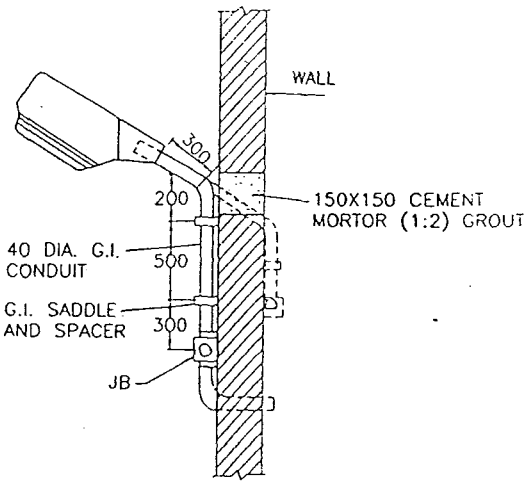
SIZE	SCALE	DRG. NO.	REV. NO.
A4	NTS	0000-217-POE-A-001 SH. 16 OF 20	RB

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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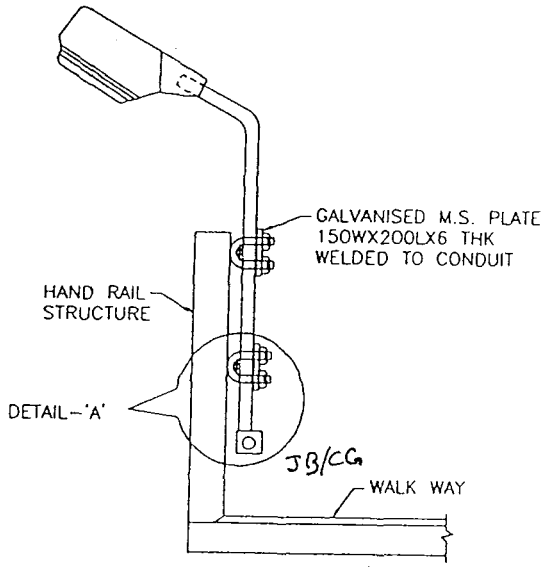
ENGINEERING DIVISION

PROJECT: STANDARD

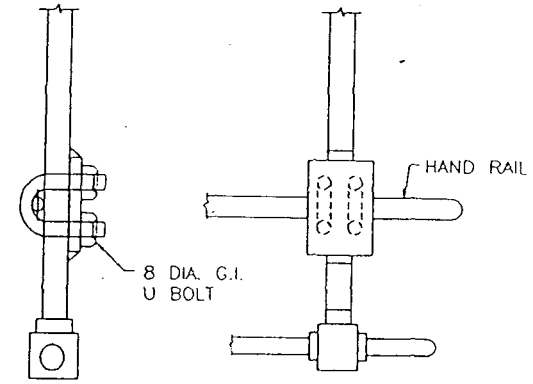
TITLE: TYPICAL MOUNTING DETAIL OF AREA LIGHTING FIXTURES

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

L16.DWG

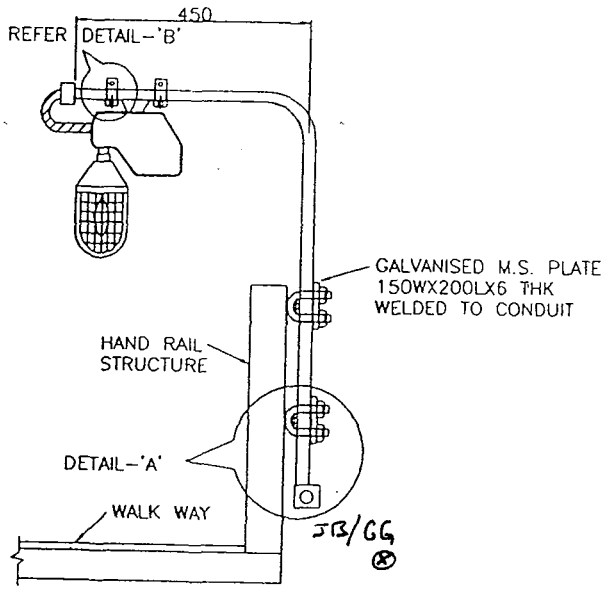


TYPE-T

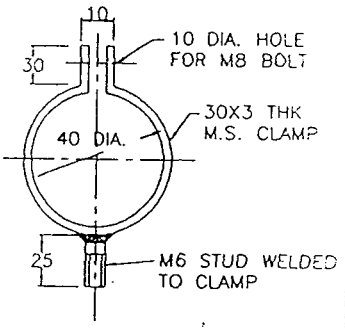


ELEVATION SIDE VIEW

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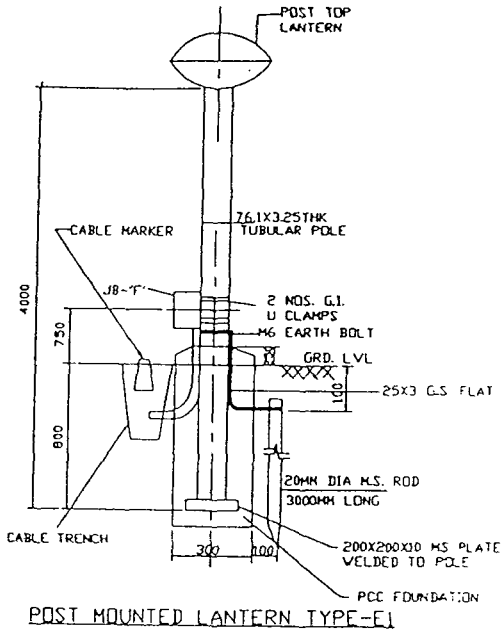
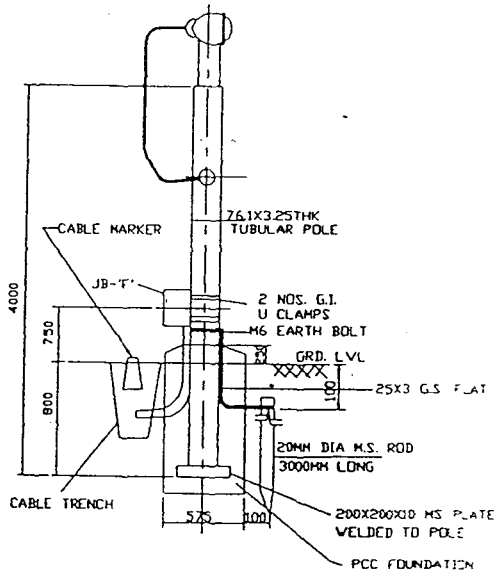
PROJECT	STANDARD		
TITLE	TYPICAL HANDRAIL MOUNTING DETAIL OF FIXTURES		
SIZE A4	SCALE NTS	DRG. NO. 0000-217-POE-A-001 SH. 18 OF 20	REV. NO. RB

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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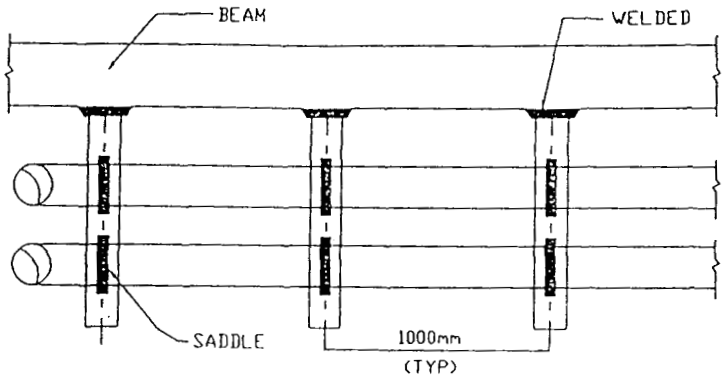
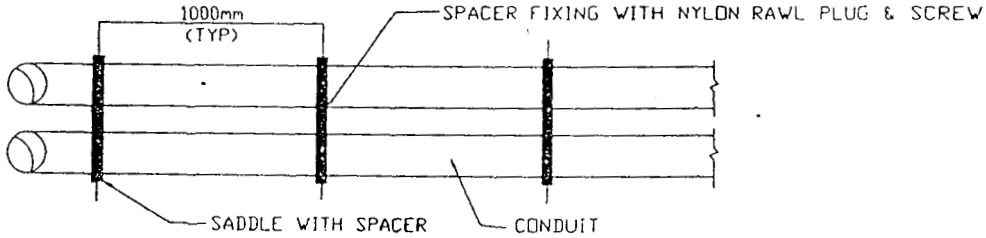
ENGINEERING DIVISION

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

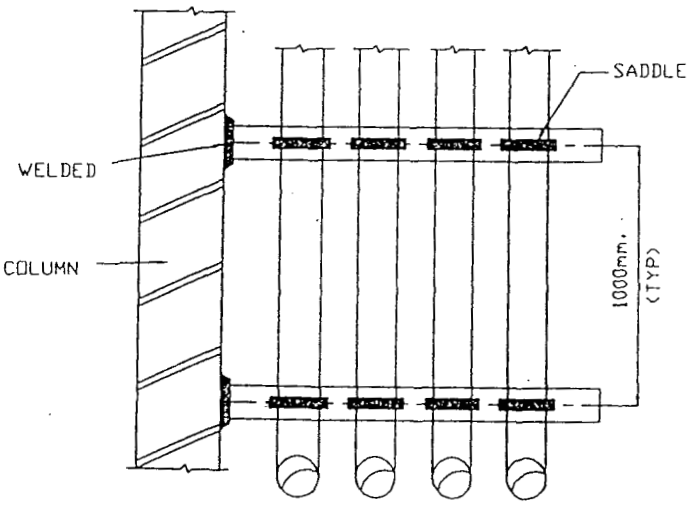
LS.DWG



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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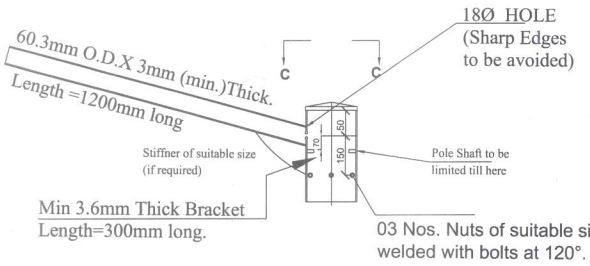
ENGINEERING DIVISION

PROJECT: STANDARD

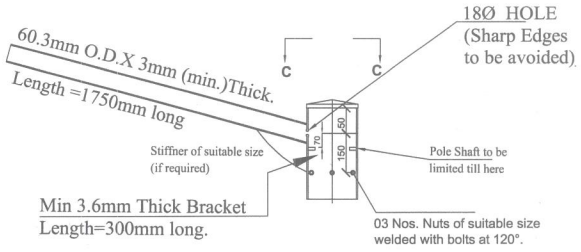
TITLE: CONDUIT FIXING ARRANGEMENT (TYPICAL)

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

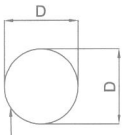
L20.DWG



BRACKET FOR
A1 POLE

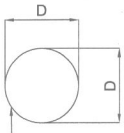


BRACKET FOR
A2 POLE



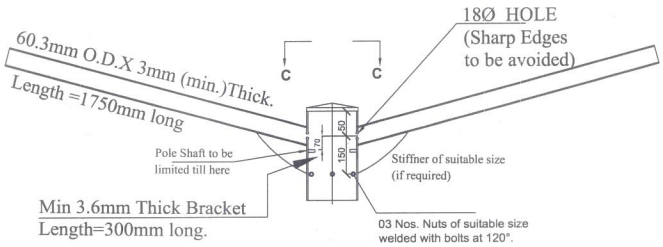
DX6 DIA CIRCULAR M.S.
GAL. PLATE (COVER PLATE).
TO BE WELDED AT TOP
OF BRACKET.

VIEW-C-C

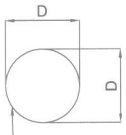


DX6 DIA CIRCULAR M.S.
GAL. PLATE (COVER PLATE).
TO BE WELDED AT TOP
OF BRACKET.

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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ENGINEERING DIVISION

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

TECHNICAL PARAMETERS

Outdoor Transformers

(a)	Rated output	1600 KVA (MIN.) or As per the system requirement whichever is higher.
(b)	C o o l i n g	O N A N
(c)	Type	Two winding
(d)	Voltage Ratio	6.6/0.433 kV
(e)	Frequency	50 Hz
(f)	Phase	Three (3)
(g)	Service	Outdoor
(h)	Duty	Continuous
(i)	Overload capacity	As per IS: 6600/IEC60076-7 and specified elsewhere in the specification.
(j)	Permissible Temperature rise over an ambient temp. of 50 deg. C	
(1.)	Winding (by resistance method)	45 deg.C
(2.)	Top oil (by thermometer)	40 deg.C
(k)	Impedance at 75 deg.C	As per SLD and System requirements
(l)	Noise Level	AS PER NEMA TR-1
(m)	System fault level	As per requirement.

(n) **Winding**

1.	Highest System Voltage(kV)	**7.2**	**0.433**
2.	Lightning impulse withstand voltage, kVp	60	-

3.	One min power frequency withstand voltage, kVrms	20	3
4.	Insulation	uniform	uniform

5. Method of neutral earthing and Vector group (Indicative only/As per system requirement):

KVA RATING	HV RATING (kV)	LV RATING (kV)	Vector Group	Method of Neutral Earthing
1600	6.6	0.433	Dyn11	As per system requirement

(o) Tap changer details:

i) Tap range	As per system requirement
ii) Tap Control	As per system requirement

(p) **Bushing CT Parameters** (Indicative only)

Sl NO.	Transformer Rating	CT Parameters	
		Earth fault CT Class: 5P20	R.E.F.CT Class: PS
1.	1.6 MVA,6.6/0.433 kV		2500/1A, RCT ≤ 12.5Ω, VK ≥480V, Im ≤ 30mA at VK/2

(q) Bushing Parameters

	Parameters	7.2KV	433 V	
(1 .)	Rated Voltage(kV)	7.2	1.1	
(2 .)	Lightning impulse withstand voltage, kVp	60	-	
(3 .)	One min power frequency withstand voltage , kV	22	3.0	

	(rms)			
(4 .)	Minimum total creepage distances (mm)	25mm/kV x Rated Voltage of Bushing.		
(5 .)	Mounting	Tank / Transformer body		
(6 .)	Rated Current	As per details of Transformers under (r) Subsection.		

(r) Bushing Rated Current (in Amperes) (Indicative only)

SR. No.	KVA RATING	HV RATING (kV)	LV RATING (kV)	HV-Line	LV-Line	Neutral
(1.)	1600	7.2	0.433	320	3000	3000

(s) Termination Details (Indicative only)

(1.)	HV Phase Terminal 6.6 kV	As per system requirement
(2.)	LV Phase Terminal 0.433KV	As per system requirement
(3.)	LV Neutral Terminal	As per system requirement

(t) Minimum Clearance in air (mm)

System voltage	6.6 kV	433 V
Phase to Phase	100	25
Phase to Earth	90	25

1.01.00 STANDARDS

All equipment provided under the specification shall in general, conform to the latest issue of the following standards:

Indian Standards No.	Title	International & internationally recognized standards
IS: 2026, IS 1180	Transformers	IEC: 60076,
IS: 3639	Fittings & accessories for power transformers	
	Insulating oils for transformer and switchgear	IEC: 60296, BS:148
IS: 2099	Bushing for alternating voltages above 1000 V	IEC: 60137, BS: 223
IS: 2705	Current transformers	IEC: 60185
IS: 325	Three phase induction motors	IEC: 60034
IS: 3637	Gas operated relays	
IS: 10028	Code of practice for selection installation & maintenance of transformers	
IS: 4691	Degree of protection provided by enclosure for rotating electrical machinery	
IS: 13947	Specification for low voltage switchgear & control gear Part – I	IEC: 144
IS : 5	Colours for ready mix paints	
IS: 1866	Code of practice for maintenance & Supervision of mineral insulating oil in equipment	
IS: 6272	Industrial cooling fans	
IS: 6600	Guide for Loading of oil immersed transformers	IEC: 60076-7
IS: 3347 IS:8603	Specification for dimensions of porcelain bushing	
IS: 8468	Tap changers	IEC: 214
	High voltage test technique	IEC: 60
	Insulation co-ordination	IEC: 71

Indian Standards No.	Title	International & internationally recognized standards
	NEMA standard publication for Power transformers	NEMA-TR-1
IS: 10596	Code of practice for selection, Installation operation & maintenance of pumps for Industrial applications	
IS: 9434	Guide for sampling & analysis of free & dissolved gas & oil from oil filled electrical equipment	IEC: 567
IS: 2544	Porcelain post insulators for systems with nominal voltage greater than 1000 V	
IS: 5561	Specification for electric power connectors	
IS: 5621	Hollow insulators for use in electrical equipment	
IS: 2633	Methods for testing uniformity of coating of Zinc coated articles	
IS: 12676	Dimensions for OIP insulated condenser bushings	
BEE Guideline & CEA notification		

1.02.00 The electrical installation shall meet the requirements of Indian Electricity act 2003.

2.00.00 PERFORMANCE

(a) The maximum flux density in any part of the core & yoke at the rated MVA, voltage & frequency shall be such that under 110% continuous voltage condition it does not exceed 1.9 Tesla.

(b) The transformer & all its accessories including CT's etc, shall be designed to withstand without injury the thermal & mechanical effects of any external short circuit to earth & of short circuits at the terminal of any winding for a period of 2 sec.

(c) Transformers shall withstand, without injurious heating, combined voltage & frequency fluctuations, which produce the following over fluxing condition:

1)	110 %- continuous
	125%- for one minute
	140%- for five seconds
2)	Bidder shall indicate 150% & 170% over voltage withstand time.
3)	Over fluxing characteristics up to 170 % shall be submitted.

(d) The transformers shall be capable of being operated continuously without danger on any tapping at the rated MVA with voltage variation of ±10% corresponding to the voltage of tapping.

(e) The transformers shall be capable of being loaded in accordance with IS: 6600 / IEC: 60076-7 up to load of 150 %. There shall be no limitation imposed by bushings, tap changers etc. or any other associated equipment.

(f) Outdoor transformers shall have energy efficiency level 3 as per IS 1180.

3.00.00 CONSTRUCTION

The features & construction details of each transformer shall be in accordance with the requirement stated hereunder.

3.00.00 TANK AND TANK ACCESSORIES

(a) Tank shall be of welded construction & fabricated from tested quality low carbon steel of adequate thickness. The welding procedure specification (WPS), procedure qualification record (PQR), shop welding schedule, welder's qualification shall be subject to Employer's approval. After completion of welding, all joints shall be subjected to visual examination. In case of doubt particular weld shall be checked by D.P. Test. However weld joints of load bearing member shall be left unpainted till carrying out of jacking test followed by DP Test during final inspection of transformer. Details of acceptance norms of welding shall be submitted for Employer's approval which shall include permissible undercut, overlap, surface crack, porosity, out of alignment of plate surface in butt joints, maximum gap due to incorrect fit up of fillet joint etc.

(b) Each tank shall be provided with :

(i.) Lifting lug suitable for lifting the equipment complete with oil.
(ii.) A minimum of four jacking pads in accessible position to enable the transformer complete with oil to be raised or lowered using hydraulic or mechanical screw jacks.
(iii.) Suitable haulage holes shall be provided for transformer wheeling in all four directions.

(c) For all transformers, suitable bi-directional skids with pre-drilled holes shall be provided integral with the tank body for fixing the transformer tank on foundation. These skids shall be such that the bottom of the tank body is at a sufficient height above foundation for cleaning purposes.

The transformers (except transformers upto and including 2 MVA) are to be provided with four no. of bi - directional flat rollers of detachable type & shall be mounted on wheels on foundation. Suitable locking arrangement shall be provided for the wheels to prevent accidental movement of transformer.

(d) At least two adequately sized inspection openings one at each end of the tank shall be provided for easy access to bushing & earth connections. The inspection covers shall not weight more than 25 Kg. Handles shall be provided on the inspection cover to facilitate lifting.

(e) All bolted connections shall be fitted with weather proof, hot oil resistant, rubberized cork gasket in between for complete oil tightness. If gasket is compressible, metallic stops shall be provided to prevent over compression.

(f) The tank shall be designed in such a way that it can be mounted on the plinth directly.

(g) Wherever possible the transformer tank & its accessories shall be designed without pockets wherein gas may collect. Where pockets can not be avoided, pipes shall be provided to vent the gas into the main expansion pipe.

(h) The main tank body shall be capable of withstanding full vacuum.

3.01.00 Core

(a) The core shall be constructed from cold rolled, super grain oriented (CRGO), silicon steel laminations of equivalent to M4 or better grade.

(b) The core isolation level shall be 2 kV (rms.) for 1 minute in air.

(c) Adequate lifting lugs will be provided to enable the core & windings to be lifted.

3.02.00 Windings

(a) The contractor shall ensure that windings of all transformers are made in dust proof & conditioned atmosphere. The bidder shall furnish details of the facilities available at his works along with the Techno- Commercial bid.

(b) The conductors shall be of electrolytic grade copper free from scales & burrs.

(c) All windings of the transformers having voltage less than 66 kV shall be fully insulated.

(d) Tapping shall be so arranged as to preserve the magnetic balance of the transformer at all voltage ratio.

3.03.00 Insulating Oil

No inhibitors shall be used in the transformer oil. The oil supplied with transformers 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

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:

(a) After placement of transformer on foundation, Oil of main tank shall be tested for

i)	BDV	60 kV (min)	Applicable for all transformers including 16 MVA.
ii)	Moisture content	10 ppm (max.)	

iii)	Tan delta at 90 deg. C	0.002 (max.)	Applicable for 16 MVA & above Transformers only.
iv)	Resistivity at 90 deg. C	35 x 10^{12} ohm-cm (min)	
v)	Interfacial tension	0.040 N/m (min)	

(b) Prior to energization at site for following properties & acceptance norms:

i)	BDV	60 kV (min)	Applicable for all transformers including 16 MVA.
ii)	Moisture content	10 ppm (max.)	
iii)	Tan delta at 90 deg. C	0.05 (max.)	Applicable for 16 MVA & above Transformers only.
iv)	Resistivity at 90 deg. C	1 x 10^{12} ohm-cm (min)	
v)	Interfacial tension	0.035 N/m (min)	

3.03.01 Oil Preservations System

(a) The transformers rated below 7.5 MVA shall have the following types of oil preservation systems:

(i.) Conventional Conservator

The transformer shall be provided with conventional single compartment conservator with dry air filling the space above the oil. The top of the conservator shall be connected to the atmosphere through a cobalt free indicating type silica gel breather with transparent enclosure. The Buchholz relay shall also be provided.

The conservator shall be fitted with a cobalt free non-carciogenic indicating type silica gel filter breather of transparent enclosure breather, which shall be so designed that:

→ Passage of air is through a dust filter and silica gel.

→ Silica gel is isolated from atmosphere by an oil seal.

→ Moisture absorption indicated by a change in colour of the tinted crystal can be easily observed from a distance.

→ Breather is mounted not more than 1400 mm above rail top level.

3.04.00 Terminal Arrangements

3.04.00 Bushings

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

Bushings of rating below 52 kV shall be solid porcelain/oil communicating/condenser type. All condenser bushings shall be non-communicating type.

(b) Condenser type bushings shall be provided with :

(i.) Oil level gauge,
(ii.) Oil filling plug & drain valve (if not hermetically sealed)
(iii.) Tap for capacitance & tan delta test.

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

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

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

(f) Wherever cable termination is specified, bushing terminals shall be provided with suitable terminal connectors of approved type and size for cable termination.

(g) Where current transformers are specified, the bushings shall be removable without disturbing the current transformer.

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3.04.01 Neutral Terminal Arrangement

3.04.02 Neutral Termination

(a) The neutral terminal of 433 V winding shall be brought out on a bushing along with the 433 V phase terminal to from a 4 wire system for the 433 V. Neutral CT's shall be located in the lead coming out of the winding and location of these CT's shall not be inside the tank.

(b) The neutral terminal of winding not connected to NGR (as per "Key Technical Parameter-Transformers" Subsections), shall also be brought out through an outdoor bushing. Further this neutral terminal shall be connected by a copper flat of size 50 mm x 8 mm, which shall be brought down upto 100 mm above ground. The copper flat shall be insulated and supported from the tank body. The connection shall be made by using two (2) bolted neutral grounding terminals with necessary accessories.

(c) The neutral terminal of winding connected to NGR (as per "Key Technical Parameter-Transformers" Subsections), shall be brought to an outdoor bushing, away from the busduct termination arrangement (wherever applicable). It shall be connected to associated neutral grounding resistor by a copper flat, which shall be supplied & installed by the contractor along with the necessary intermediate supporting insulators & supporting structure. Also NGR shall be grounded through copper flat which shall be insulated and properly supported and shall be brought down upto 100 mm above ground.

3.04.03 Bus Duct Terminations

(a) A flanged throat or equivalent connection shall be provided for termination of busduct enclosure. The winding termination shall be on outdoor type of bushings. The Employer would provide necessary flexible connection between the bushing terminal & the bus duct conductor. The material of the busduct termination shall be non-magnetic.

(b)	The shape of the bus duct conductor shall be informed during detailed engineering. The bushing pads shall be silver/tin plated. A drain with stopcock arrangement shall be provided at flange to drain leakage of oil/water at termination. As bus duct will be pressurized stopcocks shall be airtight.
(c)	Tolerance permissible for the height of the terminal connected to busduct over rail top level is ± 10 mm. Contractor has to ensure that radiator & conservator does not obstruct the path of the bus ducts in position & during movement of transformer. The contractor shall co-ordinate final design of terminal arrangement to suit bus duct arrangement during detailed engineering.
(d)	The transformer bushing enclosed in bus duct enclosure shall be designed for satisfactory operation in the high ambient temperature existing inside the bus duct enclosure. The temperature inside the bus duct enclosure may be of the order of 90 – 100 deg. C. The bus duct conductor temperature may be as high as 105 deg. C & temperature in the bus duct enclosure will be of the order of 80 deg. C.
3.04.04	**Cable boxes & disconnecting chamber**
(a)	HV Cable boxes shall be of phase segregated air insulated type & shall be of sufficient size to accommodate Employer's cable & termination (as applicable). Phase segregation shall be achieved by insulating barriers.
(b)	Cable boxes shall have bus bars / terminal connectors of adequate size & bolt holes to receive cable lugs.
(c)	A suitable removable gland plate of non-magnetic material drilled as per the Employer's instruction shall also be provided in the cable box.
(d)	The support from base for the cable box shall be of galvanized iron.
(e)	The contractor shall provide earthing terminals on the cable box, to suit Employer's GI flat.
(f)	The final cable size & type, number & length of terminating cable (from cable gland plate to the cable lug) shall be furnished during detailed engg.
(g)	Cable boxes shall be designed such that it shall be possible to move away the transformer without disturbing the cable terminations, leaving the cable box on external supports.
(h)	Cable boxes shall have removable top cover & ample clearance shall be provided to enable either transformer or each cable to be subjected separately to high voltage test.
3.04.05	**TERMINAL CONNECTOR** (If applicable)
(a)	Bushing terminal shall be provided with terminal connectors of approved type & size for connection to external part. Terminal connectors must have been successfully type tested as per IS: 5561.
(b)	Aluminium alloy if used shall conform to designation 4600 M of IS: 617 or of better quality.

(c) No current carrying part of a clamp shall be less than 10 mm thick.

(d) All ferrous parts shall be hot dip galvanized conforming to IS: 2633.

(e) For bi-metallic clamp, copper alloy liner of minimum 2-mm thickness shall be cast integral with aluminum body. Alternatively Bidder may offer bimetallic connector with loose bimetallic sleeve.

(f) Flexible connectors shall be made from tinned copper sheets.

(g) Size of terminal/conductor for which the clamp is suitable & rated current under the conditions shall be embossed / punched on each component of the clamp, except hardware.

(h) Rated current of the terminal connectors shall be same as that of corresponding bushing.

3.05.00 Bushing Current Transformer

(a) Current transformer shall comply with IS: 2705.

(b) It shall be possible to remove turret mounted current transformers from the transformer tank without removing the tank cover. Necessary precautions shall be taken to minimize eddy currents & local heat generated in the turret.

(c) All secondary leads shall be brought to a weatherproof terminal box near each bushing. These terminals shall be wired out to transformer marshalling box using separate cables for each core.

3.06.00 Terminal Marking

The terminal marking & their physical position shall be as per IS: 2026 unless specified otherwise.

3.07.00 Marshalling Box(M. BOX) Unit

(a) Each transformer shall be provided with one Marshalling Box housing all the cooler control, OTI & WTI etc.

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. The gasket used shall be of neoprene rubber. A space heater & cubicle lighting with on–off switch shall be provided in each cabinet. A circuit breaker/contactor with thermal overload device for controlling the AC auxiliary supply shall be provided.

(b) Terminal Blocks

(1.) The terminal blocks to be provided shall be fully enclosed with removable covers & made of molded, non-inflammable plastic material with blocks & barriers molded integrally. The terminal blocks shall be of 650V grade & have 10 A continuous rating. Terminal blocks for current transformer secondary leads shall be provided with test links & isolating facilities. Also current

transformer secondary leads shall be provided with short circuiting & earthing facilities. At least 20% spare terminals shall be provided on each panel & these spare terminals shall be uniformly distributed on all terminal blocks.

(2.) Terminal blocks shall be suitable for connecting the following conductors on each side :

(i.) Current transformer circuits – minimum of two No. of 2.5 sq. mm copper wires each side

(ii.) Other circuits— minimum of one No. of 2.5 sq. mm copper wire each side

(iii.) Terminal blocks numbering shall be made inline with the tender drawing no. 0000-203-PVE-B-001 (Title: "Standard Terminal Numbers for Marshalling Box of all Transformers") enclosed

(c) The temperature indicators shall be so mounted that the dials are not more than 1500 mm from ground level. Glazed door of suitable size shall be provided for convenience of reading.

(d) All incoming cables shall enter the marshalling box from the bottom. A removable undrilled gland plate shall be provided at the bottom of the box for accommodating glands for Employer's incoming and outgoing cables, which shall not be less than 450 mm from finished floor level.

(e) All devices and terminal blocks inside the marshalling box shall be clearly identified by symbols corresponding to those used on applicable schematic or wiring diagram.

(f) It shall be located in such a way that, the same shall not face towards the transformer.

(g) The gland plate shall be made into two detachable halves, for facilitating the termination of Employer's cable and Contractor's cables separately. The gland plate and the associated compartment shall be sealed in a suitable manner to prevent the ingress to moisture, rodents, insects etc.

(h) One dummy terminal block in between each trip wire terminal shall be provided.

(i) Wiring Scheme shall be engraved in a plate and the same shall be fixed inside the Marshalling Box door.

3.08.00 Control Wiring & Cabling

Supply, laying & termination of all cables & accessories required of proper termination from the M. Box except for those stated under next clause below so as to make equipment complete & functional shall be in scope of supplier. The cable between the M. Box & transformer shall be laid by the supplier through GI conduits/ pipes. Cable box / sealing end shall be suitable for following types of cables

1)	415 V power	1100 V grade PVC insulated aluminum conductor cable with armour.
2)	Control	1100 V grade PVC insulated 2.5 sq. mm stranded copper

		conductor with armour.

3.09.00 PAINTING

Painting of transformer and its accessories shall be in accordance with the following chart.

	PARTS NAME	TYPE OF PAINT	No.of Coats	Total DFT
(1.)	Inside of tank and accessories (except M Box)	Oil & heat resistant fully glossy white	One coat	Atleast 30 micron
(2.)	External surface of transformer and accessories (except radiator)	Chemical resistant epoxy zinc phosphate primer, MIO (Micaceious iron oxide) as intermediate paint followed by polyurethane finish paint of blue colour corresponding to RAL 5012.	One coat each	Atleast 100 micron
(3.)	External radiator surface	Anticorrosive primary paint followed by high quality full glossy outer finish paint (blue colour corresponding to RAL 5012.)	Two coats each	Atleast 100 micron
(4.)	Internal radiator surface	Hot oil proof, low viscosity varnish and subsequent flushing with transformer oil		

3.10.00 Cooling Equipment

The radiators shall be detachable type, mounted on the tank. Each radiator shall be provided with the following:

(a) A drain plug at the bottom.

(b) An air release plug at the top.

3.11.00 TAP CHANGER DEVICE

3.11.00 Off Circuit Tap change Switch

(a) The tap change switch shall be three phase, hand operated for simultaneous switching of similar taps on the three phases by operating on external hand wheel.

(b) The tap changing shall be possible without disturbing the transformer in any way except de-energising.

(c) Arrangement shall be made for securing and pad-locking the tap changer in any of the working positions, and it shall not be possible for setting or padlocking it in any

intermediate position. An indicating device shall be provided to show the tap in use.

(d) The Cranking device for manual operation of the off circuit tap changing gear shall be removable and suitable for operation by a man standing on ground level. The mechanism shall be complete with the following:-

(i.) Mechanical tap position indicator which shall be clearly visible from near the transformer.
(ii.) Mechanical stops to prevent over cranking of the mechanism beyond the extreme tap positions.
(iii.) The manual operating mechanism shall be labeled to show direction of operation for raising the secondary voltage and vice versa.
(iv.) A warning plate indicating "The switch shall be operated only when the transformer has been de-energised" shall be fitted.

3.12.00 VALVES

(a) 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. They shall be of full way type with internal screw and shall open when turned counter clockwise when facing the hand wheel.

(b) Suitable means shall be provided for locking the valves in the open and close positions. Provision is not required for locking individual radiator valves.

(c) Each valve shall be provided with the indicator to show clearly the position of the valve.

(d) Gland packing/gasket material shall be of teflon rope/nitrile rubber. In case of gate/globe valves, gland packing preferably of teflon rope shall be used to prevent oil seepage through the gland.

(e) After testing, inside surface of all cast iron valves coming in contact with oil shall be applied with one coat of oil resisting paint/varnish with two coats of red oxide zinc chromate primer followed by two coats of fully glossy finishing paint conforming to IS:2932 and of a shade (Preferably red or yellow) distinct and different from that of main tank surface. Outside surface except gasket setting surface of butterfly valves shall be painted with two coats of red oxide zinc chromate conforming to IS:2074 followed by two coats of fully glossy finishing paint.

(f) All hardware used shall be cadmium plated/electro galvanised.

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

3.13.00 Neutral Grounding Resistors (If applicable)

The earthing resistors are required for LV neutral point earthing of the various transformers. (as specified elsewhere in this specification)

(a) Resistor Elements

The resistors shall be of punched stainless steel grid element type. The grids shall be securely supported at sufficient number of points so that no damage is caused to the grids due to vibrations and no mechanical stresses are developed. The resistor element shall be insulated from supporting base by mica tubes. The insulating material used in the construction shall be heat resistant such as mica.

(b) Stacking

Various sections comprising the neutral grounding resistor shall be capable of being stacked one above the other. The insulators supporting the resistor assemblies shall be of outdoor type. Connecting links shall be provided to connect adjacent stacks.

(c) Enclosure

The neutral grounding resistor shall be housed in a 2.5 mm thick sheet steel enclosure. The enclosure shall be weather proof having IP 33 degree of protection in accordance with IS: 13947. The resistor neutral side terminal shall be brought out on the roof and the ground side terminal at the side of the enclosure through porcelain bushings. The ground side terminal shall be brought to ground level by a copper flat supported from the mounting structure by porcelain insulators. The copper bar shall have two (2) bolted neutral grounding terminals with hole size suitable for M10 bolt size and necessary accessories for connecting to ground mat through two MS 'flats'. The enclosure shall be supported on insulators placed on the mounting structure.

(d) Mounting Structure

The Contractor shall supply and erect a galvanized structure to support the NG resistor enclosure so that the base of the enclosure shall be at a minimum height of 2.4M above ground level. The NG resistor enclosure mounting and the neutral connection shall be such that it does not obstruct the busduct routing in any way.

A heating circuit with Thermostat to be provided inside the enclosure to control humidity.

3.14.00 Bolts & Nuts

All bolts & nuts exposed to weather shall be hot dip galvanised steel /cadmium plated steel.

3.15.00 Gasket

The gaskets shall not deteriorate during the life of transformer if not opened for maintenance at site. Supplier shall also recommend quality & make of gaskets to be used for replacement during maintenance if required. 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.

4.00.00 FITTINGS

4.00.00 The following fittings shall be provided with each transformer covered in this specification:

1) Conservator for main tank with oil filling hole and cap, isolating valves, drain valve, magnetic oil level gauge with low level alarm contacts and dehydrating cobalt free non-carciogenic indicating type silica gel breather with transparent enclosure. Breather for conservators shall be mounted not more than 1400 mm above rail top.
2) Oil preservation system: - as specified elsewhere.
3) Minimum two Nos. of spring operated pressure relief devices with alarm/trip contacts for transformer of 2 MVA & above rating. Discharge of PRD shall be properly taken through pipes & directed away from the transformer /other equipment.
4) Buchholz relay double float type with isolating valves on both sides, bleeding pipe with Gas collecting device at the end to collect gases and alarm and trip contacts. Control cable termination at Buchhloz relay shall be properly sealed to prevent water entry.
5) Air release plug.
6) Inspection openings and covers.
7) Bushing with metal parts and gaskets to suit the termination arrangement.
8) Cover lifting eyes, transformer lifting lugs, jacking pads, towing holes and core and winding lifting lugs.
9) Protected type Mercury or alcohol in glass thermometer.
10) Bottom and top filter valves with threaded male adapters, bottom Sampling valve & drain valve.
11) Rating and diagram plates on transformers (English & Hindi) and auxiliary apparatus.
12) Radiator as specified.
13) Prismatic/toughened glass oil gauge for transformers.
14) 150 mm dial type oil temp indicator with alarm and trip contacts, maximum reading pointer & resetting device. Accuracy class shall be ± 1.5 % or better.
15) 150-mm dial type Winding temp indicator with alarm and trip contacts, maximum reading pointer & resetting device. Accuracy class shall be ± 1.5 % or better.
16) Flanged bi-directional wheels.
17) Marshalling Box.

18) Off load tap changing gear
19) Cooling equipment.
20) Bushing current transformers.
21) Insulating oil.
22) Drain valves/plugs shall be provided in order that each section of pipe work can be drained independently. Sludge valve at bottom most point of tank to be provided for easy flush out/removal of sludge during maintenance.
23) Terminal marking plates.
24) Valves schedule plates.
25) Two (2) earthing terminals on all the equipment mounted separately suitable for connection to suitable GI flat along with 2 Nos. tapped holes. M10 bolts etc.
26) Rain hoods to be provided on Buchholz, MOG & PRD. Entry points of wires shall be suitably sealed.

4.01.00 The fittings listed above are only indicative and other fittings, which generally are required for satisfactory operation of the transformer, are deemed to be included.

5.00.00 INSPECTION AND TESTING

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.

d) The type test reports once approved for any projects shall be treated as reference. For subsequent projects of NTPC, an endorsement sheet will be furnished by the manufacturer confirming similarity and "No design

Change". Minor changes if any shall be highlighted on the endorsement sheet.

Type and Routine tests

Routine Tests

Sr. No.	Routine Tests	OIL FILLED OUTDOOR TRANSFORMER
1	All routine test in accordance with IEC 60076 shall be carried out in all the transformers.	√
2	Measurement of Voltage Ratio	√
3	Measurement of winding resistance on HV & LV on all the taps (as per IEC 60076-1)	√
4	Vector group and Polarity Check (as per IEC 60076-1)	√
5	Magnetic Balance Test	√
6	Measurement of no load current with 415 V, 50 Hz AC supply	√
7	Measurement of no load losses and current at 90%, 100% & 110% of rated voltage (as per IEC 60076-1)	√
8	Impedance & Load Loss Measurement on principal, Max & Min. Taps	√
9	IR measurement (As per IEC 60076-1)	√
10	Dielectric tests shall be carried out as per IEC 60076-3.	√
11	Separate Source Voltage Withstand Test (As per IEC 60076-3)	√
12	Induced Over Voltage Withstand test as per IEC 60076-3	√
13	Repeat no load current/loss measurement & IR measurement after completion of all dielectric test	√
14	Measurement of capacitance & tan delta to determine capacitance between winding & earth. (As per IEC 60076-1),also see note (iv)	√
15	Oil leakage test	√
16	Jacking test followed by D.P. test	√
17	Marshalling Box/Cable box: It shall not be possible to insert a thin sheet of paper under gaskets and through enclosure joints.	√
18	IR measurement on wiring of Marshalling Box.	√
	Type Tests	
19	Dynamic Short circuit test (special test) as per IEC 60076-5.	√
20	Temp. rise test at a tap corresponding to maximum losses. DGA 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).	√
21	Lightning impulse (Full & Chopped Wave) test on windings	√
22	Lightning impulse test on Neutral	√ (refer note iii)
24	Measurement of acoustic noise level as per NEMA TR-1 (special test)	√

Note:

i) (√) mark indicates that the test to be carried out.
(x) mark indicates that the test need not be carried out.

ii) All the type tests shall be conducted after short circuit test. If Tank Vacuum & Pressure Test is to be carried out then it shall be conducted before SC test.

iii) Applicable on transformer neutral connected with NGR.

iv) For outdoor transformer the limiting value of tan delta shall be 1.0% @ 20 deg C.

5.00.00 Type tests on Components

Type test reports shall be submitted for following:

(a) Tank Vacuum & Pressure Test

(b) Neutral Grounding resistors

5.01.00 TANK TEST

(a) Routine test

Oil leakage test on assembled transformer

All tank & 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 & applying pressure equal to the normal pressure plus 35 KN/sq. m measured at the base of the tank. The pressure shall be maintained for a period of not less than 6 hours during which time no sweating shall occur. This test shall be done on completely assembled transformer.

(b) Type Tests

Vacuum Test

Each type of transformer tank shall be subjected to the vacuum test as per CBIP norms.

Pressure Test

Transformer tank of each type shall be subjected to a pressure test as per CBIP norms.

5.02.00 NGR Testing

(a) The following routine tests shall be conducted on each resistor covered in this package.

(1.) Ohmic resistance value measurement Insulation resistance measurement before & after HV test

(2.) HV test for 1 min. at a voltage corresponding to the insulation level of the resistor.

(b) DOP test on enclosure (routine test) as follows.

It shall not be possible to insert a 2.5mm dia. steel wire into the enclosure from any direction without using force.

Type tests

Type test reports shall be submitted for following:

(a) Short time current test along with temperature rise test.

(b) Degree of protection test for IPX3.

5.03.00 Pre-shipment Checks at Manufacture's Works

(a) Check for interchangeability of similar transformers for mounting dimensions.

(b) Check for proper packing and reservation of accessories like radiators, bushings, dehydrating breather, rollers, Buchhloz relay, fans, control cubicle, connecting pipes, conservator etc.

(c) Check for proper provision for bracing to arrest the movement of core and winding assembly inside the tank.

5.04.00 Inspection and Testing at Site

The Contractor shall carry out a detailed inspection and testing program for field activities covering areas right from the receipt of material stage up to commissioning stage. An indicative program of inspection as envisaged by the Employer is given below. This is however not intended to form comprehensive program, as it is contractor's responsibility to draw up and carry out such a program duly approved by the Employer. Testing of oil sample at site shall be carried out as specified elsewhere in this specification.

5.05.00 Receipt and Storage Checks

Following checks as detailed out in finalized/agreed FQP shall be followed.

(a) Check and record condition of each package, visible parts of the transformer etc. for any damage.

(b) Visual check for wedging of core and coils before filling up with oil and also check conditions of core and winding in general, if transformer filled with N2/dry air.

5.06.00 Installation Checks

(a) Inspection and performance testing of accessories like tap changers etc.

(b) Check whole assembly for tightness, general appearance etc.

(c) Check oil sample.

(d) Leakage test on bushing before erection, if bushing is transported separately.

(e) Capacitance & tan delta measurement of condenser bushing before fixing / connecting to the winding, contractor shall furnish these values for site reference.

5.07.00 Commissioning Checks

(a) Check the colour of silica gel in silicagel breather.

(b) Check the oil level in the breather housing, conservator tanks, cooling system, condenser-bushing etc.

(c) Check the bushing for conformity of connection to the lines etc. and tan delta test for bushing.

(d) Check for correct operation of protection devices and alarms:

(i.) Buchhloz relay.

(ii.) Excessive winding temperature

(iii.) Excessive oil temperature

(iv.) Low oil level indication

(v.) Pressure relief valve

(e) Check for the adequate protection on the electric circuit supplying the accessories.

(f) Check resistance of all windings on all steps of the tap changer.

(g) Insulation resistance measurement for the following:

(i.) Control wiring.

(ii.) Main windings

(iii.) Tank & turret mounted CT's

(h) Check for cleanliness of the transformer and the surroundings.

(i) Check the following

(i.) Buchholz, oil level indicator, pressure gauges, temp indicators etc. for fitting & operation.
(ii.) Earthing of main tank, marshaling Box, tap changer driving gear, cable box, fan motor etc.
(iii.) Neutral earthing
(iv.) Calibration of WTI and OTI
(v.) Earthing of bushing test tap
(vi.) Connection of WTI CT with its heater
(vii.) Tightness of CT secondary connection and shorting of unused CTs
(viii.) All valves for their correct opening and close sequence

(j) Phase out and vector group test.

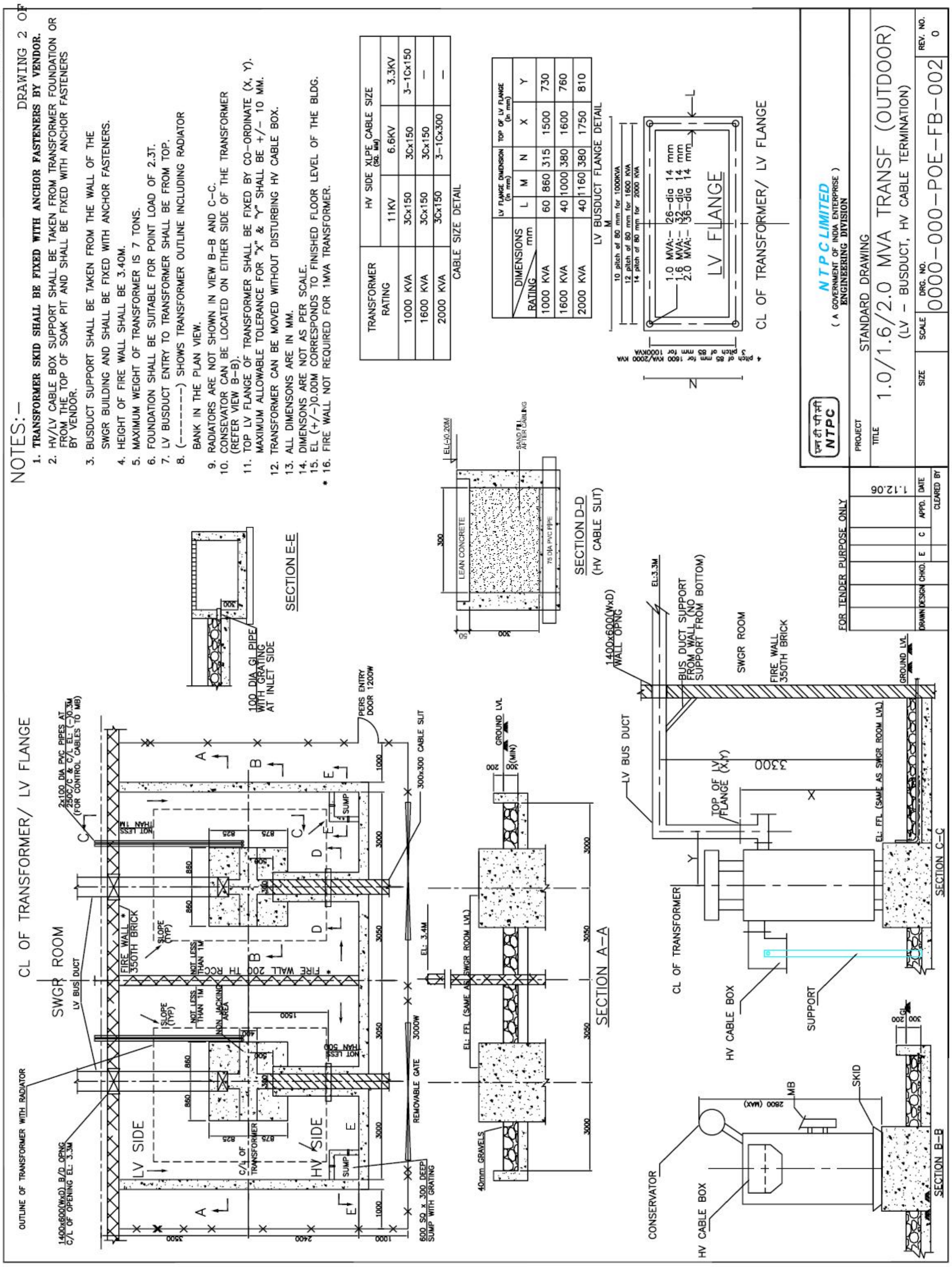
(k) Ratio test on all taps.

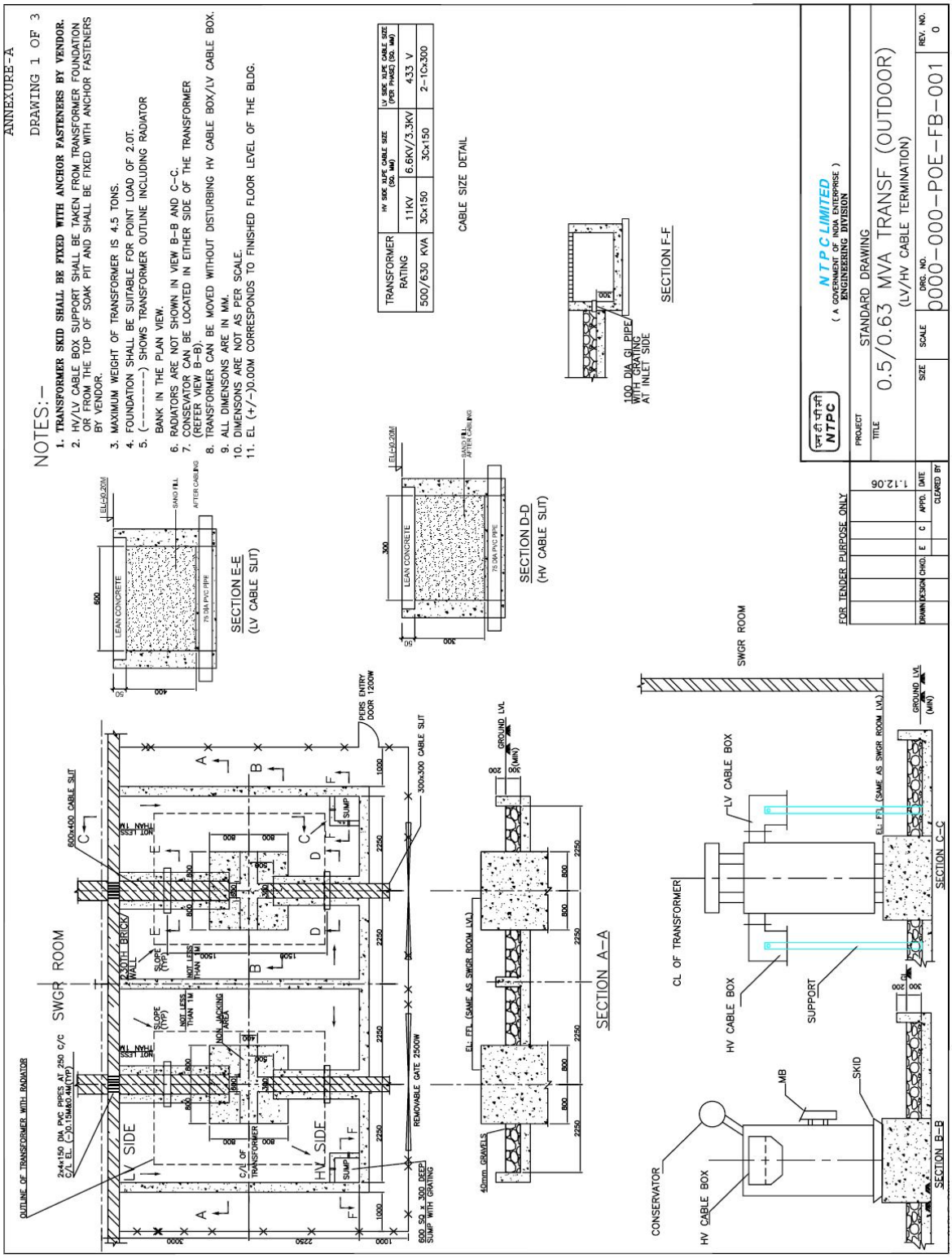
(l) Magnetizing current test (HV winding & LV winding).

(m)	Capacitance and Tan delta measurement of winding
(n)	Oil Dielectric strength test-the various test on oil shall be conducted prior to filling in main tank at site & prior to energization at site as specified elsewhere in this specification. Oil samples are to be drawn from top & bottom of main tank & cooling system.
(o)	DGA of oil before commissioning
(p)	Magnetic balance test
(q)	Short circuit impedance measurement
(r)	Test on tank/turret mounted CT's (i.) IR value between secondary winding & earth and between windings (ii.) Secondary resistance (iii.) Polarity (iv.) Ratio test (v.) Magnetization current
(s)	WTI and OTI setting for alarm/trip, fan start/stop (if applicable) and pump start/stop (if applicable).
(t)	Final IR Value (i.) HV/E+LV (ii.) LV/E+HV (iii.) HV/LV
(u)	Continuously observe the transformer operation at no load for 24 hrs. w.r.t. Voltage, no load current, temperature rise and noise.
(v)	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.

6.00.00 Bidder may refer enclosed standard tender drawings as mentioned below for LT Outdoor transformers upto and including 2 MVA rating with appropriate primary and secondary voltage level (as mentioned in the drawings).

	Drawing title	**Drawing No.**
a.)	1.0/1.6/2.0 MVA Transformer (Outdoor)	0000-000-POE-FB-002
b.)	0.5/0.63 MVA Transformer (Outdoor)	0000-000-POE-FB-001
c)	Standard Terminal Numbers for Marshalling Box	0000-203-PVE-B-001


ANNEXURE-A
DRAWING 2 OF 3
NOTES:-
1. TRANSFORMER SKID SHALL BE FIXED WITH ANCHOR FASTENERS BY VENDOR.
2. HV/LV CABLE BOX SUPPORT SHALL BE TAKEN FROM TRANSFORMER FOUNDATION OR FROM THE TOP OF SOAK PIT AND SHALL BE FIXED WITH ANCHOR FASTENERS BY VENDOR.
3. BUSDUCT SUPPORT SHALL BE TAKEN FROM THE WALL OF THE SWGR BUILDING AND SHALL BE FIXED WITH ANCHOR FASTENERS.
4. HEIGHT OF FIRE WALL SHALL BE 3.40M.
5. MAXIMUM WEIGHT OF TRANSFORMER IS 7 TONS.
6. FOUNDATION SHALL BE SUITABLE FOR POINT LOAD OF 2.3T.
7. LV BUSDUCT ENTRY TO TRANSFORMER SHALL BE FROM TOP.
8. (-------) SHOWS TRANSFORMER OUTLINE INCLUDING RADIATOR BANK IN THE PLAN VIEW.
9. RADIATORS ARE NOT SHOWN IN VIEW B-B AND C-C.
10. CONSEVATOR CAN BE LOCATED ON EITHER SIDE OF THE TRANSFORMER (REFER VIEW B-B).
11. TOP LV FLANGE OF TRANSFORMER SHALL BE FIXED BY CO-ORDINATE (X, Y). MAXIMUM ALLOWABLE TOLERANCE FOR "X" & "Y" SHALL BE +/- 10 MM.
12. TRANSFORMER CAN BE MOVED WITHOUT DISTURBING HV CABLE BOX.
13. ALL DIMENSONS ARE IN MM.
14. DIMENSONS ARE NOT AS PER SCALE.
15. EL (+/-)0.00M CORRESPONDS TO FINISHED FLOOR LEVEL OF THE BLDG.
* 16. FIRE WALL NOT REQUIRED FOR 1MVA TRANSFORMER.
TRANSFORMER RATING | HV SIDE XLPE CABLE SIZE (SQ. MM) 11KV | 6.6KV | 3.3KV
1000 KVA | 3Cx150 | 3Cx150 | 3-1Cx150
1600 KVA | 3Cx150 | 3Cx150 | —
2000 KVA | 3Cx150 | 3-1Cx300 | —
CABLE SIZE DETAIL
DIMENSIONS mm / RATING | LV FLANGE DIMENSION (in mm) L | M | N | TOP OF LV FLANGE (in mm) X | Y
1000 KVA | 60 | 860 | 315 | 1500 | 730
1600 KVA | 40 | 1000 | 380 | 1600 | 760
2000 KVA | 40 | 1160 | 380 | 1750 | 810
LV BUSDUCT FLANGE DETAIL
10 pitch of 80 mm for 1000KVA
12 pitch of 80 mm for 1600 KVA
14 pitch of 80 mm for 2000 KVA
1.0 MVA:- 26-dia 14 mm
1.6 MVA:- 32-dia 14 mm
2.0 MVA:- 36-dia 14 mm
LV FLANGE
CL OF TRANSFORMER/ LV FLANGE
OUTLINE OF TRANSFORMER WITH RADIATOR
SWGR ROOM
LV BUS DUCT
1400x600(WxD) B/D OPNG
C/L OF OPENING EL: 3.3M
2x100 DIA PVC PIPES AT 250C/C & C/L EL: (-)0.3M (FOR CONTROL CABLES TO MB)
FIRE WALL * 350TH BRICK
FIRE WALL 200 TH RCC
LV SIDE
HV SIDE
C/L OF TRANSFORMER
NOT LESS THAN 1M
NON JACKING AREA
SUMP
PERS ENTRY DOOR 1200W
REMOVABLE GATE 3000W
300x300 CABLE SLIT
600 SQ x 300 DEEP SUMP WITH GRATING
100 DIA GI PIPE WITH GRATING AT INLET SIDE
SECTION E-E
LEAN CONCRETE
SAND FILL AFTER CABLING
75 DIA PVC PIPE
SECTION D-D
(HV CABLE SLIT)
40mm GRAVELS
EL: FFL (SAME AS SWGR ROOM LVL)
EL: 3.4M
GROUND LVL
SECTION A-A
CONSERVATOR
HV CABLE BOX
MB
SKID
SECTION B-B
CL OF TRANSFORMER
LV BUS DUCT
1400x600(WxD) WALL OPNG
EL:3.3M
BUS DUCT SUPPORT FROM WALL (NO SUPPORT FROM BOTTOM)
TOP OF LV FLANGE (X,Y)
SWGR ROOM
FIRE WALL 350TH BRICK
SUPPORT
SECTION C-C
FOR TENDER PURPOSE ONLY
1.12.06
NTPC
N T P C LIMITED
(A GOVERNMENT OF INDIA ENTERPRISE)
ENGINEERING DIVISION
PROJECT
STANDARD DRAWING
TITLE
1.0/1.6/2.0 MVA TRANSF (OUTDOOR)
(LV - BUSDUCT, HV CABLE TERMINATION)
DRG. NO. 0000-000-POE-FB-002
REV. NO. 0


ANNEXURE-A
DRAWING 1 OF 3
NOTES:-
1. TRANSFORMER SKID SHALL BE FIXED WITH ANCHOR FASTENERS BY VENDOR.
2. HV/LV CABLE BOX SUPPORT SHALL BE TAKEN FROM TRANSFORMER FOUNDATION OR FROM THE TOP OF SOAK PIT AND SHALL BE FIXED WITH ANCHOR FASTENERS BY VENDOR.
3. MAXIMUM WEIGHT OF TRANSFORMER IS 4.5 TONS.
4. FOUNDATION SHALL BE SUITABLE FOR POINT LOAD OF 2.0T.
5. (--------) SHOWS TRANSFORMER OUTLINE INCLUDING RADIATOR BANK IN THE PLAN VIEW.
6. RADIATORS ARE NOT SHOWN IN VIEW B-B AND C-C.
7. CONSEVATOR CAN BE LOCATED IN EITHER SIDE OF THE TRANSFORMER (REFER VIEW B-B).
8. TRANSFORMER CAN BE MOVED WITHOUT DISTURBING HV CABLE BOX/LV CABLE BOX.
9. ALL DIMENSONS ARE IN MM.
10. DIMENSIONS ARE NOT AS PER SCALE.
11. EL (+/-)0.00M CORRESPONDS TO FINISHED FLOOR LEVEL OF THE BLDG.
TRANSFORMER RATING
HV SIDE XLPE CABLE SIZE (SQ. MM)
LV SIDE XLPE CABLE SIZE (PER PHASE) (SQ. MM)
11KV
6.6KV/3.3KV
433 V
500/630 KVA
3Cx150
3Cx150
2-1Cx300
CABLE SIZE DETAIL
SECTION E-E
(LV CABLE SLIT)
SECTION D-D
(HV CABLE SLIT)
SECTION F-F
100 DIA GI PIPE WITH ELBOW AT INLET SIDE
SWGR ROOM
LV SIDE
HV SIDE
OUTLINE OF TRANSFORMER WITH RADIATOR
2x4x150 DIA PVC PIPES AT 250 c/c C/L EL. (-)0.15M&0.4M(TYP)
600x400 CABLE SLIT
300x300 CABLE SLIT
PERS ENTRY DOOR 1200W
REMOVABLE GATE 2500W
900 SQ x 300 DEEP SUMP WITH GRATING
C/L OF TRANSFORMER
SECTION A-A
SECTION B-B
SECTION C-C
LV CABLE BOX
HV CABLE BOX
CL OF TRANSFORMER
SUPPORT
MB
SKID
CONSERVATOR
GROUND LVL (MIN)
EL. FFL (SAME AS SWGR ROOM LVL)
NTPC LIMITED
(A GOVERNMENT OF INDIA ENTERPRISE)
ENGINEERING DIVISION
FOR TENDER PURPOSE ONLY
PROJECT
STANDARD DRAWING
TITLE
0.5/0.63 MVA TRANSF (OUTDOOR)
(LV/HV CABLE TERMINATION)
SIZE
SCALE
DRG. NO.
0000-000-POE-FB-001
REV. NO.
0

ANNEXURE-

DRAWING 3

Terminal No.	Description	Remarks
T-01	230V, Single Phase, 50Hz, AC Supply	
T-02		
T-03	MOG (Oil Level) Alarm	
T-04		
T-05	Buchholz Relay Alarm	
T-06		
T-07	Buchholz Relay Trip	
Dummy		
T-08		
T-09	PRV-1 Alarm	If applicable
T-10		
T-11	PRV-1 Trip	
Dummy		
T-12		
T-13	PRV-2 Alarm	
T-14		
T-15	PRV-2 Trip	
Dummy		
T-16		
T-17	OTI Alarm	
T-18		
T-19	OTI Trip	
Dummy		
T-20		
T-21	WTI-1 Alarm	
T-22		
T-23	WTI -1 Trip	
Dummy		
T-24		
T-25	WTI-2 Alarm	If applicable
T-26		
T-27	WTI -2 Trip	
Dummy		
T-28		
T-29	Neutral CT (for 64-REF Protection)	If applicable
T-30		
T-31	Neutral CT (for 51N-Earth Fault Protection)	
T-32		
T-33	CT Shorting Terminal	
T-34	CT Shorting Terminal	
T-35	WTI 1-CT	
T-36		
T-37	CT Shorting Terminal	
T-38	WTI 2-CT	If applicable
T-39		
T-40	CT Shorting Terminal	
T-41	Spare Terminals for NTPC use	
T-42		
T-43		
T-44		
T-45		
T-46		
T-47		
T-48		

Notes:

1 The Terminals from T-01 to T-48 shall be designated as indicated in the chart for all outdoor transformers (upto 16MVA)

2 The Terminals which are not used for a particular Transformer shall be left as spare. e.g. in case there is only one WTI alarm & trip, then terminals T-25 to T-28 & T-38 to T-40 shall be left as spare terminals.

Title:	Standard Terminal Numbers for Marshalling Box of all Transformers
Drawing No:-	0000-203-PVE-B-001

1.00.00 DRY TYPE TRANSFORMER (LT INDOOR)

Sr. No.	PARAMETERS	INDOOR TRANSFORMER
a)	Type	Epoxy cast resin/resin encapsulated
b)	Service	INDOOR
c)	MVA & Voltage ratio	1.6 MVA, 6.6/0.433 kV
d)	Vector group	Dyn1
e)	Impedance	8%
f)	Tap changer type & range	As per system requirement
g)	SC withstand time & Fault Level	As per system requirement
h)	Termination	As per system requirement
i)	Number of phases	Three (3)
j)	Type of cooling	**AN** Additionally Transformer shall be provided with fans/blowers (with 100 % standby) for forced air cooling however all tests and performance guarantee shall correspond to air natural (AN) cooling.
k)	Duty	Continuous
l)	Insulation level	As per chapter B-0, Part-B
m)	Maximum Temperature rise of winding over 50 deg. C ambient. (by resistance method)	**70** deg.C
n)	Earthing	Solidly earthed via cu flat./ As per system requirement
o)	Noise Level	Not to exceed values specified in NEMA TR-1.
p)	PD Level for HV coil (max.)	20 pc
q)	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.
r)	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.

2.00.00 CODES AND STANDARDS

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

3.00.00 DESIGN AND CONSTRUCTIONAL FEATURES

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.

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.

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

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

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

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.

4.00.00 **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.

5.00.00 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.	

6.00.00 TESTING REQUIREMENTS

A) The contractor shall carry out the type tests as listed in this specification on the equipment to be supplied under this contract. The contractor 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.

B) The type tests shall be carried out in presence of the employer's representative, for which minimum 15 day notice shall be given by the contractor.

C) 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.

D) 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.

E) All routine tests in accordance with IS: 11171 shall be carried out on each transformer. Type Test shall be carried out on 1 transformer of each rating.

F) 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.

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.

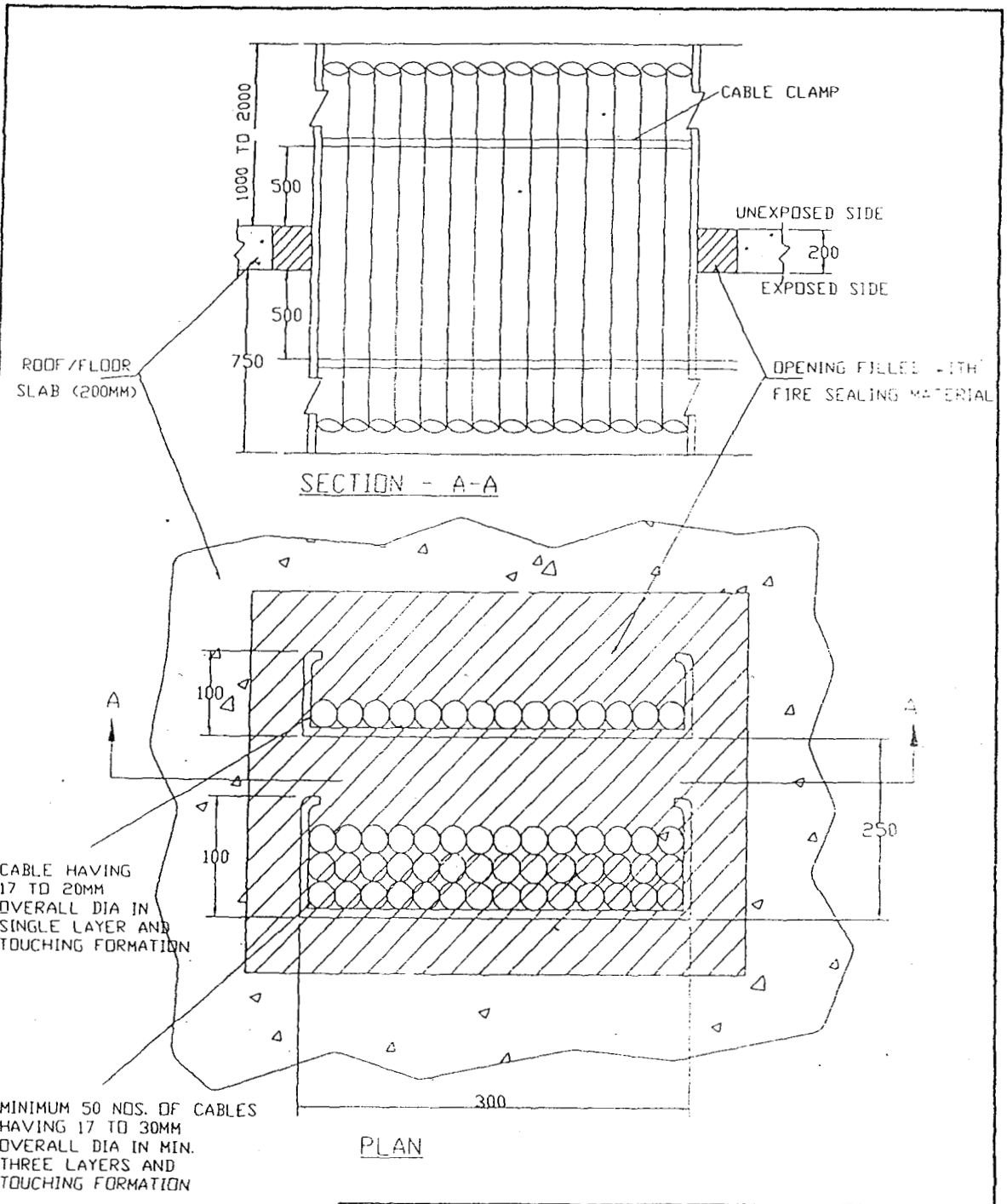
   During the test the specimen shall meet all the three criteria simultaneously.

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	M	E	C	C&I	ARCH	APPD	DATE
		CLEARED BY									
RB	FOR TENDER PURPOSE	NJ			-		-	-	-		15/7/04
RA	FOR TENDER PURPOSE	NJ			-		-	-	-		17.1.2004

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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	$0\text{-}50^{0}$ 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.

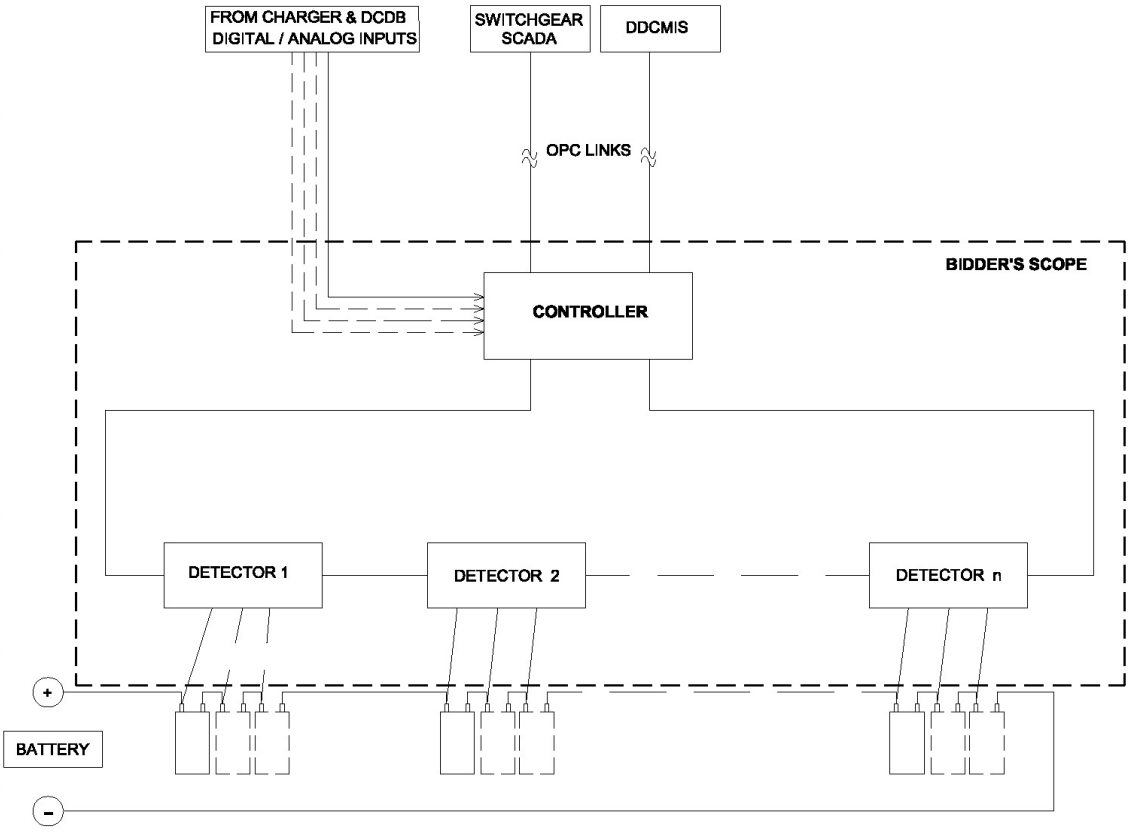
DC FAIL alarm shall be generated and given in Control Room buzzer (Audio Visual Fascia).

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
11.00.00



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

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 visibility 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.