

**Design, Build and Commissioning of 7 MLD
Common Effluent Treatment Plant (CETP) and
0.5 MLD Package Sewage Treatment Plant (STP)
at DPIA on EPC basis with 4 years Operation and
Maintenance -Package B**

VOLUME 3

PART 2 GENERAL ELECTRICAL SPECIFICATIONS

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1. INTRODUCTION

1.1 Purpose

- a) The purpose of this document is to include general electrical requirements for Sewage treatment plant and Common effluent treatment plant.
- b) Requirements that are particular to the installation are elaborated in the Electrical Technical Specifications.

1.2 Scope

- a) This Specification covers the general and overall requirements for design, manufacturing, construction, storage and deliver to site as well as installation and test of the electrical power supply system for the “Sewage treatment plant and Common effluent treatment plant.” at Dighi Location and shall be read in conjunction with all other documents of any Contract requirements or Electrical Specification, or both. The clauses in this Specification are applicable in varying degrees to each and every part of the Works. This Specification applies to the entire Works, whether on the Site or in yards, workshops, and factories employed elsewhere in connection with the Works.
- b) This Specification covers – Power Transformers, Medium Voltage Switchgear, Low-Voltage Switchgear, Low-Voltage Motor Control Centre, Standby Generators, Cables, Lighting and Motors etc.

1.3 Objective

- a) The electrical system design comprises the calculation of electrical load requirements of various electrically operated equipment based on load requirement during average and peak flows.
- b) The electrical equipment should be designed to take care of various functional requirements of the equipment like inclusive but not limited to screens, pumps, cranes, and utilities inclusive but not limited to office building, internal / external lighting and all other building services.
- c) Appropriate level of automatic and manual operation shall be considered for system operation.
- d) Spare and future feeders and terminals shall be provided as per system requirement.
- e) Diesel engine generator shall be provided for backup operation of STP and CETP.
- f) Consideration of Rooftop Off Grid Solar system for Lighting & HVAC. Rooftop Solar Panels shall be installed on Chemical house, Blower Room, MCC Room, Admin Building, Pump houses etc.

2. GENERAL REQUIREMENTS

2.1 Design Criteria

For electrical design and construction of Power Supply System in STP and CETP, following design criteria to be followed-

Description	Voltage Level
Incoming power supply to Plant	AC, 11 kV, 3 Phase, 3 Wire, 50 Hz
Low Voltage level at Plant	AC, 415/240 V AC, 3 Phase / 1 Phase, 50 Hz

Operating System Voltages:

Description	Voltage Levels
MV Switchgear	11 kV, 3 Phase, 3 Wire, 50 Hz
LV Motors upto 200kW (3-phase)	415V, 3 Phase, 4 Wire, 50 Hz
LV Motors (1 Phase)	230 V AC, 1 Phase, 3 Wire, 50 Hz, for motor rated < 0.37 kW
LV Switchboards, lighting and small power distribution boards, power distribution boards	415/230 V AC, 3 Phase / 1 Phase, 4 Wire, 50 Hz, effectively earthed
AC UPS system (including AC distribution board)	230 V AC UPS supply, 1Phase, 2 Wire, 50 Hz
Instrumentation and telecommunication (24V/48V/110V DC users shall be fed from internally derived DC supply)	230 V AC UPS supply, 1Phase, 2 Wire, 50 Hz
Fault Level:	20kA for 11kV System 50kA for 415V System 10kA for 230V System

Control and Protection Voltages:

Description	Voltage Levels
MV Incomer and Outgoing Circuit Breaker's Tripping, Closing, Alarm, Control and Indication (MV Switchgear)	24V DC
Protection Relays in MV Switchgear	24 V DC
Spring Charging Motor of MV Circuit Breakers (MV Switchgear)	24V DC
LV Incomer and Bus-coupler Circuit Breaker's Closing, Tripping, Alarm, Control & Indication (LV Switchgear)	24V DC
Spring Charging Motor of LV Breakers (LV Switchgear)	24V DC
Control supply for Motor Outgoing Feeder (LV Switchgear & MV switchgear)	24V DC

Variation in Supply Voltage and frequency:

Description	% Variation
Supply voltage variation for MV and LV system	±10%
Supply frequency variation for MV and LV system	±5%

Combined voltage and frequency variation	10 % (absolute sum)
Maximum allowable voltage variation at motor terminal during starting or re-acceleration of motors (for LV & MV motors)	+10 % or -15%-
Load Factor	
Motors	0.9
Auxiliary Load (valve actuators, crane etc.)	0.9
Lighting Load	1.0
Diversity Factor:	
Motors	1.2
Auxiliary Load (valve actuators, crane etc.)	1.5
Lighting Load	1.2

2.2 References

2.2.1 General

The design and installation shall be in accordance with established codes, sound engineering practices and shall confirm to the statutory regulations applicable in India.

The main codes, standards and statutory regulations considered as minimum requirements are as given below.

2.2.2 Statutory regulations

MSEDCL Guidelines.

Indian electricity act.

Indian electricity rules.

2.2.3 Codes and standards

IS 13234	Guide for short circuit calculations in three phase AC systems.
IS 12360	Voltage bands for electrical installation including preferred voltages and frequencies
IS 3961	Recommended current ratings for cables
IS 4201	Application guide for CT
IS 3842	Application guide for electrical relays for AC systems
IS 4146	Application guide for VT
IS 10028	Code of practice for selection, installation and maintenance of transformers
IS 1255	Code of practice for installation and maintenance of power cables up to and including 33KV rating
IS 3043	Code of practice for earthing
IS 732	Code of practice for electrical wiring installations
IS 10561	Application guide for power transformer
IS 2309	Code of practice for the protection of buildings and allied structures against lightning
IS 10118	Code of practice for selection, installation and maintenance of

	switch gear and control gear
IS 5216	Guide for safety procedures and practices in electrical work.
IS 9676	Reference Ambient temperature for electrical equipment
IS 8130	Specification for conductors for insulated electric cables and flexible cords
IS 1554	PVC insulated cables
IS 325	Three Phase Induction Motors
IS 4691	Degrees of protection provided by enclosures for rotating electrical machinery
IS 4029	Measurement and guide for testing 3 phase induction Motors
IS 1231	Dimensional of 3 phase foot mounted induction Motors
IEC60076, IS2026, IS1180, IS335	Oil type transformer

2.3 Environmental Condition

All electrical equipment will be rated for 50-degree ambient temperature.

3. ELECTRICAL WORK REQUIRED

3.1 General

- a) All equipment shall be brand new and of make and type having proven track record with at least two years of satisfactory operation in an industry.
- b) All equipment shall be subjected to routine and acceptance tests as per the applicable specifications and all type test certificates shall be submitted as a minimum requirement. The type test certificates for MV and LV system shall not be more than 5 years old at the time of contract award. In case this criterion is not met, then the type tests shall be conducted before delivery of equipment without any additional cost and impact.
- c) Special tools/tackles required for operation and maintenance of equipment shall be included in the lump sum price.
- d) Equipment/ panels installed outdoors in direct sun with shields against the sun.

3.2 Sewage Treatment Plant and Common Effluent Treatment Plant

Electrical Substation with adequate size is to be sited at ground level of treatment plant. There shall be a substation building for the current phase of CETP & STP. The Electrical Substation location shall provide easy access for the installation of equipment such as switchgear, Control Panel from the access road.

4. 11KV MV SWITCHBOARD

4.1 Scope

This section covers the design, manufacturing, testing, inspection, packing and supplying of integrated cubicle type metal clad, floor mounted and draw out type free standing, front operated indoor type 11KV MV switchgear panel as per IS/IEC standards.

4.2 Codes and Standards

MV switchboard shall comply with the following Standards, including those referred to therein. IEC 60044, 60186, 60255, 60265, 60282, 60298, 60466, 60529, 60694, 60787, 62271 IEC/TR2 61211 and IS 9046, 9920, 9921, 13118, 3427, 4237, 2156, 2705, 3156, 10118, 722, 13118.

4.3 General

The switchboards shall be suitable for installation and satisfactory operation in a pressurized Substation with restricted natural air ventilation in a tropical, humid and corrosive atmosphere.

The switchboards shall be designed to operate under site conditions as specified in the data sheets. If not specifically mentioned therein a design ambient temperature of 50°C and altitude not exceeding 1000 meters above mean sea level shall be considered.

4.4 HT Switchboard Components

4.4.1 Circuit Breaker

Circuit breakers shall be vacuum type and of the draw out pattern.

The short circuit fault level of MV Panel shall be obtained from nearest power distribution agency grid station and shall be taken as 350 MVA.

Vacuum breakers shall have completely sealed interrupting units for interruption of arc inside the vacuum. All breakers shall be provided with contact wear gauge and we should be able to measure snatch gap below the interruptible vacuum bottle. It shall be possible to isolate easily the vacuum interrupted unit from the breaker operating mechanism for testing of the interrupter.

Circuit breakers shall be fully rated for the specified ambient temperature 50degree Celsius.

4.4.2 Operating Mechanism for Circuit Breaker

Circuit breakers shall preferably vacuum type. Circuit breaker along with its operating mechanism shall be mounted on a wheeled carriage moving on guides, designed to align correctly and allow easy movement. Plugs and sockets for power circuits shall be silver faced and shall be insulated with suitable insulating material shrouds. All corresponding components of circuit breaker cubicles of same rating shall be interchangeable with one another.

There shall be Service, Test, Fully withdrawn positions for the breakers. In the Test position the circuit breaker shall be capable of being tested for operation without energizing the power circuits, i.e. the control circuits shall remain undisturbed while the power contacts shall remain disconnected. Separate limit switches, each having a minimum of 2 NO + 2 NC contacts shall be provided for both Service and Test positions of the circuit breakers for future SCADA.

Electrical tripping shall be performed by shunt trip coils. Local / Remote|| selector switch lockable in Local position shall be provided on the cubicle door. Red and Green indicating

lamps shall be provided on cubicle door to indicate breaker close and open positions. Breaker Service and Test positions shall be indicated by separate indicating lamps on the cubicle door, in case mechanical indication of Service and Test positions are not available on the cubicle door.

Connection of the control / interlocking circuits between the fixed portion of the cubicle and the breaker carriage shall be preferably by means of plug socket arrangement.

4.4.2.1 Operating Mechanism Control

- Circuit breakers shall be operated by a motor spring charging type of mechanism. The mechanism shall be complete with motor, opening spring, closing spring and all accessories to make the mechanism a complete operating unit
- Operating mechanism shall normally be operated from the breaker cubicle itself.
- The tripping spring shall be charged by the closing action, to enable quick tripping. Closing of the circuit breaker shall automatically initiate recharging of the springs to enable the mechanism to be ready for the next closing stroke. Charging time for the springs shall not exceed 30 seconds. It shall be possible to manually charge the springs in an emergency. Transfer from motor to manual charging shall automatically disconnect the charging motor. All operating mechanisms shall be provided with "ON" "OFF" mechanical indication. The charging mechanism shall be provided with mechanical indicators to show "charged" and "discharged" conditions of the spring. Failure of any spring, vibration or mechanical shock shall not cause tripping or closing of the circuit breaker.
- Only one closing operation of the circuit breaker shall result from each closing impulse (manual or electrical), even if the breaker trips while the control device (manual or electrical) is being held in the "close" position.
- The circuit breaker mechanism shall make one complete closing operation, once the push button (PB) or control switch has been operated and the first device in the control scheme has responded, even though the PB or control switch is released before the closing operation is complete, subject to the condition that there is no counter- impulse for tripping.
- Means shall be provided to manually open and close the breakers slowly, when the operating power is not available, for maintenance and adjustments. A local manual trip device shall also be provided on the operating mechanism.
- Circuit breaker control shall be on 110 V DC. Closing coils and other auxiliary devices shall operate satisfactorily at all voltages between 85-110% of the control voltage. Trip coils shall operate satisfactorily between 70 -110 % the rated control voltage.
- Provision for remote control shall be provided for future SCADA.

4.4.3 Isolator and Earth Switches

Unless otherwise specified isolators and earth switches shall be off-loading and fixed type. For vertical isolation type switch gear integral earthing facility for busbar side (for incomer breaker) or circuit side (for outgoing breaker) shall be provided by breaker transfer

position principle. For horizontal isolation type switch gear earthing should be provided by integral earthing switch or earthing truck for busbar and circuit side. Mechanical and electrical interlocks shall be provided where applicable to ensure that the isolators cannot be operated unless the associated breakers are open.

4.4.4 Interlocks and Safety Devices

The following interlocks shall be provided:

- a) The truck cannot be moved from either test to service position or vice versa, when the circuit breaker is 'ON'.
- b) The circuit breaker cannot be switched 'ON' when the truck is in any position between test and service position.
- c) Front part of the truck cannot be removed when the breaker in 'ON' position.
- d) The low voltage plug and socket cannot be disconnected in any position except test/isolated position.
- e) The truck cannot be moved inside the panel, when the LT plug and socket is disconnected.
- f) Earthing switch cannot be switched 'ON' when the truck is inside the panel.
- g) The truck cannot be inserted when the earthing switch is 'ON'.

4.4.5 Safety Devices

The following Safety devices shall be provided for the safety of the operating personnel:

- a) Individual explosion vents shall be provided for breaker/bus bar/cable chambers on the top of the panel to let out the gases under pressure generated in case of fault inside the panel
- b) Cubicle with front plate to withstand the pressure for internal arc fault as per PEHLA recommendation.
- c) Circuit breaker and sheet metal enclosure shall be fully earthed.
- d) Self-locking shutters shall be provided which shall close automatically when the truck is withdrawn to 'Test position' and no separate padlocking of the shutter shall be required.
- e) Caution name plate, "Caution Live Terminals" shall be provided at all points where terminals are 'Live'.

4.4.6 Earthing Switch

Cable earthing switch shall be provided in the cable chamber and shall be operated from the front of the panel. The ON/OFF position of switch shall be indicated by mechanical indicator. The earthing switch shall be suitably interlocked with the breaker, so that it can be operated only when the breaker is in OFF position.

Earthing switch shall also be provided on bus bar side. The ON/OFF Switch shall be indicated by mechanical indicator. The earthing switch shall be suitably interlocked with

the breaker, so that it can be operated only when the breaker is in OFF position.

4.4.7 Bus Bar Compartment

Bus bars of rectangular cross section of copper conductor supported by cast epoxy insulator to withstand full short circuit currents up to 18.4 KA for one second for 11 KV system shall be provided at the rear. Bus bar chamber shall be provided with inter panel barriers with epoxy cast seal off bushings. Bus bar shall be rated for the maximum temperature of 80 degrees Celsius.

4.4.8 Circuit Earthing Facility

It shall be possible to connect each circuit or set of 3 phase bus bars of the switchboard to earth through earthing switches.

Earthing switches /earthing devices shall be mechanically interlocked with the associated breakers / switch disconnectors to prevent accidental earthing of live circuit or bus bars.

In case the earthing facility comprises earthing trucks to be inserted in place of circuit breakers, separate earthing trucks shall be supplied for each type / size of breaker.

The earthing facilities proposed to be provided by the Contractor shall be clearly detailed in the Bid and shall be subject to Employer or their representative 's approval.

Auxiliary contacts (min. 2 NO + 2 NC) shall be provided on each earth switch /earthing device and shall be wired to the terminal block for interlocking purpose.

4.4.9 Current Transformer

4.4.9.1 General Requirements

Accommodation shall be provided in the circuit breaker panel, to mount one set of dual ratio CT. Access to the CTS for cleaning, testing or changing shall be from the front, back or top of the panel.

4.4.9.2 Rating

Dual ratio CTS of suitable burden (but each not less than 15 VA) shall be preferred with 5 amps secondary or suitable specification. Related document and calculations to be provided by supplier. Instrument Security Factor (ISF) of each CT shall not be more than 5.

The CTs shall conform to relevant Indian Standards. The design and construction shall be dry type, epoxy resin cast robust to withstand thermal and dynamic stresses during short circuits. CT terminals shall be shorting type. Current and voltage circuits shall be laid in separate wire ways. Secondary terminals of CTS shall be brought out to a suitable terminal block which will be easily accessible for terminal connections. Test terminal block shall be provided in the front side of the panel for testing purpose.

CT'S shall have 2 Nos. of cores for following application:

Core -1 for metering

Core -2 for protection

Class of accuracy of each winding

Metering class	1.0
Protection class	5P10
Insulation	E class or better

4.4.10 Potential Transformer

The potential transformers shall be confirming to IS 3156/ IEC 60185. The primary windings of the potential transformers shall be insulated and shall be of the cast rest in type. Potential transformer (PT'S) shall be mounted on a draw out trolley and housed in separate metal compartment and shall have control fuses on the H.V. side and a miniature circuit breaker on the L.V. side of the windings. HT HRC Control fuses shall be confirming to IS – 9385/ IEC 60282. Miniature Circuit breaker shall comply with IS – 8828/ IEC – 60898. Padlocking facilities shall be provided for both service and isolated position.

The potential transformer shall be as specified below:

Ratio	: 11000 / V3 / 110 / V3
Burden	: 100 V A for 100 / V3 and 110 V winding
Class	: CL –1 for both the windings.
Over voltage factor	: 1.2 Continuous

Single phase PT'S shall be used and shall be connected in Star/ Star.

4.4.11 Relays

All relays shall be numeric type microprocessor type. Relays shall be equipped with operation indicator LED's for visual indication. On three phase relays with separate phase elements, each phase element shall have separate indicator with phase identification clearly marked. Output elements of over current, earth fault and other relays shall operate through master tripping electro-mechanical relay. All relays shall be suitable for flush mounting, with only the dust tight covers projecting from the front of the panel. All relays shall be accessible for setting and resetting from the front. Access to setting devices shall be possible only after the front covers of the relays are removed. Resetting facilities shall however be accessible external to the relay case.

All protective relays except auxiliary relays shall be of the draw out type. Where it is not possible to provide protective relays of the draw out pattern due to non-manufacturing range, fixed type relays with facilities for plugging in a portable test plug shall be provided. Necessary test plugs shall be furnished along with the relays. All relays shall be provided with positive action flag indicators visible from the front. No control relay except under voltage relays, which would trip a circuit breaker when de-energized, shall be used.

Following auxiliary relays shall be provided on each breaker cubicle:

- i. Trip circuit supervision relay
- ii. Anti- pumping relay

Hand reset type lockout (tripping) relays and timers shall be provided as required in

addition to the protection relays given in the single line diagram.

Auxiliary relays and timers shall be rated to operate satisfactorily between 70 % and 110 % of the rated voltage.

Voltage operated relays with sufficient contacts to initiate tripping, alarm, annunciation for various trip functions like Buchholz relay operation. Each relay shall have four (4) pairs of self-reset contacts except for Buchholz and "PRD" trip which shall have hand-reset contact. The relays shall have hand-reset operation indicators.

Voltage operated relays with sufficient contacts to initiate alarm and data logging for various alarm functions for transformers, etc. shall be provided. Each relay shall have four (4) normally open self-reset contacts. The auxiliary relay for Buchholz alarm shall be slugged to have delay on drop off at 100ms. The relays shall have hand reset operation indicator.

4.4.12 Protection and Tripping Arrangement

4.4.12.1 Protection

All protection relay shall be numeric type of approved make. The protection and tripping arrangement of circuit breaker shall be:

a) Over Current / Earth Fault Protection

- i. This relay shall be of the multi-characteristics type which has a flexible mode selection facility so that it is possible to select one mode for the overcurrent elements and another for the earth fault element.
- ii. Phase current range shall cover at least 50-300% of in steps of 'In' not more than 10% while the earth current range shall cover at least 5-100% of in steps of not more than 5%.
- iii. The time setting range of the definite time mode shall not be less than 5 seconds in steps of 0.1 second each.
- iv. The time multiplier setting for the inverse time-current characteristic modes shall have a range not less than 0.05- 1.6 in steps of 0.05.
- v. Over current and earth fault relays shall have separate timers and operation indicators.
- vi. The high set element shall have a range of 2 - 15 times the nominal current in steps of 'In' and shall be of low transient overreach, with a tripping time of less than 25ms and possible to be selected on "blocked" position. Reset time shall be not more than 50ms for both elements.
- vii. The relays that are installed on the transformer neutral side shall be of single phase version, but they shall have the same characteristics as the phase side relays.

b) Restricted Earth Fault Protection

- i. The restricted earth fault relay shall be operated from a completely separate core of line and neutral current transformers. The dedicated CTs shall be of class PS

and have the same magnetization characteristics with a knee $_emf'$ value higher than the highest possible setting of the relay. Intermediate CTs for ratio correction are not acceptable. CT sizing shall be matched with the requirements of the relay.

- ii. For this protection, 1-phase high impedance relay shall be provided and all the aspects regarding stability of the protection, dimensioning of current transformer, considering the peak short circuit current, etc. and all the auxiliary equipment such as non-linear VDR resistor for voltage limiting, filter for harmonics and DC component suppression and variable shunt resistor for sensitivity adjustment, if required, shall be provided. The total fault clearing time shall not exceed 20 m sec. at $3 \times I_n$.
- iii. The stability of this protection against out-zone faults shall be confirmed. A calculation to show the proper selection of the relay up to the maximum short circuit of the switchboard shall be submitted.

c) Under Voltage Relays

- i. Suitable voltage operated relays for sensing loss of voltage shall be provided. The relay shall have a drop off to pick up ratio of the order 90%. The relays shall be fast operating type and shall be fitted with operation indication. The indication shall come on drop off or loss of voltage.
- ii. Additional potential free contacts for all the relay outputs i.e. trip as well as alarm signals shall be provided for connection to future SCADA.

d) Motor Protection Relay

- i. It shall be designed to protect the motor against thermal overload, locked rotor, over current and earth fault protection, under voltage, over voltage, phase reversal and negative sequence.
- ii. Thermal setting range shall cover at least 50% to 200% of $_In'$ in steps of not more than 5 % of $_In'$. Phase current range shall cover at least 5-200% of $_In'$ in steps of not more than 1% while the earth current range shall cover at least 1-100% of $_In'$ in steps of not more than 5%.

4.4.13 Control Wiring

The control wiring shall be carried out with minimum 2.5 sq. mm. PVC insulated copper conductor cables. The wiring shall be securely fixed and neatly arranged to enable easy tracing of wires. Identification PVC ferrules shall be fitted to all wire terminals to render easy identification and facilitate checking in accordance with IS 5578 and 11353.

4.4.14 Constructional Features of Switchboard

- a) Metal clad switchgear shall be totally enclosed, dust proof, vermin proof, floor mounted, free standing cubicle type. If necessary louvers with wire mesh shall be provided for ventilation.

- b) The enclosure shall have complete protection against approach to live parts or contact with internal moving parts as per IS: 3427.
- c) Metal clad switchgear cubicle shall comprise rigidly welded structural members, partition covers between panels, Rear/side cover, and partition for LT chamber of 2.0mm CRCA. All front doors of LT chambers and front door for VCB chamber shall be of 2.5mm CRCA. Shutter, Top cover/explosion cover shall be 1.0mm CRCA.
- d) The metal enclosed switchgear shall have separate compartments for the following and all metal enclosures shall be earthed effectively.
 - i. (a) Main Bus bars
 - ii. (b) Current Transformers
 - iii. (c) Voltage Transformers
 - iv. (d) Circuit breaker/isolator
 - v. (e) Power cable termination
 - vi. (f) Controls, metering and relaying devices
- e) All the three compartment i.e. breaker, bus bars and outgoing feeder shall be completely isolated from each other by metal barriers. No incoming section of the breaker, busbar shall be visible in outgoing compartment.
- f) All bus bars shall be sleeved and shrouds shall be provided on joints. Shrouds shall be provided at uncovered portion of bus bars. All breakers and cable compartment shall have 4 nos. barriers. CTs in all incomers, bus couplers and outgoing feeders shall be easily accessible on opening the rear door for easy CT mounting and maintenance. CTs shall not be mounted close to breaker cradle terminals.
- g) Draw out type circuit breakers and all corresponding components of similar type and rating shall be interchangeable with one another. However, circuit breakers of lower ratings and different type shall be prevented from engaging with stationery element of switchgear with higher rating.
- h) Switchgear design shall be fully compartmentalized with separate vertical sections for each circuit. Access to operating mechanism shall be so arranged as not to expose high voltage circuits. Switchgear cubicle shall be provided with hinged doors on the front with facility for padlocking the door handles.
- i) Instruments, relays and control devices shall be flush mounted on the hinged door of the metering compartment located in front portion of the switchgear. Main functioning parts of the switchgear shall be accessible for maintenance from the front side. Breaker cubicle shutter assembly shall be provided with a padlocking facility.
- j) Provision shall be made so that main bus bar can be extended from either end of switchgear, or future extensions. This shall include structure and wire ways for control wiring, earthing, etc.
- k) Switchgear cubicle shall be provided with bottom sheet steel plates of 2mm thick (Min.).

Cubicle shall be fitted with a removable gland plate of sufficient thickness at the bottom of the cubicle for fixing glands for power and control cable termination. Where single core power cables are used, the gland plate shall be of nonmagnetic material.

- l) Ample space shall be provided in each cubicle, to terminate incoming and outgoing cables, in case standard panel depth cannot accommodate the specified no. of cables, a rear extension panel of uniform height shall be provided. Each switchgear cubicle shall be fitted with nameplates and serial number on the front and rear of the cubicle. In addition, switchgear shall be fitted with a nameplate indicating Switchgear designation and rating. All devices shall be provided with separate nameplates to indicate the function and also device numbers as marked in the control wiring diagram. The switchboard shall be supplied complete with supports for clamping outgoing and incoming cables. The minimum clearance between cable gland and terminal lugs shall not less than 600mm.
- m) All insulating material shall be flame resistant, non-hygroscopic and anti-tracking. All hardware used inside switchgear cubicles shall be zinc passivated or cadmium plated. Independent pressure release flaps shall be provided for all HV compartment viz busbar, cable and breaker compartments. Wire guards or mesh shall be provided inside the cable chamber enclosure to allow visual inspection of bus bars, CTs, VTs and cable terminations after opening the cover.

Painting

Oil, grease, dirt and rust from the sheet steel work shall be thoroughly cleaned and removed.

Rust and scale shall be removed by pickling Process with dilute acid and alkaline solution.

This shall be followed by Phosphating and thorough rinsing with clear water followed by final rinsing with dilute dichromate solution and oven drying.

Two coats of ready mixed, stoving type zinc chromate primer shall be applied and stoved.

The final finished thickness of paint film on steel surface shall not be less than 100 microns+ 25 microns.

After application of Primer, two coats of finish epoxy paint shall be applied with each coat followed by stoving. The color shade for the finish paint shall be 631 as per IS 5.

4.4.15 Earthing

A copper earthing bus shall be provided and extended throughout the length of the switchboard. It shall be bolted to the framework of each unit and brazed to each breaker earthing contact bar. It shall be located at the bottom of the board.

The earth bus shall have sufficient cross section to carry the momentary short circuit and short time fault current for at least 1 second or higher as specified, without exceeding maximum allowable temperature rise. The earth bus shall be properly supported to withstand stresses induced by the momentary short circuit current.

Suitable clamp type terminals at each end of the earth bus shall be provided to suit the size of the earthing conductors. Bolted joints, slices, tap, etc. to the earth bus shall be made with at least two bolts.

Positive earthing of circuit breaker frame shall be maintained when it is in the connected position and in all other positions whilst the auxiliary circuits are not totally disconnected.

Hinged doors shall be earthed through flexible earthing braid of adequate cross section. All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus. Positive connection of the frames of all the equipment mounted in the switchboard to the earth busbar shall be maintained through insulated conductors of size equal to the earth bus bar or the load current carrying conductor, whichever is smaller. All instrument and relay cases shall be connected to earth bus bar by means of 1100V grade, green colored, PVC insulated, stranded, tinned copper, 2.5 sq. mm conductor looped through each of the earth terminals.

4.4.16 Annunciators

Annunciators shall be of facia type with translucent plastic window for each alarm point. Annunciator facia plates shall be engraved in block lettering with respective alarm inscriptions. The inscriptions shall be clearly readable and visible when the respective facia light is lighted.

Each annunciation window shall be provided with two lamps to provide redundancy against lamp failure. Lamps shall be replaceable from the front. Lamps shall be of clustered LED type.

All facia annunciator points shall be suitable to accept external contacts of either NO or NC, Self or hand reset type for initiating the annunciation sequence. Annunciators shall be suitable for accepting fleeting faults of duration as less as 15 milliseconds.

For static annunciator schemes, special precautions shall be taken by the Contractor to ensure that spurious alarm conditions do not appear due to influence of external magnetic fields on the annunciator wiring and switching disturbances from the neighboring circuits within the panels / desks.

A Lamp Test push button shall be provided for each individual panel's group of annunciators to limit the sudden drain on the battery.

Provision of testing facilities for flasher and audible alarm circuits of annunciators is desirable. The Contractor shall give the details of the offered scheme.

Annunciators shall have following features:

- Suitable for annunciating subsequent faults immediately after the sound cancel of the previous fault.
- During lamp test, if a fault occurs, the corresponding lamp circuit shall be automatically disconnected from the —lamp test|| circuit and shall start flashing.
- Designed to prevent mal-operation of the scheme or sequence when the push buttons are pressed incorrectly or in the wrong order.

- "Alarm Supply Failure|| Alarm scheme similar to the normal annunciation sequence, but shall operate on a different DC supply or on AC auxiliary supply.

4.4.17 Indicating Lamps /Pilot Lights

Indicating lamp shall be of the double contact, bayonet cap type rated for operation at either 230 V AC or at the specified DC system voltage as applicable. Lamps shall be provided with translucent lamp covers.

Clustered LED type lamps shall be provided Lenses shall be glass or plastic in standard colors, red, green, blue, white and amber, in accordance with IEC 60073.

Bulbs and lenses shall be interchangeable and easily replaceable from the front of the panel. Tools, if any, which are required for replacing the bulbs and lenses, shall also be included in the scope of supply.

Miniature pilot lamps may be provided with plastic marking plate contained inside square (or rectangular) front lens to provide indication of legend or symbols engraved on the marking plate.

The basis of colors shall be as follows:

Red: Flow of energy.

Green: No flow of energy.

White: Supervision of power available, relay coil healthy, etc.

Amber: Disagreement with original condition, abnormal 'condition or sequence—on 'condition.

4.4.18 Push Buttons

Push buttons shall be of momentary contact type with rear terminal connections. The color of the push button actuator shall be red for OPEN /STOP and green for CLOSE / START and for other applications shall be as per specified requirements. The push button knob shall be suitably shrouded to prevent inadvertent operation. The push buttons shall be provided with integral inscription plates engraved with their designation.

All push buttons shall have independent, potential free, 2NO + 2NC contacts. The contact faces shall be of silver / silver alloy. The contacts shall be rated 10A and capable of breaking inductive load of 1A at 110V DC and 5A at 110V AC.

4.4.19 Space Heaters

Adequately rated anti-condensation space heaters shall be provided for each switchboard / cubicle.

Space heater shall be of the industrial strip continuous duty type, rated for operation on a 230 V, 1 phase, 50 Hz, AC system. Space heater shall be provided with a single pole MCB with overload and short circuit release, a neutral link and a thermostat to cut off the heaters at 35 degrees Celsius.

4.4.20 Cubicle Lighting / Receptacle

Each cubicle shall be provided with interior lighting by means of 18 W fluorescent tube lighting fixture. An MCB shall be provided for the lighting circuit. The lighting fixture shall be suitable for operation from a 230 V, 1 ph, 50 Hz, AC supply.

A 230 V, 1 phase, AC receptacle (socket) plug point shall be provided in the interior of each panel with an MCB

4.4.21 Metering Instrument Panel Accessories

4.4.21.1 Metering

Digital type Load manager of approved make (Smart demand controller) shall be provided on the incomer feeder and shall be communication capable and ready with RS485 port and MODBUS protocol. Each incomer and outgoing of MV switchboard shall have energy meter.

4.4.21.2 Instrument Panels

The instrument panel shall be part of the housing. Relays, meters and instruments shall be mounted as per general arrangement drawings to be submitted by the vendors. They shall be of flush mounting type.

4.4.22 Instrumentation

- a) Digital type Voltmeter of class 1.0 accuracy and 96 x 96 mm square in size as per IS-1248 shall be provided at incomer panel, with selector switch. The instrument shall be calibrated for the ranges specified.
- b) Digital type Power factor meter of class of 1.0 accuracy conforming to IS: 1248 shall be provided at incomer panel.
- c) Digital type Ammeter of specified range to class 1.0 accuracy and 144 x 144 sq mm in size as per IS - 1248 shall be provided at both incomer and outgoing panels along with necessary selector switches.
- d) Digital type frequency meter class of 1.0 accuracy conforming to IS: 1248 shall be provided at incomer panel.

The following minimum indication lamps shall be provided in the front of Cubicle-Breaker open / closed / tripped, spring charged trip circuit healthy and control supply healthy. Lamps shall be clustered LED type and trip circuit supervision scheme shall be of continuous supervision type.

After meeting all necessary control and indication requirements 2 nos. NO and 2 nos. NC auxiliary of the breaker shall be made available for the owner, wired up to terminal block.

Separate MCB's shall be provided for lamps, heaters and other instrumentation etc. on each panel.

Anti-condensation space heaters suitable for operation on 240 V single phase, 50 Hz A.C. for each cubicle and with thermostat control one incandescent lamp with switch and 3 pin 5 amps plug socket.

4.4.23 Power and Control Cable Terminations

Terminals for power connections shall be complete with adequate phase segregating insulating barriers, shrouds and suitable crimping type of lugs for terminating the cables.

Double compression type glands with armour and bonding clamps for the termination of all solid dielectric multicore cables shall be provided. They shall be designed to secure the armour wires to provide electrical continuity between the armour and the threaded fixing component of the gland and to provide watertight seals between the cable outer sheath and gland and between the inner sheath and threaded fixing component. The gland shall preferably project above the gland plate to avoid entry of moisture.

Earthing connectors between cable armour and earth shall be routed outside the cable gland in an approved manner. Gland insulation shall be capable of withstanding test for appropriate high MV Voltage for one minute.

Cable terminations for HV / MV cables shall be heat / cold shrinkable type. Adequately sized shrouds/bolts shall be provided at connections to completely cover the terminations.

Where core-balance type current transformers are provided on the feeder cables for earth fault protection, glands for cables shall be insulated from earth in an approved manner.

4.4.24 Tests

The following routine tests shall be carried out on the assembled switchboard /panel during inspection at the manufacturer 's works in addition to other tests as per applicable standards.

- Primary injection tests to ensure correct ratios and polarity of current and voltage transformers and of the current operated protection relays and direct acting coils, over their full range of settings.
- Balance earth fault stability test by primary current injection. Care must be taken to reproduce accurately the burdens of interconnecting cables. A further test to ensure correct polarity must be made after assembly.
- Tests on auxiliary relays at normal operating voltages by operation of associated remote relays
- Correct operation of sequencing and control circuits at normal operating voltages by operation of local control switches, and simulation of operation from remote control positions.
- Carry out functionality tests, check interfacing status contacts and instrumentation.
- Checking of Differential protection relay.
- One-minute power-frequency voltage dry withstand tests on the main circuits One-minute power-frequency voltage dry withstand tests on auxiliary circuits
- Insulation resistance tests

All circuit breakers shall be subject to the following tests:

- Routine tests including HV pressure test, millivolt drop tests and mechanical tests.
- To ensure the operation of the dc closing coil and satisfactory closing of the circuit breaker with the voltage of the coil down to 80% of its rated voltage, and that mal-operation does not occur with a voltage on the coil of 120% of its rated voltage.
- Interchangeability of withdraw able identically equipped circuit breakers, and checking of all mechanical and electrical interlocks.
- Type test figures for heat test runs performed on identical panel types shall be made available.

5. TRANSFORMERS

5.1 Standards

Transformers and its accessories shall comply with the following International Standards, including those referred to therein.

IEC 60076, 60214, 60296 / IS 2026, IS 335 / BS 148, 171.

5.2 General

- a) The Transformers shall be of, cast resin, oil cooled for outdoor installations. Transformers shall be with class F insulation and temperature of winding shall be limited to Class 'B'. The noise level for all transformers shall be in accordance with NEMA TR-1. Transformers shall be designed for over-fluxing withstands capability of 110% continuous, 125% for at least 1 minute and 140% for 5 seconds.
- b) Overloads shall be allowed as per IEC 354. Under these conditions, no limitations by terminal bushings, tap changers or other auxiliary equipment shall apply.
- c) Transformers impedance shall be suitably chosen considering fault current limitation of Switchgear and voltage drop limitation of motors.
- d) Transformer shall be suitable for operation of maximum 115 C temperatures and.
- e) Transformer shall be suitable for cable/ bus duct termination with disconnect chambers as required. Cable box shall have IP 54 degree of protection.
- f) All the transformers shall be designed to withstand without injury, the thermal and mechanical stress of short circuit current at its terminal with full voltage maintained behind it for a period of 3 seconds for HT Transformers and 2 seconds for LT transformers.
- g) The transformers shall be capable of continuous operation at the rated output under the following conditions without injurious heating at that particular tap.

The voltage variation of $\pm 10\%$ of rated voltage of that particular tap.

Frequency variation of $+3\%$ to -5% of rated frequency.

Combined voltage and frequency variation of $\pm 10\%$ (absolute sum).

The capacity of transformers will be calculated based on the load factor and diversity factor given by MSEDCL plus 10% contingency.

5.3 Constructional Features

5.3.1 General

Similar parts, particularly removable ones shall be interchangeable. Screws, studs, nuts and bolts shall be as per IS. Nuts, bolts, pins used inside the transformer and tap changer compartments shall be locked.

Exposed parts shall not leave pockets where water can collect.

Internal design of transformer shall ensure that air shall not trap in any location. Facility shall be provided for lubrication of bearings and mechanisms. Mechanism shall be constructed of non-corrodible material.

Material in contact with oil shall be such as not to contribute to formation of acid in oil. Surfaces in contact with oil shall not be galvanized or cadmium plated.

Labels, indelibly marked shall be provided for all accessories like relays, switches, fans, current transformers etc.

5.3.2 Tank

Tank shall be made from good commercial grade low carbon steel and shall be electrically welded construction type. Tank shall be designed to permit lifting by crane or jacks of the complete transformer assembly filled with oil. Suitable lugs and bosses shall be provided for this purpose. Tank together with radiators, conservator, bushings and other fittings shall be designed to withstand without permanent distortion of the following conditions-

- a) Full vacuum of 760mm Hg for filling with oil by vacuum.
- b) Internal gas pressure of 0.35kg/sq.cm (5lbs/sq. in with oil at operating level).

Adequate space shall be provided at the bottom of the tank for collection of sediment. The transformer top shall be provided with a detachable tank cover with a bolted flanged gasket joint. Lifting lugs shall be provided for removing the cover. The surface of the cover shall be suitably slopped so that it does not retain rain water.

Manholes with bolted covers shall be provided in the top or sides of transformer for easy access to the power end of bushings, tap changers and to permit replacement of auxiliaries without removing tank cover.

The material used for gaskets shall be cork-neoprene or approved equivalent. Gasket joints for tank and manhole covers, bushings and other bolted attachments shall be so designed that the gasket will not be exposed to the weather.

The transformer base shall be designed to permit skidding of the complete transformer unit in any direction, when using plates or rails. The under base shall be detachable unless transport facilities permit a fix base.

5.3.3 Core

The magnetic circuit shall be of core type construction. The core shall be built out of high grade non aging, low loss 7 high permeability, cold rolled grain oriented silicon steel laminations.

The core laminations shall be insulated from each other by a suitable high temperature resistant, oil proof, adherent coating material. The core clamps and clamping bolts shall be heavily insulated from the core laminations.

The insulation of core bolt shall be minimum of class B. The bottom and top frames shall be connected with tie rods to make a complete structure rigid for carrying the weight of core coil assembly without unduly stressing the laminations and windings.

All the core sections shall be bonded together with metallic strip and connected to the tank for earthing to ensure earth return and operation of protective gear in the event of the winding to core fault. The core shall be provided with lifting eyes/lugs suitable for lifting the complete core and coil assembly from the tank.

Completed core shall be flash tested for insulation with 2500V between the core and each clamps for core bolts (core being connected to earth).

The finally assembled core shall be free from distortion. It shall be rigidly clamped to ensure adequate mechanical strength and to prevent vibrations during operations. The core clamped structure shall be designed to minimize eddy current loss.

The operating flux density shall be such that an over voltage of 10% shall not cause saturation of the core.

5.3.4 Windings

Windings shall be three phase with minimum class A insulation.

Properly insulated and stacked high conductivity electrolytic grade copper (and not aluminum) shall be used for winding. Windings shall be suitable braced to withstand the dynamic forces due to short circuit. The transformer shall be two winding type.

Winding shall be individually vacuum dried in hermitically sealed dry ovens and preshrunk fully under hot conditions. After assembly of windings on core the complete assembly shall again be vacuum dried until the desired insulation resistance of each winding is obtained.

Windings shall be subjected to a shrinking and seasoning process, so that no further shrinkage occurs during service. Adjustable devices shall be provided for taking up possible shrinkage in service.

Coils shall be supported at frequent intervals by means of wedge type insulation spacers permanently secured in place and arrange to ensure proper oil circulation. To ensure permanent tightness of winding assembly, the insulation spacers shall be dried and compressed at high pressure before use.

Winding shall not contain sharp bends, which might damage the insulation or produce high dielectric stress. No strip conductor wound on edge shall have width exceeding six times the thickness. Materials used in the insulation and the assembly of the winding shall

be insoluble, non-catalytic and chemically inactive in the hot transformer oil and shall not soften or be otherwise affected under the operating conditions.

All threaded connection shall be locked. Leads from the windings to the terminal board and bushing shall be rigidly supported to prevent injury from vibrations. Guide tubes shall be used where practicable.

Clamping bolts for current carrying parts inside oil shall be made of oil resistant material, which shall not be affected by acidity in oil.

Terminals of all windings including unloaded stabilizing windings shall be brought out of the tank through bushing for external connection.

5.3.5 Internal Earthing

All internal metal parts of the transformer with the individual clamping plates shall be earthed. Core clamps and core bolts shall be insulated from the core by class B insulation unless otherwise insulation is approved by purchaser.

The top clamping structure shall be connected to the tank by copper strap. The bottom clamping structure shall be earthed by one of the following methods:

- By connection through vertical tie rods to the top structure.
- By direct metal to metal contact with tank base.
- By a connection to the top structure on the same side of the core as the main earth connection to the tank.

The magnetic circuit shall be connected to the clamping at one point only, through a link placed in accessible position beneath an inspection on the tank cover. The link shall be on the same side of the core as the main earth connection.

When the magnetic circuit is sub divided by oil ducts or insulated barriers above 0.25mm thick, tinned copper strip bridging pieces shall be inserted to maintain electrical continuity between packets.

Coil clamping rings of metal at earth potential shall be connected to the adjacent core clamping structure on the same side as the main earth connection.

5.3.6 Under Carriage

The under carriage of the transformer shall be provided with detachable steel flanged wheels or flat rollers. Flanged wheels shall be spaced to allow specified rail gauge. Wheels shall be provided with suitable bearings, which will resist rust and corrosion and shall be equipped with fittings for lubrication. Unless otherwise approved, it shall be possible to swivel the wheels or rollers in two directions at right angles to or parallel to the main axis of the transformer, thereby pertaining movement in two directions. The wheels or rollers will be swiveled after jacking the transformer and they shall be lockable in two positions.

5.3.7 Insulating Oil

Transformer oil be mineral type (not synthetic, PCB based) conforming to IS: 335. Comparatively small transformers shall be supplied "Under Oil". For large transformer

with radiator banks, it may not be feasible to ship the transformer "Under Oil", oil being supplied separately. Tested including oil required for filling or topping up the transformer including radiator banks and conservator shall be supplied loose, in non-returnable drums. No inhibitors shall be used in the oil.

5.3.8 Terminal Arrangement

a) Terminal Chamber and Cable Box

When connection is by cable, terminals shall be brought out into a terminal chamber and a suitable cable box shall be provided. A disconnecting chamber between the terminal chamber and cable box shall be provided for easy isolation and removal of the transformer from foundation without disturbing the cable box leaving the cable box behind on external support to be provided by the contractor. The terminal and disconnecting chamber may be air filled or oil filled, if oil filled suitable vent and drain plug shall be provided.

Terminals for connection to external cables shall be complete with compression/solder type copper/aluminum lugs and hardware. Where cable boxes with stem type connections are provided, interconnecting strips from cable box stems to the terminals shall be provided.

Cable box shall be suitable for accommodating specified type of cable and termination kit. Sufficient space shall be available inside the cable box for heat shrinkable type cable termination kit. Cable box shall be complete with undrilled removable gland plate, access cover and earthing terminal

b) Bus Duct Termination

If specified in data sheet, a flanged weatherproof throat shall be provided on transformer Primary/secondary terminal box to suit Purchaser's bus duct termination. Winding termination shall be made through bushings with adequate clearance. The flanges shall be horizontal/vertical to suit the bus duct take off horizontally/vertically from the transformer.

c) Separate Neutral Bushing for Earthing

Separate neutral terminal (other than that provided in the terminal chamber) of star connected winding of the transformer shall be brought out with an outdoor type bushing. The terminal shall be suitable for connection of two flat earth conductors.

d) Marshalling Box

For the required fittings on the transformer, a dust tight, vermin proof and weather proof, sheet steel (2mm thick) enclosed marshalling box with hinged door having padlocking facility shall be provided on the transformer tank.

Marshalling box shall be provided with a rain hood at top, removable gland plate at bottom and hinged door at the front.

All door covers and plates shall be fitted with neoprene gaskets. Bottom shall be at least 200mm from floor level.

All devices mounted on the transformer and requiring electrical connection such as buchholz relay, oil and winding temperature indicator contacts, pressure release valve contacts etc. and their controls shall be wired to marshalling box.

All interconnection between these devices and marshalling boxes shall be carried out with either 1100/650V grade PVC insulated armored cables or PVC insulated wires in GI conduits. The size of the conductor shall be minimum 2.5 sq.mm. copper.

All internal wiring with marshalling box shall be carried out with PVC insulated, copper conductor wires of minimum size 2.5 sq.mm. Marked ferrules shall be provided at the wire terminations.

All contacts for alarm, trip and indication circuits shall each be electrically free, wired for auxiliary D.C supply as specified and brought out to separate terminals at the terminal blocks in the marshalling box.

Marshalling box shall have one door switch operated 230V AC fluorescent lamp, thermostat controlled 20W space heater and one 5A plug socket.

5.3.9 Transformer Cooling Arrangement

Radiators and coolers shall be designed to withstand the vacuum and pressure conditions specified for the tank and made of pressed sheet steel of thickness not less than 1.4mm. They shall be so designed as to avoid pockets in which moisture may collect.

5.3.10 Built in Radiators

Unless otherwise approved, tank mounted radiators shall be of the detachable type with bolted and gasketed flanged connections. The following accessories shall be provided with each radiator:

- Shutoff valve and blanking plates on transformer tank at each point of connection. Up and bottom shut off valves and blanking plates on each radiator.
- Lifting lugs.
- Top oil filling plug, 19mm size
- Air release plug at top.
- Oil drain plug at bottom, 19mm size

5.4 Off Circuit Tap changer (OCTC)

Transformer shall be provided with off circuit tap changing switch for varying its effective ratio of transformation while the transformer is de-energized and without providing phase displacement. Off circuit taps of transformer shall have tap range of (+) 5% to (-) 5% in steps of 2.5% each on HV winding for HV variation to give normal voltage on LV side at each tap.

Tap changing switch shall be located in convenient position so that it can be operated easily. Switch handle will be provided with a locking arrangement along with tap position indicator and direction of operation, thus enabling the switch operated and locked in position. Operation shall result in simultaneous position change on all three phases, with spring loaded snap action and ensure positive pressure contact.

5.5 Accessories

Accessories required as per requirement and relevant IS.

a)	Buchholz relay for 11 kV/ 0.415 kV transformers	Required
c)	WTI with 2 mercury contacts for 11 kV/ 0.415 kV transformers	Required
c)	OTI with 2 mercury contacts for 11 kV/ 0.415 kV transformers	Required
d)	MOG with 1 mercury contact for 11 kV/ 0.415 kV transformers only	Required
e)	Silica gel breather	Required
f)	Oil conservator tank	Required
g)	Pressure relief valve for 11 kV/ 0.415 kV transformers only	Required
h)	Inspection manhole for 11 kV/ 0.415 kV transformers only	Required
i)	Lifting lugs	Required
j)	OLTC locking arrangement for 11 kV/ 0.415 kV transformers only	Required
k)	Tap position indicator for 11 kV/ 0.415 kV transformers only	Required
l)	Jacking pad for 11 kV/ 0.415 kV transformers only	Required
m)	Detachable radiators	Required
n)	Oil drain cum sampling valve for 11 kV/ 0.415 kV transformers only	Required
o)	Air release drive for 11 kV/ 0.415 kV transformers only	Required
p)	Explosion vent	Required
q)	Skids	Required
r)	Wheels	Bi-directional, plain wheels

5.6 Testing

The transformer shall be subjected to the following tests at the factory before dispatching the same and test certificates, in quadruplicate, shall be furnished:

- i. Measurement of winding resistance.
- ii. Ratio polarity and phase relationship
- iii. Impedance Voltage
- iv. Load Losses.
- v. No load loss and no load current
- vi. Insulation resistance
- vii. Induced over voltage withstand
- viii. Separate source voltage withstands
- ix. Temperature rise by no load plus short circuit method

6. LT PANEL AND DISTRIBUTION BOARDS

6.1 Standards

The equipment shall be designed to confirm to the requirement of:

IS:25623 & IEC:439	Factory built assemblies of switch gear and control gear
IS:4237	General requirements for switch gear and control gear not exceeding 1000V.
IS:2147	Degrees of protection provided by enclosures for low voltage switch gear and control gear.
IS: 375	Marking and arrangement of bus bars
IS: 2959	AC conductors of voltage not exceeding 1000V
IS:4064 (part II)	Air break switches and fuses combination units for voltage not exceeding 1000V
IS:694 and IS:25130	PVC insulated cables and aluminum conductor
IS:12425	Direct action electrical indicating instruments
IS:9224	Low voltage fuses
IS:2516	AC circuit breakers
IS:2705	Current transformers
IS:3156	Voltage transformers
IEC 61439 PART I & II EDITION 3	Factory built assemblies of low voltage alternating current breaker

6.2 Main PMCC

The main PMCC shall be metal clad totally enclosed, rigid, floor mounted, air insulated, cubicle type for use on 415V, 3 phase, 50Hz system. The PMCC shall be single front, draw out type compartmentalized.

The equipment shall be designed for operation in high ambient temperature and high humidity tropical atmospheric conditions. The equipment shall be for indoor installation.

10% spare feeders with minimum one no. of each type and rating shall be provided in PMCC.

6.3 Sub PCC/MCC/Control Panel

The sub PCC/MCC/Control panel shall be metal clad totally enclosed, rigid, floor mounted, air insulated, cubicle type for use on 415V, 3phase, 50Hz system.

The local/sub MCC cum control panel shall have all controls mounted on the body and with only user required controls approachable from the outside.

Panels shall be single front type with draw out type power supply feeders.

20% spare feeders shall be provided for LT boards like PCC/MCC/ACDB/DCDB/LDB etc.

Rating of power contactors, overload relays and protective equipment shall be as per Type-2 Co-ordination chart.

IP protection for above shall be minimum IP-54 for indoor panels and for outdoor it shall be IP-55.

Each panel incomer shall have energy meter and for biological process drives (i.e. anoxic tank mixers, internal recirculation pumps, aeration blower, permeate pumps, AS pumps blower, valves in air line and in RAS pump line) separate energy meter shall be provided for each drive.

6.4 Constructional Features

- All cubical panel shall be fabricated out of cold rolled sheet steel, thickness of 2 mm. Internal Partition panel thickness shall be 1.6mm.
- The structure shall be mounted on a rigid base frame of folded sheet steel of minimum 3mm thickness and 75mm height.
- All Power panels should be compliant with IEC 61439, 1& 2 and Arc fault compliances as per IEC 61641 for 70kA/300ms.
- Panels shall be totally enclosed dust and vermin proof rubber gasket shall be provided around doors, covers and other cut outs. Degree of protection shall be IP – 52 as per IS standards for LT panels.
- All floor mounting panels/ boards shall be provided with 50 mm high channel base frame. Total height of all floor mounting cubicles / panels shall be 2500 mm (maximum).
- Metal clad switchgear shall be extensible on both ends.
- Switch handles shall be provided with padlocking facility in off position.
- All sheet steel work shall be phosphatised in accordance with the relevant IEC/IS: 6005 Code of Practice of phosphatizing Nanoceramic coating, electrophoretic dip coating followed by powder coating with C5H painting if required.
- After application of the primer, two coats of finishing synthetic enamel epoxy paint of reputed make shall be applied, each coat followed by stoving. The second finishing coat shall be applied after completion of tests. The colour for the finishing paint shall

be light grey as per shade no. 631 of IS:5 or other equivalent standard shade. Each coat of primer and finishing paint shall be with slightly different shade to enable inspection of the painting.

- The finishing painted surface of pillars shall present aesthetically pleasing appearance free from dents and uneven surface.
- Each Switchgear cubicles shall be fitted with a label on the front and rear of the cubicle. Each Switchgear cubicles shall be fitted with a label indicating the switchgear rating and duty.
- Medium voltage metal clad Switchgear shall comprise separate, segregated modules for each circuit.
- Bus ways, cable ways and wire ways on medium voltage Switchgear shall be run separate, segregated compartments. Cable's way width shall be less than 250 mm.
- Provision for ventilation/pressure relieving and internal arc protection

6.5 Bus Bars

- Bus bars shall be of aluminum complying with the requirements of grade E91E of IS:50252 and shall be located in air insulated enclosures non-flammable, resistant proof for acid and alkalis.
- Bus bar joints shall be bolted type and insulated spring washers shall be provided to ensure good contact at the joints.
- Bus bars shall be suitable for fault level 50KA.

6.6 Unit Module

- Each module shall be suitable for mounting a required number of power contactors, bimetal relay, auxiliary contactors, push buttons, isolators/fuse, ACB, MCCB, MCB, control fuses, main fuses, indicating lamps, meters, power and control contacts, terminal block cum secondary isolating contacts etc., to suit non reversing, reversing and assisted start motor applications.
- Each module shall be provided with an individual door and the door shall be mounted on the main structure. The front doors shall be provided with concealed hinges. Module doors shall be interlocked mechanically with isolator / fuse switch / ACB/ MCCB / MCB to prevent unintentional opening of the door while the unit is in energized condition. Means for defeating this interlock shall be provided.
- Padlocking arrangement shall be provided to permit locking of the isolator / fuse switch in "OFF" position.
- The main and control contacts shall be self-aligning type suitable for taking a mismatch up to +/- 4 mm.
- The main power contacts shall be capable of withstanding a short circuit current.
- The module shall be connected to the vertical bus bars by plug-in contacts. The contacts shall be between copper and copper, both silver plated even if, bus bars are of aluminum.

- Each vertical Panel shall be fitted with a label on the front and rear. The PMCC as a whole shall also be fitted with a label indicating the switch gear rating and duty. Each relay, instrument, switch, fuse, contactor etc. shall be provided with a separate label. The Employer/ PMC shall approve type and wording of all labels.
- Operating height; Minimum- 350 mm and maximum 1800 mm from finished floor level.

6.7 Medium Voltage Circuit Breakers

- Medium voltage circuit breaker shall be of air break type.
- Air break circuit breakers shall be of either the vertical or horizontal – isolating pattern with horizontal draw – out facilities.

6.8 Circuit Breaker Operating Mechanism

- The circuit breakers shall be manually or electrically refer on next page operated, i.e. manual operated spring charging type of mechanism.
- The spring charging mechanism shall be complete with opening spring, closing spring and all accessories to make the mechanism a complete operating unit.
- The tripping spring shall be charged by the closing action, to enable quick tripping. The charging mechanism shall be provided with mechanical indicators to show charged and discharged conditions of the spring. Failure of any spring, vibration or mechanical shock shall not cause tripping or closing of the circuit breaker.
- Only one closing operation of the circuit breaker mechanism shall result from each closing impulse even though the breaker trips while the control device (Manual or electrical), is being held in the 'close' position.
- The circuit breaker mechanism shall make one complete closing operation, once the control switch has been operated and the first device in the control scheme has responded, even though the control switch is released before the closing operation is complete, subject to the condition that there is no counter-impulse for tripping.
- Means shall be provided to manually open and close the breakers slowly when the operating power is not available, for maintenance and adjustments.
- All operating mechanism shall be provided with ON-OFF mechanical indicators.
- A local manual trip device shall be provided on the operating mechanism.
- Closing coils and other auxiliary device shall operation satisfactorily at all voltage between 80-110% of the control voltage. Trip coils shall operate satisfactory between 50-110% the rated control voltage.
- Mechanical anti pumping should be provided with the breaker.
- Interlocks: Where key interlocking is employed, tripping of a closed circuit breaker shall not occur if any attempt is made to remove the trapped key from the mechanism.

- Test operation Facilities: Metal clad switchgear shall be provided with testing facilities to test the operation of circuit breakers. A separate test position of the breaker shall be provided in the cubicle / module.
- Locking Facilities: Draw -out circuit breaker shall be provided with padlocking facilities for locking the circuit breaker carriage in the fully drawn out (isolation position) earth and test and fully plugged in positions (service position).

6.9 Safety Shutters

- Switchgears cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker carriage, to cover the stationary isolated contacts where the breaker is withdrawn. It shall, however, be possible to open the shutters intentionally against the spring pressure for testing purposes.
- Bus bar shutters shall be colored 'signal red' color 437 to BS: 381C and labeled "Bus bars" in large white letters. Circuit shutters shall be colored "Lemon", color 355 to BS: 381
- Shutters in bus- section unit shall be colored 'Signal red' and shall be labelled with a large white arrow pointing in the direction of the selection of bus bars to which the isolating contacts are connected.
- Medium voltage switchgear switch and starter modules shall be provided with laminated insulated sheet partitions, to cover the stationery contacts when the module is withdrawn.
- Circuit Breaker Alignment: Circuit breaker moving portions shall be fitted with positive guides so as to ensure correct alignment of the isolating contacts in both circuit or earth positions.
- Contacts:

The circuit breaker main contacts shall be made of silver faced copper. The contacts shall be adjustable for wear and tear, and shall be easily replaceable. Main contacts shall be first to open and last to close to minimize contact burning and wear.

Arcing contacts shall be first to close and last to open to take care of arcing. Arcing contacts shall be accessible for replacement. Tips of arcing contacts shall be silver plated or shall have a tungsten alloy tipping.

If multibreak interrupters are used, they shall be so designed as to uniformly distribute the voltage among them.

Where circuit breakers are used to control circuits, the contracts shall be designed for minimum warder to frequent operation of the circuit breakers. The number of operations determining the necessity of contacts inspection shall be as high as possible, and anyhow not less than 250 operations for oil circuit breakers and 500 operations for air circuit breakers.

6.10 Protection for Breakers

Breakers shall comprise of devices for thermos magnetic tripping and for earth fault protection.

6.10.1 **Moulded Case Circuit Breakers**

Moulded case circuit breaker (MCCBs) shall be provided in lieu of switch fuse for controls, as per the guidelines specified. The MCCBs shall conform to the latest application standards.

MCCBs in AC circuit shall be of triple pole construction arranged for simultaneous three pole manual closing and opening and for automatic instantaneous tripping on short circuit. Operating mechanism shall be quick-make, quick-break trip – free type. The ON-OFF and TRIP polling of the MCCB shall be clearly indicated and visible to the operator when mounted as in service. Front of board operating handle shall be provided.

MCCB shall be capable of withstanding the thermal stresses caused by overloads and locked rotor currents of values associates with protective relay settings of the motor starting equipment and the mechanical stress caused by the peak short circuits current of value of associated with the switch-gear rating. The maximum tripping time under short circuit shall not exceed 20 milliseconds.

The Instantaneous short circuit release shall be so chosen by the VENDOR as to operate at a current in excess of the peak motor in rush current and a range of settings shall be provided for the purchaser's selection.

MCCB terminals shall be shrouded and designed to receive cable lugs for cable sizes relevant to circuit ratings.

Under – voltages release and overload inverse time release shall be provided.

6.10.2 **Miniature Circuit Breakers**

Miniature Circuit Breakers for use on motor space heater control circuits shall comply with the requirements of applicable standards.

6.10.3 **Switches and Fuses**

Medium voltage air break switches shall be of heavy duty load break, fault make, group operate type. The switchgear shall be of triple pole type with a link for neutral wire.

Medium voltage switches and composite units of switches and fuses shall comply with the requirements of IS: 13947.

All fuses shall be of the HRC cartridge type mounted on plug- in type of fuse bases. Fuses shall comply with the requirements of IS: 9223.

Earthing and neutral links in main supply shall be of solid silver plated copper and be of the bolted panel.

An adequate number of spare fuse cartridges for each rating shall be supplied and fitted in clips inside the panel.

6.11 Current Transformers

CT Core Lamination shall be of high grade silicon steel.

Current transformer for high voltage equipment shall be of the resign cast type.

All current transformers shall comply with the requirements of IS: 2705.

6.12 Voltage Transformers

Secondary winding of voltage transformers shall be rated for a three phase line voltage of 110 V and shall have a minimum rated burden of 50 AVA.

Voltage transformers windings for metering purposes shall be of accuracy class 1.0 and for protection purposes shall be of accuracy class 3.0.

Voltage transformers shall comply with the requirements of IS: 3156.

6.13 Relays

All relays shall be suitable for flush mounting with only the dust tight covers projecting from the front of the panel and shall be accessible for setting and resetting from the front.

All relays shall be provided with positive action flag indication visible from the front.

Auxiliary relays shall be rated to operate satisfactory between 70% and 110% of the rated voltage and tripping relays between 50% and 110% of the rated voltage.

Control and selector switches shall be a rotary, stay put, maintained contact type. Properly designated escutcheon plates clearly marked to show the operating positions shall be provided with all switches.

Indicating instruments shall be mounted flush on the panels. Normal maximum meter reading shall be of the order of 60% normal full scale deflection. Watt-hour meters shall be of induction type, and shall be provided with reverse running stop. Instruments shall have an accuracy class of 2.0.

Indicating lamps shall be of the filament type, with low watt consumption and shall be provided with series resistant to avoid short circuiting of control supplies in the event of fusing of the filament. Lamp shall be provided with translucent lamp covers.

All push buttons shall be of the 'push to actuate' the contact type. Emergency stop push buttons shall be lockable in the operated position. Push button knobs for emergency stop push buttons shall be recessed to prevent accidental operation.

Adequately rated anti-condensation space heaters shall be provided one for each vertical cubical of switchgear for each separate control panel, for each distribution board, for each switch board, and for each marshaling box.

Each switch gear cubical, control panels, control cabinet and marshaling box shall be provided with suitable interior lighting and a switch.

All terminals, connection, lays and other components which may be 'live' when from access doors are open shall be adequately screen. It shall not be possible to obtain access to an adjacent cubical or module when any door is opened. The pad lock for each type of

switch board component shall have the same lock change number and two keys shall be provided.

6.14 Power and Control Cables Termination

Cable boxes for use on system with rated voltages up to 11 KV shall be suitable for cold setting epoxy resin type of compound filling.

Cable boxes shall be complete with combined armour and earthing clamps.

Provision shall be made for earthing the body of each cable box.

Equipment terminal blocks for power connections shall be complete with adequate phase segregating insulating barriers and suitable crimping type of lugs for connecting the insulated cable tails.

Brass wiping shall be provided with cable boxes for paper insulated, lead sheathed cables. Compression type cable glands shall be provided for all other power and control cables.

Gland insulation shall be capable of withstanding a high voltage test of 2000V for one minute.

All switchboards shall, unless otherwise specified, facilitate bottom cable entry. Removable gland plates shall be mounted at least 300mm above the base of the panel. If the gland plates are provided inside the switch board cubicles, entries in the base of the cubicle must be adequately vermin proof, hardwood board's being the proffered means.

Cable alley shall be minimum 250 wide.

All wiring for control, protective, alarm and indication circuits on all equipment shall be carried out with at least 650 V grade PVC insulated, standard tinned copper, 1.5 sq mm conductors a shall be colour coded as follows.

A.C Circuit - Red, Yellow or Blue determined by the phase with which the wire is associated.

A.C Neutral - Black

D.C Circuit - Grey

Earth Connections - Green.

6.15 Earthing of Switchgear / Distribution Boards

Each switch gear / distribution boards shall be provided with an earth bus bar running along its entire length. The earth bus-bar shall be located at the bottom of the board / panel.

Earth bus bar shall be of galvanized iron or copper. Earth bus bars shall be rated to carry the rated symmetrical short circuit current of the associated board / panel for one second. Earth bus bar shall be supported to withstand stresses induced by the momentary current of the value equal to the momentary rating of the associated switchgear / distribution boards.

Positive connection of all the frames of equipment mounted in the switchgear/ distribution board to the earth bus bar shall be maintained through insulated conductor

of size equal to the ground bus bar or the load current carrying conductor. Whichever is smaller, Ear thing of draw out equipment frames shall be achieved through a separate plug in contact.

All instrument and relay cases shall be connected to earth bus bar by means of 650 v grade, PVC insulated, stranded, tinned copper, 2.5 sqmm conductor looped through the case earth terminals.

Door earthing shall be done by using 2.5 square mm standards flexible copper conductor PVC insulated.

6.16 Tests

The design of the switchgear / distribution board shall have been type tested in accordance with the relevant sections of IS: 25623. In absence of type test certificates, the following type tests have to be carried out by the Contractor free of charge to the Employer/ PMC.

- i. Verification of short time current withstands and peak current withstand of main and vertical bus bars.
- ii. Temperature rise tests on main bus bars, vertical risers, power contacts and control contacts.
- iii. Routine test shall be conducted on the Panel in accordance with IS: 25623.
- iv. Dielectric tests.

6.17 ACDB/Lighting Panel/ELDB Distribution Boards

- Double door distribution board shall be flush mounted. The boxes shall be weather and flame proof (for Flammable Material, Acetylene, Fuel storage area) sheet steel with external fixing lugs and detached gland plates.
- An external rust proofed bolt or stud shall be provided for earthing purposes.
- The cover shall be flat, close fitting and gasketed and provided with locking facilities.
- Ample wiring capacity shall be provided and the M.C.B banks shall be easily removed or titled to give access to the terminals.
- The neutral bar shall be provided with a separate neutral connection for every M.C.B way of each pole.
- All MCB DBs shall be factory fabricated, of the type as specified in the Schedule of Quantities and shall be the same make as that of MCBs.
- Identification of Circuits: All outgoing circuits shall be identified with PVC numbering ferrules/tags.
- Circuit Diagram: Inside of the door of the MCB distribution board, a well prepared circuit diagram showing circuit numbers, the areas/rooms/utilities being served, conductor size etc., shall be pasted.

7 SWITCH TRIPPING UNIT

7.1 Batteries, Battery Chargers and DC Distribution Boards

7.1.1 General

Switch tripping unit shall comprise battery, charger and DC distribution board housed in a common sheet steel enclosure. The enclosure shall be of cold rolled cold annealed (CRCA) and thickness shall not be less than 2mm. Enclosure shall be of indoor, floor standing, totally enclosed, dust, damp and vermin proof of adequate strength and rigidity. Degree of protection shall be IP-42.

The equipment shall be so housed in the cabinet as to facilitate easy inspection and maintenance. To prevent accident all live parts inside the cabinet shall as far as possible be adequately insulated to avoid contact during maintenance. All external fasteners shall be cadmium plated/ zinc passivated to withstand the atmosphere conditions. The cabinet shall be complete with all necessary wiring, cable glands and sockets for incoming and outgoing circuits and suitable circuit label/inscriptions made of non-rusting metal, 3 ply lamicaid or engraved PVC. Two earthing terminals shall be provided to earth the cabinet.

All the steel works of the cabinet shall be painted after suitable pretreatment with anti-rust paint and special finishing paint. The internal surface shall be painted in white and the external surface in dark admiralty gray color.

7.1.2 Battery

Batteries shall be of high performance 24V DC lead acid SMF conforming to relevant IS. Batteries shall be suitably sized to supply the control requirements of HT and LT breakers and annunciations wherever required.

Batteries shall have cells housed in translucent, high impact plastic containers. The containers shall be fitted with vented filler pumps. High and low electrolyte levels shall be permanently marked on the container.

Cell terminals shall be of bolted type. The terminal polarity shall be permanently marked. Battery cells shall be arranged so that each is accessible for test and inspection. Cells shall be arranged in single steps, double tier rack formation and shall be not less than 300mm above floor level. Batteries shall be supplied complete with all necessary connections. The connections between tiers and cells and disconnection links and fuses shall be of the multi-stranded plastic insulated type.

The battery rack shall be made of mild steel painted with alkali resistant paints and shall be supplied in knocked down condition which could be bolted and assembled at site. The batteries shall rest on treated wooden planks inside battery racks.

7.1.3 Battery Charger

Battery Charger shall conform to relevant and IS code. The charger shall be a float cum boost charger suitable for rating lead acid cells up to 1.85V per cell and also capable of quick charging the battery up to 2.2V / cell. The charger should be able to supply continuous DC load during boost charging with 10% margin.

7.1.4 Terminal Arrangement

The Battery and Battery Charger shall have terminals suitable for connecting PVC insulated, armored aluminum cables. Approved type of terminal lugs and screwed type glands for the entry of cables in the panels shall be provided.

7.1.5 Accessories

Each battery shall be complete with all accessories and devices including but not limited to the following:

- a) Battery stands.
- b) Set of inter-cell, inter-row and inter-bank connectors and number plates as required for the complete installation.

One number each of the following accessories shall be supplied with each battery unit.

- i. I-centre zero cell testing voltmeter to IS: 1248 scaled 3-0-3 volts/
- ii. Plastic filling bottle
- iii. Insulated box spanner
- iv. Insulated Tommy bar
- v. End lugs
- vi. Bellavee washers
- vii. Lugged inter row cable
- viii. Vent caps
- ix. Insulated spanner
- x. Rubber gloves

7.1.6 Battery Charger and DCDB shall be provided with the following Components

- a) Double pole rotary switch for AC input
- b) MCCB with fittings for the above
- c) Pilot lamp to indicate the equipment ON condition
- d) Variac to give step less control of DC output voltage from 0-48V.
- e) Double wound, impregnated, naturally air cooled single phase mains transformer with taps.
- f) Single phase, full wave bridge connected, silicon controlled rectifiers. Stack with RC network for each SCR for surge suppression.
- g) Filter circuit to reduce the ripple content to 3% RMS.
- h) Moving coil ammeter of suitable range and size to measure the DC output current
- i) Moving coil voltmeter of suitable range and size to measure the DC output voltage.
- j) MCB with fittings for DC output.

- k) Voltage dropping diode with selector switch and contactor.
- l) Cable connection from battery to charger.
- m) Cubicle internal light operated from a 240V, single phase, AC system with on-off switch.
- n) Battery earth leakage relay comprising of solid state sensing/ triggering circuit with electromagnetic relay with center zero millimeter isolating switch and fuse.
- o) Space heater suitable for operation on 240V, 1 phase, 50 hz, A.C system with ON-OFF switch.
- p) Local auto/visual annunciations for the following faulty conditions shall be provided for:
 - Mains fuse failure
 - Rectifier fuse failure
 - Capacitor fuse failure
 - D.C output overload
 - Rectifier control supply failure

7.1.7 DCDB

- Incoming feeder for DCDB comprising 1 No. double pole on/ off rotary switch and 2 Nos. HRC cartridge fuses of suitable rating.
- Required number of outgoing feeders each comprising 1 No. double pole on/ off rotary switch and 2 Nos. MCB of suitable rating.

7.1.8 DC Power Supply

The Power supplies will operate from 230V AC, and produce a 24V DC output voltage at full load current

Voltage regulation : 0.02% for $\pm 10\%$ mains voltage variation

Load regulation : 0.3% from zero to full load conditions

Triple at full load : <1 mV RMS

The power supply shall incorporate an over voltage protection circuit, the components of which shall be independent of the voltage regulating circuit.

The protection circuit shall operate within 50ms of an over voltage occurring and shall cause rupturing of the mains input or output fuses.

Automatic reset of the over voltage protection circuit is not permitted.

8 POWER GENERATING SET

8.1 Diesel Generator

8.1.1 General

2 Nos. Diesel generator set shall be provided by bidder, Each DG set shall be sufficient for running the one phase of STP and one phase of CETP load.

Specification for the DG set is as per CPWD, General Specifications for Electrical works, Part-VII (DG Sets).

Diesel Generator of adequate capacity 4 stroke shall be provided to generate rated KW load at 415V 3 phase, 50 Hz continuously comprising of totally enclosed water cooled diesel engine with multi-cylinders developing suitable BHP not less than 120% of rated BHP at 1500 RPM or 1000 RPM with 10% overload for 1 hour in 12 hours with starting lead acid batteries, necessary fuel storage, pumping and handling system and other standard accessories such as:

- Fly wheel with guard
- Battery charging alternator unit and voltage regulator, suitable for starting batteries, battery racks with interconnecting leads and terminals.
- Lube oil system shall comprise oil pump, strainer, lube oil cooler, oil filter, and bye pass filter and associated self-contained piping.
- Electronic governing system
- Cylinder head, cylinder jacket, lube oil shall be water cooled.
- Exhaust system with necessary supports, fittings, bellows and exhaust silencer shall be provided.
- Minimum 225ltr. Day tank diesel for 24hrs of operation along with piping to DG and back. The tank shall have fuel level gauge, drain pipe with isolation valve. Output pipe complete with water trap and isolation valve and filling point at top of tank with removable gauze filter.
- 12/24 volts electric starting equipment complete with standard battery, static battery charger, cut outs, ammeter or compressor air start comprising of compressor, air bottle, air compressor motor, pressure gauge.
- Heavy duty domestic exhaust silencer and vertical hot air duct boot logged with wool and alum. Cladding inside Diesel Generator building along with exhaust piping of required length.
- Engine and alternator shall be mounted on a steel fabricated base plate. Access platforms and ladders shall be provided.
- Manual engine turning equipment.
- Crank case breather pipe.
- Lubricating oil cooler and lube oil, filters pressure pump gauge, pressuring (bulk fuel storage tank equal to 24 hrs. capacity with required pumps and piping with flam proof motors shall be provided to pump diesel to day tank).
- Complete wiring and protection system of diesel handling equipment in case of leakage. - All required instruments such as tachometer, pressure gauges, temperature gauges, protection devices, sensors and transmitters for safe and

reliable working of the equipment shall be provided. Both the engine and alternator fitted on a common fabricated steel base plate with anti-vibration pads and both connected to each other by flexible flange coupling.

- As per CPWD general specifications for electrical works part-vii, the exhaust stack height in order to dispose exhaust above building height, minimum stack height should be as follows:

For DG set up to 1000KVA:

$$H = h + 0.2 \times \text{sqrt. (KVA)}$$

Where H = height of exhaust stack

h= height of building

8.2 Silent Diesel Genset

8.2.1 General Description

The diesel generator shall be totally enclosed on the cold rolled sheet steel Acoustic Enclosure. The acoustic enclosure shall be supported on a M.S. Channel Framework.

Suitable Insulated ducting is provided for air inlet/ outlet. Suitable louvers / sound attenuates/ bird guards are provided at all the openings for air inlet/ outlet top facilitate free airflow and to prevent sound leakage. Detachable partitions are provided inside the Acoustic Enclosure to prevent reverse flow of hot air. The insulated partition also helps in sound absorption. It is recommended that sufficient free space be provided on all the four sides for easy access. Generally, the Acoustic Enclosure is delivered at site as single unit. However, it can also be fabricated in sub-assemblies and can easily be constructed at site, if so desired. These enclosures are designed to be installed outdoor. However, for any specific application of installing the equipment indoor, Acoustic Enclosure is designed as per ventilation requirement at site.

8.2.2 Insulation

A layer of rock wool/ mineral wool is provided on all the sides of the Acoustic Enclosure, including base and roof. The rock wool / mineral wool is duly covered with tissue paper, which avoids any chances of small particles being sucked by the Diesel Engine air cleaner, at a later stage. The rock wool / mineral wool along with tissue paper is covered with G.L. perforated sheet to contain the insulating material in sheet framework, specially made for the purpose.

8.2.3 Doors

Suitable doors are provided to facilitate easy access and maintenance of the engine.

8.2.4 Locking Arrangement

Heavy-duty brass locks are fixed to provide air tight locking of the doors.

8.2.5 Packing

Suitable size of rubber packing is fixed on all the doors. Suitable packing is also provided at all such joints where any two metal parts are bolted to avoid entry of dust / water.

8.2.6 Ventilation

A careful study of the air requirement of the Diesel Engine (as per manufacturer's recommendation) is kept in view to facilitate smooth running of the machine within specified parameters i.e. oil pressure, temperature, etc.

8.2.7 Lighting

Suitable lighting arrangement is provided inside the enclosure to help easy maintenance of the Diesel Generator. The light point is required to be connected with 220V AC at site.

8.2.8 Exhaust Extension

The exhaust gas is taken out through the roof of enclosure with the help of flexible connector and M.S. Pipe. The inside portion of M.S. Pipe is clad with glass wool and aluminum sheet to avoid any heat dissipation inside the enclosure.

Specially designed Residential silencer is mounted on roof tops of enclosure / any other convenient place. The exhaust gas can be further extended to any other convenient location with the help of M.S. Pipe.

8.2.9 Painting

The Acoustic Enclosure is painted with two coats of polyurethane paint. Before painting, primer is applied after pretreatment by seven tank process, for making it suitable for installation in open areas.

8.2.10 Trunking

Suitable trunking is provided in the enclosure for routing of cable with proper glands.

8.2.11 Diesel Tank

For easy filling and monitoring, it is recommended that the Diesel Tank should be kept outside the Acoustic Enclosure. In such case suitable openings are provided in the Acoustic Enclosure for fuel piping.

If you require the fuel tank to be fit inside the enclosure, a compromise on the capacity of the fuel tank is desired.

8.3 Alternator

8.3.1 General

Alternator and accessories shall include, but not limited to generator, excitation system, automatic voltage regulator, generator control panel and relay panels. Alternator shall be self-excited ventilated with drip proof open screen protected construction. Alternator insulation shall be of class 'H'. It should have capacity of supporting short circuit current

in 3 phases for 3 seconds. Alternator shall have minimum reactance and low voltage waveform distortion. The line and neutral end of each phase winding of the Generator shall be brought out on six suitably located terminals. Contractor shall provide suitable clamping arrangement for connecting cable to the machine terminals. The terminals shall be suitably enclosed to prevent short circuits by rodents, etc. Suitable cable glands shall be provided on the enclosure to facilitate entry of the above cables. Voltage drop calculations shall be submitted to ensure that voltage drop during starting of biggest motor (when other loads are on) besides other loads does not exceed 15%. Suitable sizing shall be worked out and mentioned along with the bid.

230V single phase space heaters of adequate ratings shall be provided in the lower part of the stator frame. The generator shall be provided two (2) grounding terminals with clamps suitable for connecting to the separate GI earthing system exclusively for generator body. Similarly, minimum two copper earthing station pit shall be made of Generator neutral earthing resistance shall be maximum one ohm each for Generator body, Generator neutral.

8.3.2 Excitation System

The excitation system shall have brushless type rotating field or static exciter with rectifier. The response ratio of the excitation system shall be not less than 0.50. The excitation system shall be so designed and or protected, that harmful over voltage cannot occur at the main exciter due to combined effect of maximum exciter field current and machine over speed.

8.3.3 Voltage Regulator

- a) Continuous acting, non-dead-band type static automatic voltage regulators with accessories mounted in a suitable panel shall be provided for the generator. The automatic voltage regulator shall be capable of working over the whole load and voltage range of the generator.
- b) The voltage regulator shall be of continuously acting, high response, static type and shall be complete with the cross current compensation preferably of static type. The regulator shall be supplied complete with voltage setting device, all accessories and other contacts.
- c) AVR shall control generator voltage under steady state load conditions and over the whole of the operating range of exciter to within 1.5% of rated voltage.

8.4 Control Panel

Local engine control panel shall be provided for engine generator set. Also, a composite main control panel shall be provided for control, instrumentation and monitoring of the generator and associated equipment. The composite panel shall have all necessary metering, protection etc. for the isolated and synchronized operation of the diesel engine generating sets (if required).

The generator sets shall be provided with AMF panel. The AMF Panel shall have provision such that on switching over to DG supply; it shall not put all the drives into operation on load at a time. But the same shall be put into operation one by one with suitable time lag.

The control panel shall be floor mounted, comprising of volt-meter, ammeter, frequency meter, power factor meter, KW meter, energy meter, selector switches, circuit breakers of adequate capacity, indicator lamps duly wired with MCB.

Switch gear shall have drawn out circuit breakers with electro static over current, short circuit, earth fault with separate indications, ON/OFF indication, contactor ON indication, annunciator for all electrical and mechanical parameters with trip and alarm facility. Differential relay shall also be provided for alternators.

The alternator and control panel shall be connected with suitable capacity armored cable and complete with erecting, commissioning and testing as per manufacturer's requirements with filling of fuel, oil etc, with guarantee of complete system for one year. Alternator box shall be amended accordingly to accommodate total number of cables. The Diesel Generator set shall have monitoring system to monitor and give alarm with indication in case any of the following parameters are not normal in such cases the engine can be automatically / manually stopped.

- Low lube oil pressure.
- High cylinder head temperature.
- High jacket water temperature.

8.5 Testing

The following test shall be conducted on each alternator and D.G. Set.

Factory Test

- i. Routine Tests.
- ii. High Voltage Test.
- iii. Short circuit Current Test.
- iv. Instantaneous short-circuit withstand test.
- v. Insulation resistance test.

These tests shall be conducted as per the requirements of the original test certificates shall be furnished to the Employer/ PMC.

Site Tests

After the erection and wiring and earthing for DG set, the following tests shall be conducted:

- i. Insulation resistance of the generator.
- ii. Speed, no load voltage and full load voltage regulation.
- iii. Frequency at no load, half load and full load.

The readings shall be observed with calibrated meters. Only one meter shall be used for the tests. The reading shall properly tabulated and submitted in triplicate to the Engineer.

9. EARTHING AND LIGHTNING PROTECTION

Earthing system for the plant shall be carried out in compliance with the requirements of IS: 3043 and the following specifications-

Earthing system design and installation shall generally be as per IS: 3043.

The material of earthing conductor laid above ground or buried in concrete will be galvanized steel, while that of the conductor buried in soil will be mild steel. Fault current withstand time for sizing of earth conductor will be taken as 3 secs. While sizing the buried earth conductor, a corrosion allowance of at least 20% will be taken.

9.1 Pipe Electrode

GI pipe electrodes shall be of medium class, 40 mm dia and 3 m in length. Galvanizing of the pipe shall conform to relevant Indian Standard. GI pipe electrodes shall be tapered at the bottom and provided with holes of 12 mm dia drilled not less than 75 cm from each other and up to 3 m height from bottom. The electrode shall be buried in the ground vertically with the top not less than 200 mm below ground level.

9.2 Plate Earth Electrode

For plate electrodes, minimum dimensions of the electrode shall be 600 mm x 600 mm x 6 mm thick. Heavy duty CI/MS frame with cover shall be suitably embedded in the masonry enclosure.

9.3 Equipment Earthing Connection

Each transformer body and neutral, and lightning arrestor shall be connected to separate earth electrodes by two separate distinct earth lids. LT motors, switchgear, distribution boards and other electrical equipment shall be earthed at two separate points and connected to earth electrodes through above ground main earthing grid (65 x 10 mm x GI Flat) and 65 x 10 mm GI flat risers (from earth electrodes to above ground main earthing grid).

9.4 Earthing Pit

Earthing pit shall be of minimum 1200 mm x 1200 mm. An inspection chamber of size 300 mm x 300 mm x 300 mm in cement concrete of 1:3:6, 50 mm thick for side walls and 100 mm thick for bottom, shall be provided. The chamber shall be provided with CI cover on MS frame. The cover shall be hinged to the frame and shall be with padlocking arrangement. The frame and cover shall be painted with anticorrosive paint.

Size of earthing conductor shall be arrived as per calculations subjected to minimum rating suggested below:

Type of Equipment	Earth Conductor Size
Main Earthing Grid	65x10mm GI Flat

HT Panel, Main LT Switch board	50X6 mm GI Flat
Capacitor Panel	50X6 mm GI Flat
Local Push Button Station	14 SWG GI Wire
Motors, Lighting Distribution Board	25 X 6 mm GI Flat
Lighting and receptacle system	14 SWG GI Wire
Outdoor Street Lighting	8 SWG GI Wire
Cable Tray at suitable point	25 X 3 mm GI Flat
Hand Rails and metallic structure	25 X 3 mm GI Flat
Small equipment and instrument	8 SWG GI Wire
Transformer, DG set	50X6 mm GI Flat

9.5 Testing

The Engineer may ask the Contractor to carry out earth continuity tests, earth resistance measurements and other tests in his presence. The Contractor shall have to bear the cost of all such tests.

9.6 Lightning Protection

For tall structures and buildings, lightning protection system shall be provided as per relevant IS with horizontal and vertical air terminations, down conductors with test links and separate earth electrodes.

10 CABLE

10.1 XLPE Power Cables (11KV)

10.1.1 Applicable Standards

The materials shall conform to the latest editions of the following Indian/International Standards.

IS 7098 Part 2: 1985	XLPE insulated PVC sheathed cables for working voltages from 3.3 kV up to and including 33 kV
IS 5831: 1984	PVC Insulation and Sheath of electric Cables
IS 8130:1984	Conductors for insulated electric cables and flexible cords
IS 613:1984	Copper rods and bars for electrical purposes

IS 3975:1988	Mild steel wires, formed and tapes for armoring of cable
IS 10810:1984	Method of tests for cables
IEEE-383:1974	Standard for type test of class IE electric cables, field splices, and connections for nuclear power generating stations
ASTM-D2843, 1993	Standard test method for density of smoke from burning or decomposition of plastics
ASTM-D2863, 1991	Standard test method for measuring minimum oxygen concentration to support candle - like combustion of plastics (oxygen index).
NEMA-WC5, 1992	Thermoplastic Insulated Wire and cable for the transmission and distribution of Electrical Energy.
IEC:754	Test on gases evolved during combustion of electric cables
IEC:332	Test on electric cables under fire conditions - (Part I):1993 Test on a single vertical insulated wire or cable
IS 3961	Recommended current rating for cables – (Part II):1967 PVC insulated and PVC sheathed heavy duty cables
IS 10418:1982	Drums for electric cables

10.1.2 General Requirement

All cables shall be suitable for high ambient, high humid tropical Indian Climatic conditions. Cables shall be designed to withstand the mechanical, electrical and thermal stresses under the unforeseen steady state and transient conditions and shall be suitable for proposed method of installation.

Conductor shall be of uniform, of good quality, free from defects Aluminum copper. Insulation shall be Cross Linked Polyethylene (XLPE).

For 11 kV cables (Earthed Grade), conductor screen and insulation screen shall both be extruded, semi-conducting compound and shall be applied along-with XLPE insulation in a single operation by triple extrusion process. Method of curing for 11 kV shall be "Dry curing/ gas curing / Steam curing".

Cable shall be provided with copper metallic screen suitable for carrying earth fault current. For single core armoured cables the armouring shall constitute the metallic part of the screening.

10.1.3 Inner sheath

All armoured and multi-core un-armoured cables shall have distinct extruded inner PVC sheath of black color.

10.1.4 Armouring

Material for armour for Single Core Cable shall be Aluminum wire. For multicore cable it shall be GS wire/flat. Armouring shall be as per relevant IS and it shall have minimum 90% coverage.

Breaking Load of the joints shall be minimum 95% of the normal armour.

10.1.5 Outer Sheath

It shall be of black colour PVC (type ST2 as per IS 5831) with Cable size and Voltage grade embossed on it. Sequential marking shall be at every 1 (one) Meter distance. Word "FRLS" shall also be embossed on it at every 5 (Five) meter distance.

10.1.6 FRLS Properties

All cable shall be Flame Retardant, Low Smoke (FRLS) type. Outer sheath shall have the following properties:

Acid Gas Generation: Max 20% (as per IEC 754-1).

Smoke density rating: 60% (as per ASTM D 2843).

Flammability test - As per Swedish chimney test F3 as per SEN 4241475.

As per IEC 332 Part-3 (Category B).

Minimum bending radius shall be 10 D.

Repaired cables shall not be acceptable.

10.1.7 Current Rating of Cables

Normal current rating shall not be less than that covered by IS 3961. Vendor shall submit data in respect of all cables in the prescribed format.

De-rating factors for various conditions of cable installation including the following, for all types of cables shall be furnished.

- Variation in ambient air temperature.
- Variation in ground temperature.
- Depth of laying.
- Cables laid in the ground.
- Cables laid in trench.
- Cables laid in ducts.
- Soil resistivity.
- Grouping of cables.

The value of short circuit withstand current ratings of all cables shall be indicated for a short circuit for 1 second duration and should also specify the maximum temperature during short circuit.

10.2 1.1 KV LT Cable

All power and control cables for use on medium voltage shall be heavy duty type, aluminium /copper conductor. PVC/XLPE insulated, inner sheathed, armoured and overall PVC sheathed as described below.

The Power and Control cables shall have the following minimum overall cross sectional areas:

- a) Medium Voltage Power 2.5 sq.mm (Copper)
- b) Control Cables 1.5 sq.mm (Copper)
- c) Lighting Cables 2.5 sq.mm (Copper)

Cables up to 10 sq.mm conductor size have copper conductor, round steel wire armour. Above 10 sq.mm size aluminum conductor flat steel armour shall be used.

Cables shall be sized based on the maximum continuous load current and the voltage drop. The derating due to ambient air temperature, ground temperature, grouping of cables with each other etc. shall be taken into account. Below grade cables in paved areas shall be in concrete lined trenches with concrete covers having proper slope and suitable drainage arrangement to avoid water collection. In unpaved areas cables shall be in lined trenches or directly buried in ground. In hazardous areas and transformer bays, trenches shall be completely filled up with sand. Concrete lined cable trenches shall be sealed against ingress of liquids or gases wherever the trenches leave a hazardous area or enter control room or substation. The cable trenches shall be sized depending upon the number and voltage grade of cables. Where underground cables cross roadways, pipe sleepers at grade, etc., they shall be protected by being drawn through PVC sleeves/ducts or suitable RCC Pipes to provide a permanent crossing. Pipes laid for mechanical protection shall be sealed at both ends.

High voltage, medium voltage, control and signal cables shall be separated from each other by adequate spacing or running through independent pipes, trenches or cable trays as applicable. Cable trays, racks and trenches shall be sized to allow for future cables. Cable installation shall provide minimum cable bending radii as recommended by cable manufacturer.

Cable route markers shall be installed at every 30m interval all along the routes of directly buried cable trench and also at locations where the direction of cable trench changes.

All power and control cables shall be of continuous lengths without intermediate joints. Where joints are unavoidable, these shall be provided with the permission of Engineer-in-charge. All cables shall carry tag numbers for easy identification. In case of control cables all cores shall be identified at both sides by their terminal numbers Using PVC ferrules as per interconnection diagrams.

10.2.1 Insulation

The insulation shall be chemically cross-linked polythene conforming to the physical, electrical and ageing properties as required by IS 7098 (Part - II). Only natural colour compounds shall be used for insulation of cables. It shall be free from voids and shall withstand all mechanical as well as thermal stresses under steady state and transient operation conditions.

Insulation screening shall be in two parts, first non-metallic semi-conduction part and second metallic part. Non-metallic part shall be applied directly over insulation of each core and shall consist of tapped of extruded semi-conduction compound. On top of this, metallic screening of non-magnetic tap or braid or concentric serving of wire shall be applied.

In cables have three cores, the individual core shall be laid up with suitable non-hygroscopic fillers and then applied with common covering of PVC or thermoplastic material by extrusion or tapping such that circulation of cable is maintained. The sheath shall conform to requirements of type ST-2 compound of IS 5831. The thickness of sheath shall be as per IS 7098 (Part II).

The Armouring and outer sheath of XLPE cables shall be generally in line, as described above/elsewhere of this document. However, size and tolerance for XLPE Cables shall be as per IS 7098 (Part II), except for outer sheath to be of type ST-2 as per IS 5831.

10.2.2 Cable Accessories

- 10.2.3 All accessories like cable glands, lugs and terminal markings etc. shall be used conforming to relevant standards / as specified. The end termination for HT cables shall be heat shrinkable type. For 1100 V grade cables, Ni-Plated Brass Double Compression type glands WP to IP-65 as a minimum and tinned copper crimping type lugs shall be used.

10.3 Cable Laying

LV and control cables shall be separated from each other by adequate spacing or by running through independent pipes, trenches or cable trays. Cable Laying and termination shall be such that chances of cable getting damaged are remove.

LT cable shall be laid in cable tunnel or tray racks or buried underground with appropriate protection. Black shall indicate the neutral, while red, yellow and blue for three different phases. All LT cables when laid on the cable racks shall be properly dressed and clamped as required without crisscrossing and unnecessary overlapping. Cables shall be properly dressed and clamped.

10.4 Laying of LT underground cables

The cables shall be protected by filling outdoor trench bottom with a layer of sand after clearing the bottom from all rocks, stones and sharp objects, before the cables are placed. This sand shall be leveled and cables laid over it. These cables shall be covered with 150mm of sand on top of the largest diameter cable and sand shall be lightly compacted. A flat protective cover of 75mm thick second class red bricks shall then be laid and competed and then remainder of the trench shall then be backfilled with soil, rammed and leveled.

In routing, necessary barriers and spacing shall be maintained for cables of different voltages in case they lie side by side. Telephone cables shall cross the power cables only at about right angles and these two shall not run in close proximity.

Cable routing between cable trench and equipment/motors shall be taken through GI pipe sleeves of adequate size. Pipe sleeves shall be laid at an angle of maximum 45 Deg to the trench wall. Bending radii of pipes shall not be less than 8D. It is ensured that both ends of the GI pipe sleeves shall be sealed with approved WP sealing plastic compound after cabling. In places where it is not possible, cables shall be laid on smaller branch trays.

All cable shall be identified close to their termination point by cable tag numbers as per cable schedule. Cable tags shall be punched on aluminium straps (2mm thick, 20mm wide of enough length) securely fastened to the cable and wrapped around it.

Routes of these cables shall be arrived at on the basis of the relevant drawings and after consulting the Engineer in charge

10.5 Cable Terminations

- i. For termination of MV cables, single compression type glands shall be used for indoor locations. Glands shall be of brass, Lugs of Al / Cu or tinned copper shall be used as applicable, and lugs shall be properly crimped on conductors. All glands used must be of heavy duty type.
- ii. In outdoor areas, except within outdoor substation area, cables shall be laid directly buried between building entry/exit points. Within buildings, cables shall be laid on cable trays to be supported from building walls columns/ beams/floors / ceilings. In outdoor substation area, cables shall be laid on cable trays in buildup cable trenches. Ladder and perforated type cable trays shall be proposed. Side members of ladder type cable trays shall be fabricated using structural steel angles of at least 6 mm thick. Perforated cable trays shall be of the formed type made from 2 mm thick sheet steel. For supports, structural angles or channels of appropriate strength shall be proposed. Vertical runs of cable trays shall be enclosed using perforated sheets as above. Cable trays, supports and covers shall be painted with epoxy paint of shade acceptable to JDA. Tray width shall be so sized that at least future margin is available for addition at later date.
- iii. At road crossings Hume pipe/s of adequate size shall be provided at a depth of 1000 mm (center line depth) of passage of cables, earthing conductors etc. At building entry point's pipe sleeves of GI or PVC shall be provided for the passage of cables and earthing conductors, such sleeves shall have projections on either side to facilitate extension.

10.6 Fire Proof Sealing (FPS) System

Fire proof sealing system shall be provided and shall consist of:

Fire-stops / fire-seals for sealing of cable / cable tray and conduit / pipe penetrations, both horizontal and vertical, through brick or RCC walls / floors, to prevent the spread of fire from one area to other areas by fire-resistant barriers.

The FPS system shall also include all the necessary accessories and equipment required for supporting, holding in position, fixing and installation of the fire-stop.

The FPS system shall comply in all respects with the requirements of the codes and standards mentioned herein IEC-331 and IEC-332.

10.7 Fire Stop / Seal

The FPS system adopted for cables or cable trays penetrating through walls and floor openings, or cables passing through embedded conduits / pipes / pipe-sleeves, constitutes a 'fire stop / seal', which is meant to prevent spreading of fire between areas separated by fire-resistant barriers.

10.8 Test

- a) Routine tests as per IS: 1554 shall be carried out for each type % size of cables used for the project. Type test certificates to be furnished. In absence of type certificates for each test shall have to be carried out without any extra cost to the Employer/PMC.
- b) At site after installation, HV test and continuity test shall also be done on cables: The LT cable termination shall include the following:
 - i. Making necessary holes in bottom gland plates for fixing cable gland.
 - ii. Fixing cable gland, connecting armour clamp to cable armour.
 - iii. Dressing cable, provide termination kit, necessary to make termination complete.
 - iv. Putting cable lugs, crimping them on to cores of cables, taping base conductors up to lugs wherever necessary.
 - v. Termination of individual core to equipment terminals.
 - vi. Supply and fixing of cable and core identification ferules.

11. LT BUS DUCT

11.1 General

The following to be considered during Design and Manufacturing of Bus duct:

- Sufficient working space to operate on the farthest bus bar joint / bolt shall be maintained.
- All opening-mating surfaces like surface inspection openings etc., shall be gasketed using Neoprene gasket with sufficient overlap.
- Provision for draining moisture shall be provided. Provision of insulated separators between the adjacent flexible joints.

11.2 Standards

IS:8623	Factory built assemblies of switchgear and control gear for voltage up to and Part (II) including 100V AC and 1200V DC – Particular requirement for bus duct trunking system
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IS:11353	Guide for uniform system of marking and identification of conductors and apparatus terminals
IS:5578	Guide for marking of insulated conductors
IS:1271	Thermal evaluation and classification of electrical insulation
IS:10026	Insulating varnishes containing solvents
IS 5082	Wrought aluminium and aluminium alloy bars, rods, tubes and sections for electrical purposes
IS:3043	Code of practice for earthing

Wherever Indian standards do not exist, the equipment/components shall be designed, assembled and tested in accordance with the latest editions of International standards.

11.3 Scope of Supply

The bus duct shall include the following based on the requirement (for each bus duct).

- Straight Run in Standard length.
- 90-degree bends.
- One - Adapter box with tinned copper flexible for connection at transformer end.
- One - Adapter box with aluminium flexible for connection at switchgear panel.
- One set of wall frame assembly with FRP sealing plate for wall entry.
- Laminated Aluminum Expansion joints in straight run as required shall be provided in every section of 4 m.
- Space heaters shall be provided every section of 4 m.
- One set of galvanized supporting structure for complete bus duct trunking.
- Silica gel breather at suitable length.
- Inspection covers to access insulators, joints, etc., k. Rubber bellows as required shall be provided.

11.4 Technical Specification

The following to be considered during Design and Manufacturing of Bus duct:

- Sufficient working space to operate on the farthest bus bar joint / bolt shall be maintained.
- All opening-mating surfaces like surface inspection openings etc., shall be gasketed using Neoprene gasket with sufficient overlap.
- Provision for draining moisture shall be provided. Provision of insulated separators between the adjacent flexible joints.

11.5 Construction

- The bus trunking will be used for interconnection between LT transformer and LT switchboard.
- The bus bars and bus bar supports shall withstand the maximum thermal and electromagnetic stresses and strains due to the maximum short circuit current corresponding to the fault level indicated, without any deformation, deterioration or damage. Span and arrangement / type of insulator shall be in-line with the type tested prototype.
- Suitable provisions shall be made for the expansion of the bus bars caused by temperature variation/thermal expansion. Due consideration shall be given to proximity / skin effects and reactance, while choosing the sizes of the bus bars and spacing.
- Appropriate identification markings/labels shall be provided on the bus bars and tapings for distinguishing the various phases and neutral.
- Additional busbar supports for the bus bars shall be provided at all bends.

11.6 Busbar Joints

- All joints of bus bars shall have effective treatment (Thoroughly cleaned to remove any Aluminum oxide layer prior to joining and applied with sufficient quantity of Oxide inhibiting grease) for maintaining the conductivity of the joints as per relevant standards.
- Busbar joint contact surfaces are silver plated. Bimetallic strips shall be made between copper and aluminum conductors for the prevention of any electrolytic action. Sufficient clearances shall be ensured at all joints.
- Straight through in standard length shall be provided.

11.7 Enclosure

- Composition of material of enclosure shall be chosen to avoid any possible hysteresis effect on the bus trunking. Wall cross over assembly shall have hot dipped galvanized after fabrication.
- Bus trunking enclosure and its terminations on the equipment shall be designed in such a way that vibrations of the 415V Switchgear and transformer shall not be transmitted to them. The entire bus trunking shall be made dust and vermin proof.
- Special care shall be taken while designing the joints of bus trunking unit to prevent any moisture getting inside through joints.
- Arrangement offered shall be proven and type tested one and easy for maintenance (Especially features like sufficient space for inspection of Bus bar joint tightness using torque Wrench without removing anything). All similar parts of equipment shall be interchangeable

11.8 Earthing

- Two copper earth flat green painted and tinned of 50X6 mm shall run along the entire length of bus trunking.

- A minimum of two terminals, shall be provided on both ends of earth bus for external connections to earth grid with connecting hardware.

11.9 Testing

Routine Tests

- Measurement of resistance.
- High voltage test.
- Insulation resistance test (before and after the HV test).
- One (1) minutes power frequency dry and wet with stand voltage 2.5KV.

Site Tests

- Check for physical damage.
- Check for tightness of fixing bolts, nuts, clamps, etc.,
- Check for earth connections.
- Check for cleanliness of insulators.
- Check for name plate details as per specifications.
- HV Test.
- Insulation resistance test.

Any other physical check as recommended by equipment manufacturer/Indian Standards/Codes for Practice. Any other pre-commissioning tests as recommended by the manufacturer

12. POWER CAPACITORS WITH APFC PANEL

Capacitors shall comply with IEC 60871 and IS 5553, 13925 including those standards referred to therein.

12.1 Construction of Power Capacitor

- a) The internal elements of the capacitor unit shall be made of synthetic films or Kraft paper sandwiched between synthetic films as an insulator and aluminium foil as an electrode.
- b) After congregating several numbers of these elements, the capacitor unit shall be thoroughly dried under high temperature and vacuum condition, and impregnated with synthetic insulation oil of high purity which has been beforehand completely degreased of harmful impurities not to leave any gas in the container which may cause deterioration of the dielectrics.
- c) The container shall be metal enclosed having ample strength and flexibility, and shall be capable of adjusting the volume in the container against expansion and contraction of the impregnating oil due to change of temperature.
- d) The power capacitor shall have suitable mechanical fault detector to protect the capacitor from internal faults.

- e) The detector shall be provided with the capacitor.
- f) Upon detection, the faulted capacitor shall be removed from the circuit to prevent container rupturing.
- g) Discharge device shall have function to discharge of residual electric charge can be reduce to 50V or less within five (5) seconds at the capacitor terminal.
- h) Power factor compensation above 300 KVAR is to be provided with synchronous motor and condenser.

12.2 Feature of APFC Panel

- a) The APFC panel shall be connected on main panel and the pF improvement panel shall have separate capacitors to improve the pF of the system upto 0.98 during no load and full load conditions.
- b) At least five steps shall be provided for switching
- c) Auto control is preferred to eliminate the human error.
- d) The capacitor banks shall be complete with all parts that are necessary or essential for efficient operation.
- e) The capacitor bank shall be complete with the required capacitors along with the supporting post insulators, steel rack assembly, copper bus bars, copper connecting strips, foundation channels, fuses, fuse clips, etc. The steel rack assembly shall be hot dip galvanized.
- f) The capacitor bank may comprise of suitable number of single phase units in series parallel combination. However, the number of units in series shall be such that failure of one unit shall not create an over voltage on the units in parallel with it, which will result in the failure of the parallel units. The complete banks with its accessories shall be metal enclosed (in sheet cubicle), indoor floor mounting and free standing type.
 - i. The assembly of the banks shall be such that it provides sufficient ventilation for each unit. Necessary louvers shall be provided in the cubicle to ensure proper ventilation.
 - ii. Each capacitor case and the cubicle shall be earthed to a separate earth bus in the cubicle.
- g) Each capacitor unit/bank shall be fitted with directly connected continuously rated, low loss discharge device to discharge the capacitors to reduce the voltage to 50 volts within one minute in accordance with the provisions of IS:13295.
- h) Each unit shall be non-inflammable dielectric immersed self-cooled and hermetically sealed.
- i) Each unit shall satisfactorily operate at 135% of rated KVAR including factors of over voltage, harmonic currents and manufacturing tolerance. The units shall be capable of continuously withstanding satisfactorily any over voltage up to a maximum of 10% above the rated voltage, excluding transients.
- j) The capacitor shall be of the self-healing type with a very low loss dielectric.

- k) All the material employed in the manufacture of capacitor shall be nontoxic and biodegradable.
- l) The expected life of the capacitor shall not be less than 1, 60, 000 hours.
- m) The p. f. correction capacitor shall be designed in such a way that they, not only, withstand high RMS current, but also to work under sustained harmonic overloads.
- n) The capacitors shall be characterized by the dielectric impregnated with biodegradable synthetic oil.
- o) The dielectric shall consist of films of polypropylene and paper.

12.2.1 Unit Protection

- a) Each capacitor unit shall be individually protected by an MCB/Contactor suitably rated for load current and interrupting capacity, so that a faulty capacitor unit shall be disconnected by the fuse without causing the bank to be disconnected. Thus, the fuse shall disconnect only the faulty unit and shall leave the rest of the units undisturbed. An effected fuse shall give visual indication so that it may be detected during periodic inspection.
- b) The fuse breaking time shall co-ordinate with the pressure built up within the unit to avoid explosion. Mounting of the individual fuse may be internal or external to the capacitor enclosure
- c) The fuse unit and the wires and cables chosen for the capacitors of double the current carrying capacity of the normal permissible current. Similarly, the ammeter and current transformer shall also be designed accordingly.

12.3 Power Factor Correction Relay

- a) The relay shall be microprocessor based digital solid-state type and switching device shall be solid state relay giving signal to contactors for switching ON/OFF preset number of capacitor units.
- b) The relay shall be suitable for automatic/manual control of power factor correction capacitors on three phase system. It shall detect the power factor lagging and leading reactive power (KVAR) component above present levels and then switch the appropriate number of capacitors "IN" or "OUT" to achieve the optimum average power factor without system operating under leading power factor condition.
- c) This relay/device shall have low VA burden and final switching of approximate capacitor banks shall be achieved by switching on the contractors/breakers through initiation of this device.
- d) The relay shall be provided with facility to automatic self-adjustment to any capacitor step value.
- e) The relay unit shall be provided with digital indication of power factor, preset parameters and specified installation data, no-volt relay feature to immediately disconnect all capacitor in the event of power failure, over temperature / over voltage/ harmonic over load protection, remote fault alarm indicator, power factor correction fault, LEDs for banks on inductive load, capacitive load, manual mode

indication, remote alarm tripped, multiplication factor indication, and power on, manual bank and programming on button, manual bank and programming off button, manual / automatic button, alarm reset button, data scrolling button and 3 digit display.

12.4 Tests

All tests shall be conducted in accordance with the latest edition of IS: 22534 and as applicable for the controls. Type test certificates for similar capacitor units shall be furnished.

13. LOCAL PUSH BUTTON STATION

These shall be of heavy duty construction and with the smaller sizes designed for mounting on or near the equipment to be controlled. The bottom face shall be arranged to accept with adequate space for the use of spanners, gland terminations for the number of cables required. Cables shall enter from the top generally. Terminals provided for interconnections shall be easily accessible and marked with identification numbers/ letters corresponding with the associated diagrams. Indicator lamps shall be not less than 20mm diameter and have projecting lenses with a wide angle of vision.

Pushbuttons and selector switches shall be of heavy duty, oil tight type of matching design. Legend plates shall be provided to identify equipment to be controlled and the purpose of each operating or indicating device. Pendant type control for cranes, hoists, etc. shall be of moulded neoprene or equivalent heavy flexible, high impact strength materials, with a long moulded-in cable strengthening sleeve, to minimize the possibility of cable fracture at the bending point. The enclosure shall be colored in safety yellow.

14. LIGHTING SYSTEM

All internal and external areas shall be provided with lighting. The average illumination levels to be achieved shall be as follows:

Area	Lux
Office and Labs	300
Switchgear Room	250
Control Room	300
Pump House	200
DG Area	50
Other Indoor Areas	150
Outdoor Walkways	50

Building Entrance	100
Outdoor Area	50
Transformer Area	100
Roads	15-20

14.1 General

The illumination system shall consist of lighting poles, lighting distribution boards, lighting panels / power panels complete with MCCB/ELCB/MCB, Fixtures, Cables, , cable glands, 3 pin 5A/15A convenience socket outlets, conduits and accessories and supporting and anchoring materials, lighting fixtures with fluorescent tubes, sodium vapour lamps, wires, etc. All materials, fittings and appliances use in electrical installation shall conform to the relevant IS specifications, required area classification and environmental conditions.

The wiring for lighting circuits shall be done by wires run in PVC conduits for indoor areas. For outdoor lighting, wiring shall be done by armoured cable.

14.2 Lighting Fixtures

14.2.1 Luminaries

- Luminaries shall be designed for continuous trouble-free operation without reduction in lamp life or without deterioration of materials and internal wiring. Outdoor fitting shall be weather-proof and rain proof type confirming to minimum IP-54 protection.
- The luminaries shall be designed so as to facilitate easy maintenance. Including cleaning, replacement of lamps/ starters etc.
- Connections between different components shall be made in such a way that they will not work loose by small vibration.
- All luminaries shall be supplied complete with lamps suitable for operation on a supply voltage and the variation in supply voltage and frequency indicated in the Employer's Requirement.
- CFL with accessories like lamps, power factor improvement capacitors, starters, re-wire able fuse and fuse base. These shall be mounted as far as possible in the luminary housing only. If these cannot be accommodated integral with the Luminaries then a separate metal enclosed control gear box shall be included to accommodate the control accessories together with a terminal block suitable for loop-in, loop-out connections. Outdoor type fixtures shall be provided with outdoor type weather-proof box. No mercury vapor lamps shall be used indoor and outdoor lighting. Mainly sodium vapor lamps shall be used for outdoor lighting.
- CFL Luminaries with single or double lamp shall be provided with electronic ballasts and these luminaries shall be used up to maximum height of five meters.
- Each luminary shall have a terminal block suitable for loop-in loop-out and T-off connection by 250/ 400V, 1 core, PVC insulated copper / aluminium conductor wires

up to 4 sq. mm. in size. In outdoor areas the termination at the luminary shall be suitable for 1100V, PVC insulated, copper / aluminium conductor, armored cables of sizes up to 6 sq. mm. alum conductors or suitably sizes cable as per design. Terminals shall be of stud or clamp type. The internal wiring shall be by means of insulated copper wire of minimum 1.5 sq.mm. Size and terminated on the terminal block. Terminal blocks shall be mounted with minimum two fixing screws.

- h) Mounted facility and conduit knock-outs for the luminaries shall be provided.

14.2.2 Earthing

Each Luminary and control gear box shall be provided with an earthing terminal. All metal or metal enclosed parts of the luminary/ control gear box shall be bonded and connected to the earthing terminal so as to ensure satisfactory earthing continuity.

14.2.3 Painting/ Finish

- a) All surfaces of the luminaries control gear housing accessories shall be thoroughly cleared and degreased. It shall be free from scale, rust, sharp, edges and burrs.
- b) The luminary housing shall be stove-enameled/ epoxy stove-enameled – vitreous enameled or anodized as indicated under various types of fittings.
- c) Flame proof luminaries shall be considered in all gas handling and other hazardous areas along with its control gear.

14.3 Indoor Decorative Luminaries

Luminaries shall be suitable for use with twin or single T. L. 28 watt 240 V fluorescent lamps, comprising of CRCA sheet steel channel stove enameled grey which incorporates all electrical accessories like quick fit lamp holder, starter holder, polyester filled ballast, power factor correction capacitor and duly pre wired up to the terminal block, with earthing arrangement facility, cover made for channel from CRCA sheet stove white enameled covering the channel fixed by twin screw, suitable for ceiling or pendent mounting, reflector plate for acrylic diffuser and end covers, complete in all respects ready for use. The luminaries shall conform to IS: 1913.

14.4 Industrial Luminaries

Luminary shall be suitable for use with single or twin T.L 28 watts 240 V fluorescent lamps comprising of Rail made of CRCA sheet steel stove enameled white, incorporates all electrical accessories like quick fit lamp holders, starter holder polyester filled ballast and power factor correction capacitor and duly provided up to the terminal block with earthing arrangement facility suitable for ceiling or pendant mounting with stove enameled reflector gray outside and white inside which can be installed without aid of any; tools, complete in all respects and ready for use. The luminaries shall conform to IS:10322.

14.5 Emergency Light

Emergency light unit working on 230 volts. A.C. supply shall be self-containing unit with 20 watts florescent lamp type 'SWITCH ON MAIN FAILURE. It shall be electronic automatic

fluorescent type which incorporates a unit trickle charge circuit, which shall prevent over charging or battery. The battery shall be maintenance free. The unit shall provide 4 hours illumination following power failure. The units shall generally conform to IS; 9583.

14.6 Wiring / Conduit System

14.6.1 Surface Conduit Wiring System

PVC conduits pipes of approved minimum 1.6mm wall thickness shall be used. The maximum number of the minimum PVC conduit diameter shall not be less than 25 mm. Maximum numbers of wires permissible in a conduit shall be seven/nine for wire size of 2.5 sq.mm/ 1.5 sq.mm respectively.

In long distance straight run of conduit, inspection type junction box at reasonable intervals shall be provided.

14.6.2 Fixing of Conduit

Conduit pipes shall be fixed by heavy gauge clamps, secured to suitable wood plugs or other approved plugs with screws in an approved manner at an interval of more than one meter but on either side of the couplers bends, or similar fittings, saddles shall be fixed at a distance of 30 cm from the center of such fittings. The saddle should not be less than 24 gauges for conduits up to 25 mm dia and not less than 20 gauges for larger diameter.

Where conduit pipes are to be laid along the trusses, steel joints etc. the same shall be secured by means of ordinary clips or girder lips as required by the Engineer-in-Charge. Where it is not possible to drill holes in the truss members, suitable clamps with bolts and nuts shall be used. The width and the thickness of the ordinary clips or girders clips and clamps shall not be less than as stated below.

14.6.3 Recessed Conduit Wiring System

Recessed PVC conduit wiring system shall comply with all the requirements of surface conduit wiring system specified in clauses above and in addition to the requirements specified in the following clauses.

The chase in the wall shall be neatly made and of ample dimensions to permit the conduit to be fixed in the manner desired. In the case of buildings under construction, fixed work, special care shall be taken to fix the conduit and accessories in position along within the building work, to avoid damage to the finished wall etc.

All outlets such as switches, wall sockets etc. shall be flush type. The outlet box shall be same as above and shall be mounted flush with the wall. The metal box shall be efficiently earthed with conduit by an approved means of each attachment.

14.7 Capacity of Circuits

Lights and fans may be wired on a common circuit, such circuit shall not have more than a total of ten points of light, fan and socket outlet or a load of 800 watts whichever is less. Power circuits on buildings shall be designed with a maximum of two outlets per circuit, based on the loading. Where, not specified the load shall be taken as 1 KW per outlet.

Wherever the load to be fed is more than 1 KW it shall be controlled by an isolator switch or miniature circuit breaker.

14.8 Outdoor Luminaries

The luminaries shall be - 70/150 watt H.P.S.V. or Metal Halide Lamps complete with all accessories and shall be Deep drawn aluminum reflector stove enameled grey outside and brightened and anodised inside lined with felt gasket to prevent insect entry.

Die cast aluminum housing covered with a lid shall be provided to accommodate all electrical accessories, such as independent ballast, powers factor improvement capacitor, wired up to terminal block.

A clear acrylic cover shall be fixed to the reflector by means of 4 toggles. The luminaries shall be mounted on the mast arm of 50 mm O.D. - Mirror compartment and tray compartment shall have minimum degree of protection IP-43 aluminum sheet and be painted to stove enamel grey outside and brightened and anodised inside.

14.9 Flood Lights

Flood lights luminaries shall be H.P.S.V. - 250 W lamp complete with all accessories.

The luminaries shall comprise of:

Housing made of aluminum alloy of low copper content for greater corrosion resistant, cooling fins shall be provided for effective heat designs. The housing shall accommodate reflectors made form, highly purity aluminum elector chemically brightened and anodised.

The housing shall be closed from the front by heat resistant toughened glass with silicon gaskets and held in a ring.

The rear cover also made of cast aluminum alloy of low copper content shall be provided with cooling fins. The rear cover shall accommodate a lamp holder, a lamps support internal earthing terminal, reflector setup. The lamp holder should be duly wired up to or terminal block.

The luminaries shall be using in conduction with the suitable control gear box. Minimum Degree of protection shall be IP - 54.

The housing shall be of cast aluminum LM 6 Grace (High Silicon and low copper) M.B.V. treated. The housing bracket shall be M.S. hot dip galvanised.

The reflector casing shall be high purity aluminum electrochemically brightened and anodized.

The front cover glass shall be heat resistant and toughened provided with gasket silicon rubber.

14.10 Lighting Poles

Street light poles shall be steel tubular or hot dip galvanized, of required mounting height with M.S. base plate with pipe cap and over hung 1 meters long having dia to suit the socket of 70/150 watts. 240V, High Pressure sodium vapour lamp.

Flood light pole shall be steel tubular or hot dip galvanized, of required mounting height with MS base plate and top channel suitable for mounting 250 watt, 240V High Pressure sodium vapour lamp.

14.11 Earthing of Lighting Poles

All external poles are to be looped together with continuous 8SWG GI earth wire clamped dollies provided on every fuse box of poles and looped onwards to the other pole. Every fifth pole shall be connected to earth through an earth electrode.

14.12 Accessories for Luminaries

14.12.1 Reflector

- The reflectors shall be made of CRCA sheet/ aluminum/ silvered glass/ chromium plated sheet copper as indicated for above mentioned luminaries.
- The thickness of steel/ aluminum shall comply with relevant standards. Reflectors made of steel shall have vitreous enameled finished. Aluminum used for reflector shall be anodized/ epoxy stove enameled/ mirror polished. The finish for the reflector shall be as indicated for above mentioned fittings.
- Reflectors shall be free from scratches or blisters and shall have smooth and glossy surface.
- Reflectors shall be readily removable from the housing for cleaning and maintenance without disturbing the lamps and without the use of tools. They shall be securely fixed to the housing by means of positive fastening device of captive type.

14.12.2 Ballasts (Electronic)

- The ballasts shall be designed to have a long service life, low power loss and high power factor.
- Ballasts shall be mounted using self-locking, anti-vibration fixings and shall be easy to remove without demounting the fittings. They shall be in dust tight, non-combustible enclosures.
- Electronic ballast shall have very high power factor (more than 0.95) and harmonic distortion shall be less than 10%.
- Voltage variation of ballast shall be between 140-320V.

14.12.3 Lamps

High intensity discharge lamp

These lamps include high pressure metal halide lamps and high pressure sodium vapor lamps.

High pressure sodium vapor lamp shall be with polycrystalline translucent, coated discharge tube, coated shell, quick restrike time (of within 5 minutes) and with burning life (above 10, 000 hours) in standard rating up to 400 watts.

14.13 Lighting System Equipment

14.13.1 Main Lighting Distribution Boards and Lighting Panels

Construction Features

Boards and panels shall be sheet steel enclosed and shall be fully dust and vermin proof, providing a degree of protection of IP-52. Outdoor panels shall in addition be completely weather-proof with a sloping canopy for protection against rain and providing a degree of protection of IP-55. The sheet steel used for frame shall be cold rolled of 2.0mm thick or 2.5 mm hot rolled and all frame enclosures, doors, covers along with partitions will be of same thickness.

All boards and panels shall be provided with hinged doors for access to equipment. Doors shall be gasketed all round with neoprene gaskets. For the main floor mounted distribution boards with the switch fuse units arranged in tier formation, the hinged door of each unit shall be interlocked so as to prevent opening of the door when the switch is ON and to prevent closing of the switch with door not fully closed. However, a device for by-passing the door interlock shall be provided to enable the operation of the switch with the door open, when necessary, for examination/ maintenance. For wall mounting 1-phase ways lighting panels wherever provided with MCBs, arranged latched front door shall be provided with key-locking facility and slotted Bakelite sheet shall be provided inside. Only the MCBs operating knobs or the fuse cap covers shall project out of the Bakelite sheet slots for safe operation and neat appearance. Incomer to lighting panels shall be provided with TPN MCB with RCCB. Lighting panels shall be manufactured with 1.6 mm cold rolled sheet.

All accessible live connections/ metals shall be shrouded and it shall be possible to change individual fuses, switches, MCBs from the front of the board's panels without danger contact with live metal. For floor mounting type distribution boards, adequately sized mounting channel shall be supplied and for wall/column/ structure mounting type panels' suitable mounting straps shall be provided.

Adequate interior cabling space and suitable removable cable entry plates shall be provided for top/ bottom entry of cables through glands and or conduits as required. Necessary number of glands to suit the specified cable sizes shall be provided. Cable glands shall be screwed on type and made of brass. Two earthing terminals shall be provided. All sheet steel parts shall be undergoing rust-proofing process which should include degrading de-scaling and a recognized phosphating process. The steel works shall be then painted with two coats of Zinc-chromate primer and two coats of final stove-enameled finish paint of specified colours.

14.13.2 Receptacles (Lighting and Small Power)

- a) Decorative and industrial type units of above shall be proposed in all Pumping station areas, offices, stores, control room and they shall be located at least two numbers in each room. Distance between two receptacles shall not be more than 8 – 10 mtr. All small 5 amps 5 pin lighting and small power sockets shall be wired by multi stranded copper wire of 2.5 sq. mm laid in rigid MS conduits along with earth wire of 1.5 sq.mm flexible copper wire or equivalent size armored cables. All wiring shall be coded with Red, Yellow, Blue and Black as per the phase used. If required, wiring can be done

alternatively through armored copper cables of similar size laid in MS perforated trays of minimum 2.0 mm thick.

- b) Three phase power receptacles (convenience outlets) suitable for operation of 415V, 3 Phase 4 wire, and 50 Hz power supply shall be proposed. The switches and sockets shall conform to relevant standards. These units shall be housed in epoxy painted sheet steel boxes and shall be suitable for outdoor installation. The units shall be fed from power distribution boards / switchgear etc. located in relevant areas in indoor areas one such unit shall be provided to cover areas of 20-meter radius (or at least one in each room housing plant items) and in outdoors areas on such unit shall be provided at 50-meter interval. Actual; requirement of such units shall be finalized during detailed engineering. One three phase receptacle shall be provided near entrance of each building for utilities like welding.
- c) Single phase 15 Amp 5 Pin / 6 Pin receptacles will be provided in each room and in halls they will be provided in such a way that with 15 meter cord we should reach every place in building. These shall be wired with 4 sq. mm copper earth wire in MS rigid conduits along with 2.5 sq. mm earth wire. Not more than two sockets shall be looped in one circuit. Alternatively, they can also be connected through armored cable of 4 sq. mm running in appropriate cable trays.

14.13.3 Ceiling Fans and Exhaust Fans

Ceiling fans shall be provided in areas such as offices, stores etc. Adequate ventilation arrangements shall be made for enclosed areas where ceilings fans are not proposed to be installed or cannot be provided. Power supply for the ceiling fans shall be derived from lighting circuits. Ceiling fans shall be complete with all accessories. Regulators shall be electronic type. Heavy duty exhaust fans shall be installed in pumping station as to achieve a 12 air changes per hour.

The number of ceiling fans to be provided shall be governed by the following:

- a) One no. 1200 mm sweep fan shall service not more than 10sq.m floor area.
- b) One no. 1400 mm sweep fan shall service not more than 15sq.m floor area.

14.13.4 Tests

- a) Type tests, acceptance tests and routine tests for the lighting fixtures, accessories and receptacles covered by this specification shall be carried out as per the relevant standard.
- b) Manufacturer's type and routine test certificates shall be submitted for tests conducted as per relevant standards for the fixtures, accessories and receptacles.
- c) The following routine tests shall be conducted as per the relevant Indian Standards.
 - i. Each fixture shall be tested at 1500 Volts (rms), 50 Hz, AC for one minute and no flash over or breakdown shall occur between current carrying parts and ground.

- ii. Insulation resistance of each fixture shall be tested at 500 V DC and the insulation resistance so measured shall not be less than 2 megaohms between all current carrying parts and ground.
- iii. All luminaries provided with glass covers shall be subjected to thermal shock-proof test. This test shall be conducted to ensure that the cover glass will withstand sudden variation in surface temperature due to rainfall or splashing water when the lighting fixture is lit. The cover glass shall be heated in an oven to attain a steady temperature of 1000 C and then plunged into cold water. No crack should develop.
- iv. Contractor shall ensure use of calibrated test equipment having valid calibration test certificates from standard laboratories traceable to National.

15. INDUCTION MOTOR

15.1 Scope

This specification covers the requirements of three phases of induction motors. Suitable induction motor in TEFC enclosure foot mounted type construction for indoor and outdoor installation and for operation on 3 phase, 415V 50 c/s, AC supply having continuous rating and 'F' class of insulation, with temperature rise limited to class B, with at least 20% power margin on the maximum power absorbed in the entire operating range 15% at duty point whichever is higher are to be provided for driving various pumping sets/ other equipment covered under the contract.

The tender while quoting should furnish the power factor at no load, 50%, 75% and full load.

15.2 Performance

Motors shall be capable of satisfactory operation for the application and continuous duty as required by the driven equipment.

Motors shall be capable of giving rated output without reduction in the expected life span when operated continuous under either of the following cases of supply conditions:

Variation of supply voltage from the rated Voltage: +/- 10%

Variation in supply frequency from the rated frequency: +/- 5%

Combined voltage and frequency variation: +/- 10%

Motor shall be suitable for the method of starting specified. All electric motors are to be operated through suitable starters complete with single phase protection device. For motors up to 3.7KW starters should be D.O.L and for all other motors above 3.7KW starters should be star/ delta air break type with protective devices suitable for 400/415 Volts, 50c/s, AC supply. For motors above 75KW suitable soft start type starters should be quoted. The starters should be complete with suitable cable end box and glands for cable entry.

Motors shall be capable of starting and accelerating the load with the applicable method of starting without exceeding acceptable winding temperature, when the supply voltage is 85% of the rated voltage.

The locked rotor current of squirrel cage motors shall not exceed 600% rated current.

Motors shall be designed to allow the required number of consecutive starts.

15.3 Direction of Rotation

Motors shall be suitable for either direction of rotation. Ample space shall be provided at the terminal box for interchanging external lead for change of direction of rotation.

The degree of protection for motor shall be IP-55 standards.

15.4 Insulation

Any joints in motor insulation such as at coil connections or between slot and end winding section shall have strength equivalent to that of the slot section of coil.

The insulation shall be given tropical and fungicidal treatment for successful operation of motor in hot, humid and tropical climate as per the applicable standard.

For motors specified for outdoor execution the account shall be taken of heating due to the direct solar radiation.

Motors shall be provided with class F insulation with temperature rise tested to B class insulation.

15.5 Construction

Material of Construction	
Casing	Cast Iron, IS:210, FG 260
Impeller	2.5% Ni-Cast Iron, IS: 210.FG 260
Shaft	SS, AISI:410
Motor Housing	Cast Iron, IS:210, FG 260
Stator/Rotor Core	CRGO Steel
Stator/Rotor Winding	Electrolytic Grade Copper Wire/Bar
Fasteners	SS, AISI:316
Auto Coupling System	Cast Iron, IS:210, FG260
Lifting Chain, Guide Pipe	SS, AISI:410

For squirrel cage motors the rotor bars shall not be insulated in the slot portion between the iron core lamination and the bars. Also include for moisture detector, temperature indicator and temp sensor for bearing

Bearing shall permit running of motor in either direction

If oil lubricated type bearings are provided, a drain plug and oil level sight glass shall be provided.

Terminal box shall be of weatherproof construction suitable for outdoor service. Gaskets shall be provided at the cover joints and between box and the motor frame.

Terminal box shall be suitable for side entry of cables and it shall be mounted on top of the motor. Further it shall be capable of being turned through 360-degree C. in steps of 90-degree C.

Terminal box shall be complete with stud type terminals, plain washer, spring washer, check nuts, cable glands and lugs.

When TEFC type of enclosure is specified fans mounted on the motor shaft shall be provided.

Unless specified otherwise the motor shall be provided with a bare shaft extension having a key slot and a key at the driving end.

Two (2) numbers drain holes at the bottom of stator frame shall be provided.

Motors shall have grease lubricated ball or roller bearings. Bearing shall be adequate to absorb axial thrust from the driven load together with any thrust produced by the motor itself. Bearing shall be capable of grease injection from outside without removal of covers with motor in running condition. The bearing boxes shall be provided with labyrinth seals to prevent loss of grease or entry of dust.

All TEFC motors shall be self-ventilated fan cooled. The fans shall be cast iron, diecast aluminum or poly propylene. The fan shall be corrosion resistant. They shall be suitable for rotation in either direction without affecting the performance of the motor.

The rotor shall be dynamically balanced to provide a low vibration level.

All motors of 30 KW and above shall be provided with lifting hooks of adequate capacity.

All motors of 30 KW and above shall have anti-condensation heaters operated on 240 V supply.

Two earth terminals shall be provided for each motor. These shall be located outside the terminal box. These terminals shall preferably be on diametrically opposite points. A separate earth terminal shall be provided inside the terminal box.

All outdoor motors shall have a canopy on the top.

All mounting dimensions shall conform to IS 1231.

15.6 Painting

External parts shall be finished and painted to produce a neat and durable surface which will prevent rusting and corrosion. The equipment shall be degreased and all rust, sharp

edges, scales are removed and treated with two coats of premier and finished with two coats of final paints.

Unless otherwise agreed, the motors shall be painted with shade 631 of IS 5.

Tests: All routine tests shall be conducted on motors (as per IS).

Nameplate: A stainless steel name plate shall be provided on each motor. The inspection details shall be as per IS 325.

15.7 Tests

The following routine tests in accordance with IS: 325 of latest edition shall be performed in presence of the Engineer.

- i. Insulation resistance test
- ii. Measurement of no load current and speed at rated voltage and rated frequency.
- iii. Measurement of locked rotor current at reduced voltage or rated voltage and at rated frequency.
- iv. High voltage test.
- v. Reduced voltage running up test at no load to check the ability of motor to run upto full speed at no load in both the directions of rotation with one third of rated line voltage applied to stator terminals.

The following additional test shall be performed to verify the performance, characteristics and guarantees. They shall be in accordance with IS: 325 of latest edition.

- i. Measurement of stator resistance.
- ii. Temperature rise test
- iii. Momentary overload in torque test
- iv. High voltage test
- v. Over speed test

Each type and rating of the motors should have been type tested in accordance with IS: 325. In absence of type test certificates, type tests shall be carried out without any extra cost to the Employer/ PMC.

16. SPECIFICATION FOR MOTOR STARTER

16.1 General

The DOL and Star-Delta starter shall be provided in the main LT panel of the individual units. However, a local remote selector switch shall be provided to either start/stop the motor from local (i.e. near the motors) or from remote (i.e. from the panel).

16.2 Direct On Line

Fully automatic Air break – DOL starters for Operation on 4185 V, Voltage, 3 phases, 50 hz. AC supply. The details of equipment/ accessories for the starter shall be as per the vendor's standard design and shall broadly cover the specifications give below.

16.2.1 Wiring and Terminals

Power and control wiring shall be done with PVC insulated copper conductors and shall be terminated with adequately sized compression type lugs for connections to the equipment terminals and terminal strips.

Each wire shall be identified both ends by ferrules. Not more than two wires to be terminated at one terminal and size of terminal should be used keeping in view the components for which they are used, so that sufficient surface contact can be achieved.

Incoming and outgoing to be made at terminals only. Control wiring shall be done with 1.5sq mm only. Wires shall be of ISI mark only.

16.2.2 Earthing

Two numbers of earthing terminals shall be provided for connecting the earth. All non-current carrying metallic parts of the equipment shall be earthed.

16.2.3 Isolator

An isolator of AC 23 duty shall be provided as main incoming. The isolator shall have door interlocking facility.

16.2.4 Main Fuses

HRC fuses of suitable rating shall be provided in the panel.

16.2.5 Contractor

Run, main and star contractors shall be provided having 415 coil of AC-3 duty.

16.2.6 Overload Relay

Thermal overload relay of suitable range with SPP feature shall be provided by considering minimum 1.4 times and maximum 1.6 times, the HP rating of the Motors.

16.2.7 Indicating Lamp

Filament type indicating lamp with built in resistor shall be provided as per data sheet.

Push Button: Red, Green, Black push button shall be provided for stop, start and overload reset respectively.

Earth Leakage Relay: An E.L.R with C.B.C.T of range 0.5 to 2.5 ma shall be provided. A bypass toggle switch must be provided on the door of the control panel.

16.2.8 Testing

Following tests shall be carried out a manufacturers work at his own cost and risk

- Single phasing in each phase.
- Under voltage cut off at 320V

- Over voltage cut off at 480V
- Unbalance tripping at 15% unbalance voltage
- H.V test at 2.5 K.V for power circuit
- H.V test at 1.5 K.V for control unit.
- H.V test between phases
- Meggar test.
- Phase reversal

16.3 Star Delta Starters

Fully Automatic Air Break Star – Delta Starters for Operation on 415 V, 10% Voltage, 3 phases, 50 Hz. AC supply.

The details of equipment/ accessories for the starter shall be as per the vendor's standard design and shall broadly cover the specifications give below.

16.3.1 Wiring and Terminals

Power and control wiring shall be done with PVC insulated copper conductors and shall be terminated with adequately sized compression type lugs for connection to the equipment terminal and terminal strips.

Each wire shall be identified both ends by ferrules. Not more than two wires to be terminated at one terminal and size of terminal should be used keeping in view the components for which they are used, so that sufficient surface can be achieved.

Incoming and outgoing to be made at terminals only. Control wiring shall be done with 1.5 sq. mm only. Wires shall be of ISI marks only

16.3.2 Earthing

Two nos. of earthing terminals shall be provided for connecting the earth. All non-current carrying metallic parts of the equipment shall be earthed.

16.3.3 Isolator

An isolator of AC 23 duty shall be provided as main incoming. The isolator shall have door interlocking facility with isolator and protective fuse shall be provided.

16.3.4 Fuses

Main and control fuses of HRC type of suitable rating shall be provided.

16.3.5 Contractors

Main delta and star contractor shall be provided having 415 V coil of AC-3 duty.

16.3.6 Overload Relay

Thermal overload relay of suitable range with SPP feature shall be provided by considering 60% of the full load current of the motor.

16.3.7 Timer

This shall be provided for change over from star to delta.

16.3.8 Indicating Lamp

Filament type indicating lamp with built in resistor shall be provided.

16.3.9 Push Button

Red, Green and Black push button shall be provided for stop, star and overload reset respectively.

16.3.10 Earth Leakage Relay

An E.L.R. with C.B.C.T. of range 0.5 to 2.5 MA shall be provided. A by-pass toggle switch must be provided on the door of the control panel.

16.3.11 Ammeter

96 sq. mm. size, suppress scaled, C.T. operated, ammeter shall be provided. A selector switch shall also be provided.

16.3.12 Control fuses

HRC type control fuse of suitable rating shall be provided.

16.3.13 Testing

Following tests shall be carried out at manufacturers work and test results submitted along with the equipment.

- Single phasing in each phase.
- Under voltage cut off at 320 V
- Over voltage cut of at 480 V
- Unbalance tripping at 15% unbalance voltage.
- H.V. test at 2.5 K.V. for power circuit.
- H.V. test at 1.5 K.V. of control circuit.
- H.V. test between phases
- Meggar test

16.4 Soft Starter for LV Motors

The soft starters shall comply with the requirements of IEC 60034, 60947 and IS 325 including those standards referred to therein.

16.4.1 Constructional and Performance Features

Motor soft starters shall be switched or electronic type. Soft starter panel shall be indoor, metal clad with separate metal enclosed compartments for

- a) control, metering and current transformers for differential protection, if specified
- b) shorting (bypass) arrangement
- c) bus bars
- d) power cable terminations
- e) push buttons with indicating lamps.

Soft starter shall achieve smooth starting by torque control for gradual acceleration of the drive thus preventing jerks and extending the life of equipment.

Starting current shall be limited to 2.5 to 3 times the rated current of the motor. The soft starter manufacturer shall co-ordinate with motor manufacturer for this purpose.

Separate removable gland plates shall be provided for power and control cables. Each cubicle shall be fitted with a label in the front and rear of the cubicle, indicating the panel designation, rating and duty. Each relay, instrument, switch, fuse and other devices shall be provided with separate labels.

Necessary wiring diagram shall be provided considering starting interlock, trip circuit, starting and running mode signal.

It shall be possible to manually start the motor locally from the starter panel or in Auto mode through PLC.

16.4.2 Main Bus Bars

Bus bars shall be fully insulated by encapsulation in epoxy resin /shrinkable PVC Sleeve, with moulded caps protecting all joints. Bus bars shall be supported on insulators capable of withstanding dynamic stresses due to short circuit. Bus bars shall be of Aluminum conductor (Copper is not recommended in sewage corrosive atmosphere as it is oxidized.)

16.4.3 Earthing

A copper earthing bus shall be provided at the bottom and extended throughout the length of the panel. It shall be bolted / welded to the framework.

All non-current carrying metal work of the panel shall be effectively bonded to the earth bus. Hinged doors shall be earthed through flexible earthing braid.

16.4.4 Panel Accessories and Wiring

Panel shall be supplied completely wired internally upto equipment and terminal blocks and ready for the external cable connections at the terminal blocks. Inter panel wiring between compartment of the same panel shall be provided.

All auxiliary wiring shall be carried out with 1100 volts' grade, single core, stranded copper conductor with PVC insulation. The sizes of wire shall be not less than 1.5 sq. mm.

Terminal blocks shall be of stud type, 10 A rated, complete with insulated barriers. Terminal blocks for CTs shall be provided with test links and isolating facilities.

All spare contacts and terminals of cubicle mounted equipment and devices shall be wired to terminal blocks.

Accuracy class for indicating instruments shall be 1.0 or better. Instruments shall be 110 mm square, 2400 scale for flush mounting with only flanges projecting.

Push buttons shall be provided with inscription plates engraved with their functions. Indicating lamps shall be of clustered LED type.

Space heaters of adequate capacity shall be provided inside each panel. They shall be suitable for 230 V, 1 ph, 50 Hz supply. They shall be complete with MCB and thermostat.

Each panel shall be provided with 230 Volts, 1 phase, 50 Hz, 5 A, 3 pin receptacle with MCB located in a convenient position. An interior illuminating lamp together with the operating door switch and protective MCBs shall be provided.

The DC and AC auxiliary supply shall be distributed inside the panel with necessary isolating arrangements at the point of entry and with sub-circuit MCBs as required.

16.5 Variable Frequency Drive for Air Blower

16.5.1 Scope

This specification covers the general requirements for design, manufacture, assembly, inspection and testing of variable voltage and variable frequency (VVVF) drives and control systems used to control the speed of low voltage, 3 phase AC induction motors continuously and at low losses.

16.5.2 Codes and Standards

The design, manufacture and performance of VVVF drives and control systems shall comply with all current statutes, regulations and safety codes in the locality where equipment will be installed. Nothing in this specification shall be construed to relieve the Contractor of his responsibility.

Unless otherwise specified, the VVVF drives shall conform to the relevant Indian, IEC or British Standards: -

The relevant Standards are:

- | | |
|-------------------|--|
| 1. IEC 297 | Dimensions of panels and racks |
| 2. IEC 352 | Solderless wrapped connections |
| 3. IEEE 444 | Protection standards for Thyristor convertors |
| 4. IEC 446 (1989) | Semi-conductor converters |
| 5. IS 3700 (1972) | Essential ratings and characteristics of semi-conductor devices. |
| 6. IS 4411 (1967) | Codes of designation of semi-conductor devices |

- | | |
|---------------------|--|
| 7. IS 5469 (1973) | Codes of practice for the use of semi-conductor junction devices. |
| 8. IS 10482 (1986) | Connectors for printed wiring board |
| 9. IS 12448 (1988) | Basic testing procedures and measuring methods for electro-mechanical components for electronic equipment. |
| 10. IS 12970 (1990) | Semi-conductor devices - Integrated circuits |
| 11. IS 13648 (1993) | Power electronic capacitors |
| 12. IS13947 (1993) | Low voltage switchgear and control gear |

16.5.3 Environment

- a) Storage ambient temperature range: -10 to 50 degree centigrade.
- b) Operating ambient temperature range: 5 to 50 degree centigrade without derating.

16.5.4 Output Power

The output voltage should be adjustable from 0 to rated input voltage. The output frequency range should be adjustable from 0 to 50Hz. The inverter section shall produce a pulse width modulated (PWM) waveform using latest generation techniques.

16.5.5 General arrangement

- The VVVF drive shall consist of the following:-
 - a) Incomer - MCCB
 - b) Power module
 - c) Transistorised Inverter Unit
 - d) Motor protective devices
 - e) Indicating/metering/control circuits and accessories
- VVVF drive shall be designed such that the maintenance/replacement of drive shall be easy.

Hence rack-out type drives may be considered. The VVVF's fault shall be taken as contact input to PLC as Digital Input. Other important parameters like speed, power (KW), etc shall be connected to PLC by suitable mode of communication.

- The VVVF drive shall be provided as a complete package and shall be controlled from three different locations viz., (a) VVVF panel (b) Local operator panel and (c) PLC.

A four position lockable selector switch shall be provided on the VVVF panel for selecting operation from VVVF panel/local operator panel/PLC/STOP position.

4-20mA signal from PLC shall be connected to VVVF drive. All control schemes for process control shall be implemented in PLC only.

- Local operator panel shall be conventional motor LCSs only consisting of start/stop push buttons, remote/local start selection switch and ammeter etc as discussed

elsewhere and the same shall be adequately protected from rain. Speed control from local station shall not be provided.

- VVVF panel shall be provided with the following:
 - a) Standard options (to be stated by contractor)
 - b) Incomer – ACB or MCCB
 - c) Power module
 - d) Transistor inverter unit
 - e) AC reactor
 - f) Motor starting/protective devices
 - g) Selector switch (4 position)
 - h) START / STOP P.B.
 - i) Speed controller
 - j) Input voltmeter and ammeter
 - k) Output KW meter/Ammeter and frequency meter
 - l) Instrument, current, potential and control transformers
 - m) Auxiliary relays
 - n) Audio-visual alarms/fault indicators
 - o) Alarm acknowledge/reset/test PBs.
 - p) Provision for wiring external sequential/process interlocks/signals for starting/running/tripping.
 - q) Space heater
- Besides VVVF panel shall include the following operating adjustments:
 - a) Acceleration and deceleration time-range in seconds.
 - b) Current limit-range in percent of rated output current.
 - c) Maximum and minimum frequency range in Hertz.
 - d) Volts/Hertz ratio
 - e) Voltage boost ratio in percentage.
 - f) Starting torque setting adjustment.
 - g) Starting current setting adjustment

Contractor shall propose setting ranges consistent with the operating conditions required.

- Motor winding temperature detectors shall be monitored on VVVF panel.

16.5.6 Design features

- The unit shall be capable of proper operation for voltage variations of $\pm 10\%$, frequency variations of $\pm 5\%$, and combined variations of $\pm 10\%$. Besides, the VVVF unit shall be able to ride through voltage dips down to 80% of nominal, such as those experienced during motor starting. Also VVVF shall be capable of riding through voltage outages of minimum 2 seconds duration.
- The mains voltage 415V, 50 Hz, 3 phase + Neutral supply given at one point in VVVF panel will be rectified by a controlled mains rectifier and injects an adjustable direct current through intermediate circuit choke and inverter. The speed of the motor is proportional to the switching rate of the inverter.
- The VVVF inverter shall be of voltage/current fed type. A current fed type shall have a current limiting reactor in the dc link and the rectifier output voltage is variable. Forced commutation type inverter is preferred.
- In case of voltage fed inverter, input voltage from the rectifier shall be constant and current from the rectifier is uncontrolled. The inverter output voltage and frequency shall be controlled electronically within the inverter by using pulse-width modulation (PWM) technique. Insulated Gate Bi-polar Transistor (IGBT) elements shall be preferred for switching in the inverter.
- The inverter shall be used as a speed regulator in open loop control. In case of closed loop control, suitable feedback system shall be used.
- The VVVF unit shall return the motor to operating speed upon restoration of power following an extended voltage interruption on the ac incoming line. Automatic restart shall be disabled after an adjustable time period.
- The VVVF unit shall be able to restart a rotating motor.
- Regulation of output voltage shall not be more than $\pm 2\%$ under steady state and $\pm 8\%$ under transient conditions. Maximum drift in set frequency shall be $\pm 0.1\%$. The unit should be able to hold a set speed, regardless of load torque variations. The unit shall be suitable for 150% overload capacity for one minute.
- The maximum noise level of the unit shall not exceed 85 dB (A) at a distance of 1 meter.
- The unit shall have independently adjustable/automatic load dependent voltage boost at low end of frequency. There should not be any torque fluctuations at low speed.
- The unit shall operate at automatically produced fixed ratio of V/F through the complete speed range of motor.
- The VVVF unit shall provide an analog ungrounded signal (4 to 20mA) directly proportional to motor current. Range shall be 0 to 115% of motor full load current.
- Contractor shall be responsible for the co-ordination of motor and inverter with the load/speed requirements for the following:

- a) To ensure that motor and VVVF drives are both adequately rated and sized for the required duty and if necessary, recommend alternative configurations (like separate cooling fan, choice of frequency range etc.).
- b) To arrange necessary testing of motor-VVVF drive unit to confirm compliance with requirements of load, noise, vibration, temperature rise etc.
- c) To recommend any additional motor protection arrangements which may be necessary to prevent motor winding damage.

16.5.7 Constructional features

VVVF panel shall be metal enclosed self-supporting type with hinged lockable doors and shall be dust proof and suitable for indoor use. The color and finish of cubicle shall be as per manufacturer's standard, unless otherwise stated.

All-important configuration data shall be printed/painted on the inner side of front door.

All sheet steel work shall be phosphated by removing oil, grease, dirt etc., by emulsion cleaning. This shall be followed by pickling with dilute acid for removing rust and scalp. After this, it shall be washed with running water, rinsed with slightly alkaline hot water and dried. Subsequently it shall be rinsed with dilute - Dichromate solution and oven dried.

After above process two coats of ready mixed stoved type Zinc Chromate Primer shall be applied. After application of Primer, two coats of finishing Synthetic Enamel Paint shall be applied. Each coat shall be followed with stoving. The second coat shall be applied after completion of tests.

All other parts such as handles, levers and fasteners that are not stainless steel shall be Tin, Cadmium, Nickel or Chrome plated.

Printed circuit boards shall be identified by type number and shall not be mounted on the front door of the enclosure. Components requiring manual adjustment shall be mounted to allow readjustment without removing the board from its socket. Printed circuit boards and printed circuit card cages shall be designed to prevent improper insertion of a board into the incorrect slot. Connections shall be maintained by pressure contact plugs. If connections are not properly made, electronic protection circuits shall prevent operation or switch OFF the inverter without component damage. Standardization of common circuit boards between multiple units shall be maintained.

All PCBs (electronic cards) of VVVF drives shall be designed against the corrosive environment condition.

Power bus bars shall be rated to withstand short-circuit current stresses and shall be suitably insulated.

All non-current carrying metal work shall be bonded together and connected to an adequately sized earth bus provided inside the panel. Facility for external earth connection shall be provided at two points of earth bus.

Cubicles and components shall be identified by labels.

All equipment shall be suitable for the specified area of occupancy.

All wiring, using 650/1100V grade insulated copper wires, shall be brought out to individual terminals on a readily accessible terminal block. All terminals shall be shrouded.

16.5.8 Protection, Metering and Control

Fuses for all power semi-conductors and/or other devices like chokes, capacitors, etc, which are not adequately protected against flow of abnormal currents shall be provided. The following minimum protection/alarms shall be provided-

- a) Internal short circuit protection
- b) Over and under voltage and over current protection
- c) Earth fault of main/auxiliary circuits
- d) Loss of control voltage protection
- e) Over-temperature protection of inverter elements.
- f) $\pm 0.5\%$ deviation from set point.
- g) V/F ratio or overfluxing protection
- h) Over speed/under speed protections
- i) Stalled motor protection
- j) Auxiliary system protection and failure identification.

Instruments, motors and control logic and their associated wiring shall be isolated from the power module.

Potential and current transformers shall have relaying and metering class accuracy to provide satisfactory performance for the specified burden. Current transformers shall be designed to withstand mechanical and electrical stresses.

The primary circuits of all potential transformers shall include current-limiting fuses.

Control power transformer shall supply power to all space heaters and other components. The primary and secondary circuits shall be fused.

Protection shall be provided such that failure of a part does not cause damage elsewhere in the system.

Contractor shall furnish the signal response at each test pin for a standard test signal input to the card.

Indicating meters shall be flush mounting type, SIF 96 size or as per manufacturer's standards.

16.5.9 Accessories

The VVVF drives configuration shall be done from both front panel and also from personal computer. Hence VVVF drives shall have PC interface ports. It should be possible to download the configurations from PC to VVF drive in case the VVVF is removed and replaced.

A complete set of accessories normally used for operation, breakdown/routine maintenance and testing of the specified equipment shall be furnished, including special wrenches and tools.

Contractor shall also quote for additional maintenance and test equipment (such as inbuilt diagnostic test module) individually.

16.5.10 Spare Parts

Contractor shall quote itemized prices for the spare he recommends for trouble free operation for two years.

16.5.11 Inspection and Testing

Tests and inspection shall be carried out in accordance with relevant Indian Standards, and enclosed Inspection and Test plan (ITP). Routine tests at works will be witnessed by PMC/Owner.

Type test certificates if available shall be furnished along with the offer.

Contractor shall quote unit rate for witnessing type tests, if specified in Specific Job Requirements.

17. UNINTERRUPTED POWER SUPPLY

The UPS shall be floor mounted; self-contained and metal clad and shall be suitable for operating on a nonlinear load. It should be accessible front door.

Each ups system shall have at least 10% spare capacity to meet future requirements.

Each ACDB of ups system shall be provided with 10% spare feeders.

The UPS system shall be true On-Line, The On LINE UPS shall be incorporating a six-pulse rectifier and pulse width modulation inverter technology with 100% microprocessor control with built in static and manual bypass switch.

The UPS shall incorporate a dc under voltage trip circuit to electrically trip the UPS in order to protect the battery.

The noise level of the unit shall not exceed 60dB (A) at 1m from the UPS cabinet.

The output of the inverter shall be a sine wave having less than 5% THD for linear loads and less than 4% to 50% nonlinear load. It shall be suitable for load power factor 0.8 lag.

The unit shall have dynamic response such that a 100% step load causes an output voltage transient of less than +4% with a recovery time of less than 4 ms.

For three phase output units the output voltage shall not vary by more than +1% for an unbalance for 10%.

All cables of the ups shall be of copper.

The efficiency at full load and 0.8 power factor shall be greater than 88%.

Indicators to indicate

- UPS status
- UPS alarm conditions

The UPS shall provide a volt free contact output to indicate.

- Warning, i.e. low battery capacity
- Fault
- Static bypass in use.

The UPS shall have an overload capacity of 150% for 30 seconds and shall be protected in the event of a short circuit of the output.

The batteries shall be housed, either within the UPS enclosure or within a separate matching battery cubicle suitable for location adjacent to the UPS.

The batteries shall be maintenance free lead acid type sealed for life.

Terminals shall be shrouded to prevent accidental contact. The battery enclosure shall be corrosion resistant and ventilated to prevent the buildup of gases.

Warning notices shall be provided for wall mounting to warn of the presence of charge gases.

The battery supply of the UPS shall be via a fused load break switch disconnect circuit breaker.

The battery recharge time to 90% of full charge shall be approximately ten times the discharge time at full load.

The UPS battery shall have a backup of 60 minutes at full load and supported with inverter of suitable capacity.