

Sub Section 6 ELECTRICAL SPECIFICATIONS

1. DESIGN CONSIDERATION

1.1 Design Basis:

The electrical design shall be based on following factors:

- Safety of personnel and equipment during operation and maintenance
- Reduce fire and explosion hazards due to short circuits
- Reliable, secure and efficient operation
- Ease of maintenance
- Maximum interchangeability of equipment
- Latest technology

1.2 SIZING PHILOSOPHY

A] Transformer Sizing

The entire plant shall have 1 no. adequately sized 22kV/0.433kV Transformers with on load tap changer control cubicle.

Transformer sizing shall consider the following:

- The load of all the normal working equipment and auxiliaries of the plant.
- Transformer shall be rated for full working load of the plant.

The minimum size of the transformer shall be 1500kVA. The contractor shall submit the capacity sizing calculations in the prescribed format given in the technical schedule.

B] HT Cable Sizing

HT cable from 4-pole structure to the 22kV Switchgear shall be sized for the present working load.

C] HT Switchgear

HT Switchgear shall be single incoming – outgoing type.

D] DC Battery

DC battery bank, required for 22kV switchgear control supply, shall be sized adequately considering the DC load requirement of one no. 22kV incoming outgoing panel.

1.3 SHORT CIRCUIT CAPACITIES

The equipment fault level for various voltages are as specified below:

22 kV system	:	500 MVA
415 kV system	:	20 MVA

1.4 PROTECTIONS

Following protective relays shall be provided :

a. HT Switchgear Incomer

- i) Inverse time phase over current relays
- ii) Inverse time earth fault relay
- iii) P.T. fuse failure relays
- iv) Under voltage relay
- v) Over voltage relay

b. Transformers with OLTC

- i) Instantaneous short circuit protection on all the three phases for phase faults on HV side (Source side)
- ii) Inverse time back up over-current protection on all the three phases on HV side for phase faults.
- iii) Instantaneous earth fault protection on delta connected HV side.
- iv) Inverse time earth fault protection on star connected HV side
- v) Inverse time back up over current protection on all the three phases of secondary side for phase faults
- vi) Inverse time back up earth fault protection of secondary side (relay shall be connected through CT on directly earthed neutral or neutral earthed through a resistor)
- vii) Two stages (Alarm & Trip) gas protection (Buchholz Relay)
- viii) Two stages (Alarm & Trip) oil temperature.
- ix) Two stages (Alarm & Trip) Winding temperature.
- x) Two stages (Alarm & Trip) Pressure Relief Device.
- xi) One stage (Alarm) Magnetic Oil Gauge

1.5 METERING

The following metering shall be

provided. a. Incomer:

- i) Ammeters in all the three phases
- ii) Voltmeter with selector switch
- iii) Frequency meter
- iv) kVA, kW & kWh meter
- v) Power factor meter
- vi) Load manager

b. Main Transformer HV Feeders

H.V. Side:

- i) Ammeters in all the three phases
- ii) KVA meter

L.V. Side:

- i) Ammeters in all the three phases



2 SELECTION CRITERIA FOR ELECTRICAL EQUIPMENT

2.1 Switchgear:

H.V. Switchgear

- a. 22 kV Switchgear shall be Indoor type with either Vacuum Circuit breaker. The Circuit breaker shall be draw out type and the switchgear shall be compartmentalized with single front construction and protection degree IP4X.

L.V. Switchgear

- a. 415 V Main LT Panel, Sub LT Panels etc. shall be of fixed, compartmentalized single front construction, excepting Air circuit breaker modules which shall be of draw out type and single front construction.
- b. The degree of protection for switchgear shall be IP 54 for indoor installation and IP 55 for outdoor installation.

2.2 Cables :

- a. HV Cable shall be 22 kV grade XLPE insulated and LT Cables shall be 600/1000V grade PVC insulated aluminum cored. Manufacturing certificates shall be submitted to the engineer-in-charge before commencing the installation.
- b. All cables less than 4 sq.mm. shall be copper conductor PVC insulated, PVC sheathed, round G.I. wire armoured. All cables above and including 4 sq.mm. shall be aluminum conductor PVC insulated, PVC sheathed, strip/round G.I. wire armoured.
- c. Where a neutral conductor is required, it shall be in the form of a core of half the section that of the other cores.
- d. The control cables shall be copper conductor, minimum 1.5 sq.mm PVC insulated. PVC sheathed and armoured type.
- e. The contractor shall ensure that each cable is of sufficient rating for its normal and fault conditions. To access the rating and cross section required for each cable, the following factors shall be considered-
 - Fault Level
 - Condition of ambient temperature relevant to method of laying
 - Voltage drop in motor circuits
 - Voltage drop in cables shall not exceed the following, in percent of system nominal line-to neutral voltage:
 - Motor feeders (starting)
15% Motors feeder
(running) 3%
 - Over current setting of circuit breakers
 - Disposition of cabling whether in air or ground
 - The capacity claimed by the manufacturer shall be de-rated to 70% to avoid overheating related problems of cables at end terminals, joints which may be due to improper end connections.

The contractor shall submit the detail calculations of cable sizing type of power &

for each

control cable.



- f. All power cable sizes shall be based on continuous current carrying capacity, permissible voltage drop and short circuit rating. For short circuit rating of H.V. cables, the fault clearing time shall be 1 second for H.V. plant feeders and for equipment feeders. For S.C. rating of H.V. cables the fault clearing time shall be 1 second, for L.V. incomers 0.5 Second and L.V. outgoing feeders to equipment, 0.5 second.
- g. Rating factors for variation in ground temperature, variation in ambient air temperature, grouping of cables, depth of laying etc. shall be based on the cable manufacturer's recommendations/catalogues.

2.3 Lighting system

The lighting system inside and outside plant units shall be designed taking into consideration the desired illumination level, architectural arrangement, building dimensions including mounting height, environmental conditions, ease of maintenance and reliability of the lighting distribution network. The contractor shall submit the detail lighting design calculations confirming the selection of lighting fixture quantities.

The illumination system shall be designed to minimize direct glare and shall be free from shadows. Maximum and minimum illumination at any point shall be within $\pm 15\%$ of the average illumination of the area under consideration.

Lighting fittings shall be selected from the type and range given in the general specifications for Lighting system.

The lighting system will comprise the following:

- a. Normal A.C. lighting.

All indoor and outdoor areas will be provided with A.C. lighting and the same will be available as long as A.C. supply is healthy.

- b. Emergency D.C. Lighting

At important locations (such as Load Center Sub Station) built in battery operated instalite fixtures will be provided which will come in service when A.C. supply fails.

- c. The wiring for lighting circuits shall be done by 3 x 2.5 YWY cables clamped on walls/ structure for indoor areas. For outdoor lighting, armoured cables shall be used.
- d. The illumination levels for various areas shall be as follows:

Sr.	Area	Illumination Level (Lux)
1	Pump house	200
2	Offices	300
3	H.V./L.V. switchgear rooms	250
4	Plant/Switchyard control rooms	300
5	Chemical House	200
6	Cable basement	100

Sr.	Area	Illumination Level (Lux)
7	All other indoor areas	100
8	Outdoor platforms and walkways	50
9	Building entrances	100
10	Outdoor plant areas	20
11	Switchyard and transformer yard	
	- General	10
	- On equipment	30
12	Roads	10

- f. Lighting fixtures and fans will be grouped on the circuit wherever required. However, separate circuits shall be used for receptacles wiring.
- g. For the purpose of calculating connected loads of various lighting circuits, a multiplying factor of 1.25 will be assumed to the rated lamp wattage for mercury vapour, sodium vapour and fluorescent lamp fixtures to take into account losses in the control gear. Also a loading of 100 watts and 500 watts shall be assumed for single phase 5 Amps and 15 Amps receptacles respectively.
- h. Lighting fixtures, receptacles, switches, conduits and junction boxes shall be properly earthed using 12 SWG G.I. wire unless specified otherwise.
- i. Receptacles of 5A and 15A, single phase, 3 pin shall be provided with switch. Receptacles in offices shall be decorative type and in other areas shall be industrial type. Three phase receptacles shall be associated with TPN switch housed in the same enclosure. The receptacle shall become live only when the associated switch in "ON" position. The enclosure for all outdoor receptacle shall be provided with degree of protection of IP-51.
- j. Generally maintenance factor of 0.8 shall be considered for all lighting fixtures.
- k. Except for corrosive areas such as clarifiers, filter galleries, chlorine plant etc. all other indoor areas shall be illuminated using fluorescent tube fixtures of Industrial type, complete with lamps, electronic ballast & necessary accessories for their satisfactory operation. In corrosive areas, corrosion resistant fixtures with electronic ballast shall be provided. Makes of the lighting fixtures shall be as given in the list of approved makes.

2.4 Lighting Power Supply and Distribution

One Main Lighting Distribution Board (MLDB) shall be provided for lighting supply provision. Each outgoing feeder of MLDB shall feed one miniature circuit breaker lighting sub distribution boards. (SLDB)

- a. Each SLDB shall have 63A TPN MCB with ELCB (having 100mA current sensitivity) on incomer side. Each 240V single phase circuit taken from SLDB shall control a group of fittings with the loads equally distributed on all the three phases to the extent possible. The rating of the outgoing MCB shall be selected on the basis of lamp starting current, for lamps used in the lighting fittings, such that the total load does not exceed about 70% of the MCB rating.

- b. Plant road and area lighting shall be fed from separate Lighting Distribution Board. The road and area lighting system shall be provided with timer switch for automatic switching of the street lighting.
- c. For road and area lighting 4-core underground cable shall be run along road side and connection to individual poles will be given from alternate phase and neutral.
- d. Cable sizes for lighting circuits shall be selected based on the voltage drop considering starting current of the lamps in circuit. The continuous current carrying capacity of such cables shall in no case be less than the thermal trip setting of the MCB protecting the circuit.

2.5 Safety Earthing

- a. The method adopted for system as well as equipment earthing shall be in with the Code of Practice for earthing IS 3043. It shall also comply with the clauses of Indian Electricity Rules.
- b. The CONTRACTOR shall do measurement of soil resistivity for earthing After soil resistivity measurement; length & size of conductor and no. of shall be finalized.
- c. The material of earthing conductors will be as given below :
 - Conductors above ground shall be Galvanized iron to prevent atmospheric corrosion
 - Conductors buried in ground or embedded in concrete shall be mild steel.
- d. Fault clearing time for sizing the earthing conductor shall be taken as seconds.
- e. Maximum allowable temperature rise for steel welded joints will be taken as and ambient temperature as 40 °C.
- f. Plant earthing system will be designed to ensure effective operation of gears in case of earth faults. The total earthing resistance shall be less than ohm.
- g. For plant building and indoor substations one Main Earthing Ring shall be along the building periphery connected to required number of earth electrodes.
- h. Entire plant area can be divided in to small sections and each section shall own sub main earthing grid. Earthing system for different sections interconnected by inter-connectors of maximum size conductor.
- i. Main earthing conductors inside the building will be planned such that equipment are connected to earthing system in most economical and reliable manner
- j. Earthing conductors shall be provided around the outside edge of switchyard a distance of approximately 1000 mm and every alternate fence post connected to the grid by one lead and gates by flexible braid to the earthed post
- k. Distance between two earth pits shall be (minimum) twice the length of the used for the earth pit.

2.6 Power Factor Improvement

- a. One separate Capacitor panel with adequate banks of power capacitors shall be provided on
415V bus with automatic switching to improve and maintain grid power factor to unity.
- b. Power factor control shall be controlled automatically by an Automatic Power Factor Correction relay of suitable steps.
- c. Power capacitors shall be Mixed Dielectric type.
- d. Minimum rating of the capacitor bank shall be 600kVar.

3 LAYOUT CLEARANCES AND SAFETY REQUIREMENTS

- a. For every switchgear, control panel etc. that requires back access, the space behind the equipment shall generally be around 1000mm but in no case less than 750mm. The space provided shall be adequate to permit at least 90 degree opening of doors or hinged panels. In case where back clearances are required and provided, there shall be a passage way from either end of the equipment clear to a height of 1800 mm. Where the equipment are not required to be attended from the back, the equipment shall be placed along the wall/ structure having clearances less than 200 mm.
- b. For all switchgear, control panels etc. a clear space of not less than 1000mm shall be provided in front of the equipment. In case where the equipment is provided with draw out units and the above clearance is not adequate, the front space shall be to suit the draw out unit.
- c. For all electrical equipment a minimum clear head – room of 500mm shall be provided.
- d. All motors located away from the feeding end control panels, for which control desk / posts are not within visible distance, shall be provided with readily accessible and easily operable, locally mounted lockable type “START-STOP” push-buttons in the control circuit.
- e. All electrical equipment having operating voltages, 415V and above, shall be provided with “Danger Boards” of approved type and shall be affixed permanently in a conspicuous position. Where a group of equipment is located within a switch / control room or within a fenced area, the board shall also be affixed at the entrance. Shock treatment charts shall be provided near such equipment for first aid during shock treatment. The danger board and the shock treatment chart shall be in three languages viz. English, Hindi and local language.
- f. All moving parts of equipment, which are exposed and are liable to cause hazard to the operation/maintenance personnel, shall be suitably protected by metallic guards.
- g. 750mm wide Anti-skid rubber mats shall be provided in front of all switchgear for personnel safety. The rubber mats shall be rated for applicable voltage grade as per IS 5424 with amendments.
- h. Dry CO2 type fire extinguisher of suitable capacity shall be installed in each switchgear / control room and a dry sand bucket type fire extinguisher shall be installed in outdoor switchyard/ transformer yard etc.
- i. All switchgear / control rooms and substation building including cable cellars basement shall be provided with minimum two entry/ exit doors.

4 GENERAL REQUIREMENTS OF ELECTRICAL EQUIPMENT

4.1 22 kV Switchgear

Applicable Standards

The switchgear and its components shall conform to the latest applicable standards specified below. In case of conflict between standards and this specification, this specification shall govern.

Code No.	Title
IS 13118 / BS 5311 / IEC 56, 694	Circuit Breakers
IS 3427 / BSEN60298 / IEC298	Metal Enclosed switchgear
IS 2705 / BS 7626	Current Transformers
IS 3156/BS 7625/IEC 186	Voltage Transformers
IS 5578, 11353	Arrangement for Switchgear Busbars, Main Connections and Auxiliary wiring
IS 2544 / BS 3297 / IEC 273	Busbar Support insulators
IS 13947 (Part 1) / IEC 947-1 / BSEN	Degree of Protection
IS 3231, 3842 / BS 142 / IEC 255	Electrical Relays for Power system protection
IS 1248 / BS 89 / IEC 51	Electrical Indicating Instruments
IS 9385 / BS 2692 / IEC 282	High Voltage Fuses
IS 722, 8530 / BS 5685 / IEC 145, 211	AC Electricity Meters
IS 613	Specification for copper rods and bars for electrical purposes
IS 6005 / BS 3189	Code of practice for phosphating iron and steel
IS 9920 / IEC 129, 265 & 298	Alternating current Switches for voltages above 1000 V
IS 13703 / BS 1362 / IEC 269	Low voltage fuses
IS 3452 / BS 3676	Toggle switches
IS 10118	Code of practice for selection, installation and maintenance of
IS6875/BSEN 60947/IEC 947	Control switches

CONSTRUCTIONAL FEATURES

Metal-clad switchgear and control gear shall comprise metal-enclosed switchgear and control gear in which components are arranged in separate compartments with metal-enclosures intended to be earthed. Compartments with doors for access to operating mechanism shall be so arranged as not to expose high voltage circuits.

The metal-clad switchgear and control gear shall have separate compartments for the following components :

Each set of busbars

Current transformers

Voltage transformers on incomer side

Each main switching device

Cable chambers suitable for heat shrinkable type cable termination of cables indicated in single line diagram.

Metering and relaying devices.

DEGREES OF PROTECTION:

Complete protection against approach to live parts or contact with internal moving parts i.e. IPH-6 class for all the above compartments except for each set of busbars. Compartments of each set of busbars shall be provided with protection against approach to live parts or contact with internal parts, by tools, wires or similar objects of thickness greater than 2.5 mm i.e. Class IPH-3.

Switchgear shall comprise indoor, metal-clad, Draw out type circuit breakers. The circuit breaker shall be fully horizontally draw out type. The circuit breaker shall have distinct service and test positions. In the test position the circuit breakers shall be capable of being tested for operation without energising the power circuits. Four normally open auxiliary contacts shall be provided for each of the service and test limit position switches.

The test position should preferably be obtained without the need to disconnect normal control connections and use of extension cords for testing.

The switchgear shall fully house the breaker both in the service position as well as in the test position

Switchgear shall be dust, moisture and vermin-proof.

Separate removable gland plates with minimum thickness of 3 mm shall be provided for power and control cables. The gland plate for the power cables shall be of non-magnetic material.

All doors, panels, removable covers shall be gasketed all around with neoprene gaskets. All louvers shall have screens and filters. Vent openings shall be covered by fine mesh on the vertical face. The screens and grills shall be made of either brass or galvanized iron wire mesh.

Metal-clad unit shall comprise rigid welded structural frame enclosed completely by metal sheets, minimum 2.5 mm thick (hot rolled) or 2.0 mm thick (cold rolled), smooth finished, leveled and free from flaws.

The current transformers shall be mounted on the fixed portion of the switchgear and not on the breaker truck.

Each switchgear cubicle shall be fitted with a label in the front and rear of the cubicle. Each switchgear shall also be fitted with label indicating the switchgear designation, rating and duty. Each relay, instrument, switch, fuse and other devices shall be provided with separate labels.

PAINTING

All sheet steelwork shall be phosphated in accordance with the following procedure and in accordance with relevant standards for phosphating iron and steel.

Oil, grease and dirt shall be thoroughly removed by emulsion cleaning.

Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.

After phosphating, thorough rinsing shall be carried out with clean water, followed by final rinsing with dilute dichromate solution and oven drying.

The phosphate coating shall be sealed by the application of two coats of ready mixed, stoving type zinc chromate primer. The first coat may be 'flash dried' while the second coat shall be stoved.

After application of the primer, two coats of finishing epoxy paint shall be applied, with each coat followed by stoving. The colour for the finishing paint shall be as specified.

The final finished thickness of paint film on steel shall not be less than 100 microns, and shall not be more than 150 microns.

Structure, buses and control wiring troughs shall be so designed and arranged to make future extensions readily feasible.

Instruments, relays and control devices shall be mounted flush on hinged door of the metering compartment located in the front portion of cubicle. Panel door shall be supported by strong hinges and braced in such a manner as to ensure freedom from sagging, bending and general distortion of panel or hinged parts. All auxiliary relays not requiring manual resetting will be mounted inside the L.T. compartment.

SAFETY INTERLOCKS

Switchgear shall be provided with following interlocks:

Compartment door of a breaker shall not open unless the associated breaker or an isolator is in open position.

Caution name plate, 'Caution Live Terminals' shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end.

Circuit breaker cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker carriage to cover the exposed live parts when the breaker is withdrawn.

MAIN BUSBARS

Main busbars shall be of copper conductor of hard drawn (HD) and high conductivity and non-segregated type.

Busbars shall be located in air insulated enclosures and segregated from all other compartments of the cubicle. Direct access or accidental contact with busbars and primary connections shall not be possible. To provide a seal between adjacent cubicles, busbars shall be taken through seal-off bushings or insulating pads.

All busbars joints shall be thoroughly cleaned and antioxidant grease shall be applied. Plain and spring washers shall be provided to ensure good contacts at the joints and taps. Wherever aluminium to copper connections are required, suitable bimetallic connectors or clamps shall be used.

Busbars shall be rated in accordance with the service conditions and the rated continuous and short time current ratings specified in the SLD. Maximum temperature of the busbars and busbar connections, under operating conditions, when carrying rated normal current at rated frequency shall not exceed 85 deg. C. $(40 + 45 = 85)$

Busbars shall be adequately supported on insulators, to withstand dynamic stresses due to short circuit current. Busbar support insulators shall conform to relevant standards.

The busbar clearances in air shall be suitable for the short circuit levels.

Busbars shall not be painted and all performance characteristics specified shall be obtained with unpainted busbars.

Busbars shall be fully insulated by encapsulation in epoxy resin, with mould caps protecting all joints or heat shrinkable PVC sleeves and tapes.

CIRCUIT BREAKERS**GENERAL**

Circuit breakers shall be VCB type. These shall conform to relevant standards specified and shall be of draw out type. Circuit breakers shall comprise three separate identical single pole units operated through a common shaft by the operating mechanism.

Circuit breakers shall be suitable for switching duty of transformers whose capacities are furnished in the single line diagram.

Isolating plugs and sockets for power as well as control circuits shall be of robust design and fully self-aligning. Plugs and sockets for power circuits shall be silver faced and shall be insulated with PVC or other insulating material shrouds.

SF-6 circuit breakers shall have completely sealed interrupting units for interruption of arc inside the SF6 gas chamber. It shall be possible to isolate easily the SF6 interrupter unit from the breaker operating mechanism for mechanical testing of the interrupter to check loss of SF6 gas.

The circuit breakers shall be complete with surge arrestors to provide protection to the equipment controlled by the breaker, against switching surges.

Breaker internal wiring up to the plug shall be similar for all breakers.

OPERATING MECHANISM

Circuit breaker shall be power operated, by a motor charged spring operated mechanism. Main poles of the breakers shall be such that unless otherwise specified, the maximum difference between instants of contacts touching during closing shall not exceed half cycle of rated frequency.

Operating mechanism shall be provided with non-pumping feature, electrically and mechanically. Electrical anti-pumping feature shall be obtained by means of an auxiliary relay.

Main poles of the breaker shall operate simultaneously. There shall be no objectionable rebound and the mechanism shall not require any critical adjustment. It shall be strong, rigid, positive and fast in operation.

Mechanism shall be such that failure of any auxiliary spring shall not prevent tripping and will not cause tripping or closing operation of the power operated closing devices. When the circuit breaker is already closed, failure of any auxiliary spring shall not cause damage to the circuit breaker or endanger the operator.

A mechanical indicator shall be provided to show open and closed positions of breaker. It shall be located in a position where it will be visible to the operator standing on the front of the switchgear with cubicle door closed.

The closing coil shall operate correctly at all values of voltage between 80 % and 110 % of the rated voltage. A shunt trip shall operate correctly under all operating conditions of the circuit breaker upto the rated breaking capacity of the circuit breaker and all values of supply voltage between 50 % and 110 % of rated voltage.

Mechanical trip and close devices shall be provided for manual operation of the breaker. Access to mechanical closing device shall be only after opening the cubicle door. However, the mechanical trip device shall be brought out to the front of the cubicle door.

Working parts of the mechanism shall be of corrosion resisting material. Bearings, which require grease shall be equipped with pressure type, grease fittings. Bearing pin, bolts, nuts and other parts shall be adequately pinned and locked to prevent loosening or changing adjustment with repeated operation of the breaker.

Auxiliary switches mounted on the fixed portion of the cubicles and directly operated from the breaker operating mechanism on each breaker having 8 'NO' and 8 'NC' potential-free contacts rated for 10 amps. 240V AC and 10 amp (inductive breaking) 30 V DC shall be provided. The contacts shall be in addition to those utilized in the control circuit of each breaker and shall be exclusively meant for the use in external interlocks and controls.

SPRING OPERATED MECHANISM

Spring operated mechanism, shall be complete with motor, opening spring, closing spring with limit switch for automatic charging and all necessary accessories to make the mechanism a complete operating unit.

As long as power is available to the motor, a continuous sequence of closing and opening operations shall be possible. After failure of power supply to the motor, at least one open- close-open operation of the circuit breaker shall be possible.

Breaker operation shall be independent of the motor, which shall be used solely for compressing the closing spring.

Closing action of the circuit breaker shall compress the opening spring ready for tripping.

When closing springs are discharged, after closing a breaker, closing springs shall automatically be charged for the next operation.

Motor shall be such that it requires only about 30 sec. for fully charging the closing spring. Motors shall be rated for or 240V AC and shall operate satisfactorily at all values of voltage between 80 % to 110 % of rated voltage.

Mechanical indicators to indicate charged and discharged condition of spring shall be provided.

OPERATING MECHANISM CONTROL

The closing and tripping control shall be by a control switch mounted on the cubicle door.

The mechanical trip and close devices shall be provided on the breakers in addition to above.

EARTHING

An earthing bus shall be provided and extend throughout the length of the switchgear. It shall be bolted to the framework of each unit and each breaker earthing contact bar.

The earth bus shall have sufficient cross section to carry the momentary short circuit and short time fault current for 1 second, without exceeding maximum allowable temperature rise.

Suitable clamp type terminals at each end of the earth bus shall be provided to suit the size of the Main Earthing Grid conductor.

All non-current carrying metal work of the switch-board shall be effectively bonded to the earth bus.

Bolted joints, splices, taps etc. to the earth bus shall be made with at least two bolts.

Hinged doors shall be earthed through green colour flexible earthing braid.

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.

CUBICLE MODULE ACCESSORIES AND WIRING

Cubicle accessories and wiring shall include the following:

Switchgear shall be supplied completely wired internally upto equipment and terminal blocks and ready for external cable connections at the terminal blocks. Inner panel wiring between cubicles of same switchgear shall be provided.

All auxiliary wiring shall be carried out with 650 volts grade, single core, stranded copper conductor with PVC insulation. The sizes of wire shall be not less than 1.5 mm².

Terminal blocks shall be of stud type, 650 grade, 10 amps, rated complete with insulated barriers. Terminal blocks for CTs and VTs 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. Instruments shall be 110 mm square with 240° scale for flush mounting with only flanges projecting.

Relays shall be suitable for flush mounting with only flanges projecting.

All protective relays shall be in draw-out cases with built-in test facilities. Necessary test plugs shall be supplied loose. All auxiliary relays and timers shall be supplied loose. All auxiliary relays and timers shall be supplied in non-draw-out cases. Externally operated hand reset flow indicators shall be provided on all relays and timers. Timers shall be of electromagnetic or electronic type only.

Control and instrument switches shall be rotary type provided with escutcheon plates clearly marked to show operating position and suitable for semi flush mounting with only switch front plate and operating handle projecting out.

Breaker control switches shall be pistol grip black and selector switches shall be oval or knob and black. Breaker control switches shall be three-position spring return to neutral type. Instrument selector switches shall be of the maintained stay-put type. Contacts of the switches shall be spring assisted and contact faces shall be with rivets of pure silver. The contact ratings shall be adequate to meet the requirements of circuit capacity in which they are used.

All push buttons shall have two normally open and two normally closed contracts unless otherwise. The contacts shall be able to make and carry 5 A at 110V DC and shall be capable of breaking 1 A inductive load at 30V DC. They shall be provided with inscription plates engraved with their functions.

Indicating lamps shall be panel-mounting type with series resistors. The wattage of lamps shall be 5 to 10 watts.

Provision shall be made for receiving, distributing, isolating and fusing of auxiliary D.C. and A.C. supplies for controls, space heating, etc. The fuse ratings shall be so chosen as to ensure selective clearance of sub circuit faults.

Fuses shall be HRC cartridge type mounted on plug in type fuse base

The D.C. and A.C. auxiliary supply shall be distributed inside the switchgear with necessary isolating arrangements at the point of entry and with sub-circuit fuses as required.

CABLE TERMINATION COMPARTMENT

Necessary number of cable glands shall be supplied for terminating auxiliary power and control cables. Glands shall be of heavy-duty brass castings, machine finished and complete with check nut, washers, neoprene compression ring.

Cable lugs for all power and control cable connections shall be supplied. The lugs shall be tinned copper depending on cable conductor and of solderless crimping type.

All necessary materials required for terminating the power cables such as tapes, fillers, binding wires, armour clamps, brass glands etc., shall be supplied.

INSTRUMENT TRANSFORMERS

The current transformers and voltage transformers shall conform to the requirements stipulated in relevant standards specified.

The CTs and VTs shall be of cast resin type (insulation Class 'E') and shall be able to withstand the thermal and mechanical stress resulting from the maximum short circuit and momentary current ratings of the switchgear. These shall be completely encapsulated.

CTs shall have polarity marks indelibly marked on each transformer and associated terminal block. Facility shall be provided for short circuiting



at the
and

earthing the CT secondary at the terminal blocks.

VTs shall be protected on their primary sides by current limiting HRC fuses with interrupting ratings corresponding to breaker rating and on secondary side with MCB's. Provision shall be made such that the primary fuses can be handled only in the de-energized position.

Miscellaneous Accessories

Space heaters of adequate capacity shall be provided inside each panel heater to prevent moisture condensation within the enclosure. The space heater shall be suitable for 240V, 1 ph, 50 Hz supply and complete with MCB for isolation purpose and thermostat to cut off heater at 45° C.

Each switchgear panel shall be provided with 240 Volts, 1 phase, 50 Hz, 5 amps. 3 pin receptacle with MCB located at a convenient position.

An 20 W F.T. L. interior illuminating lamp together with operating door switch and protective fuse shall be provided.

Annunciators

Fascia annunciators, suitable for operation on 30V DC shall be provided. Fascia annunciators shall be:

Equipped with 'Sound Cancel', 'Acknowledge' and 'Reset' push buttons common to annunciators on all switchgear aligned together and a 'Lamp test' push button for each annunciator on individual panels.

Provided with two lamps connected in parallel on each fascia window with series resistors

Suitable for normally open indicating contacts of either 'hand' or 'self' reset type Suitable for annunciating subsequent faults with the specified sequence, immediately after acknowledging the previous fault

Fascia Window of minimum size of 35 mm x 50 mm designed for an operating sequence indicated below :

Alarm Condition	Fault Contact	Audible Alarm	Visual Alarm
Normal	Open	Off	Off
Abnormal	Closed	On	Flashing
Sound cancel	Closed or Open	Off	Flashing

Acknowledge	Closed or Open	Off	Steady on
Back to Normal	Open	Off	Steady on
Reset	Open	Off	Off
Lamp Test	Open	Off	Steady on

TESTS AND TEST REPORTS

All routine tests shall be carried out as per the relevant standard.
Type test certificate shall be furnished along with routine tests reports.

4.2 DC BATTERY & BATTERY CHARGER

APPLICABLE STANDARDS

The battery charger and D.C. distribution board shall conform to the latest applicable standards specified below. In case of conflict between the standards and this Specification, this Specification shall govern.

Title	Code No.
Basic climatic and mechanical durability tests for components for electronic and electrical	IS:9000
Environmental tests for electronic and electrical equipment	IS:9000
Metal clad base material for printed circuits for use in electronic and telecommunication	IS:5921
Transformers and inductors (power, audio, pulse and switching) for electronic	IS:6297
Printed wiring boards	IS:7405
Environmental requirements for semi-conductor devices and integrated circuits	IS 6553
Terminals for electronic equipment	IS:4007
Factory built assemblies of switchgear and control gear for voltages upto and including 1000 V AC and 1200 V DC	IS:8623/BS: 5486 /IEC:439
Air break switches	IS : 13947 (Part –3)BSEN60947-3
Miniature circuit breakers	IS 8828/BSEN:60898
HRC cartridge fuses	IS:9224/BS:88
Contactors	IS:13947(Part-3) /BS:775/ IEC:158-
Control switches/push buttons	IS:6875
Indicating instruments	IS:1248/BC:89/ EC:51
Degree of Protection	IS:13947-(Part1)/IEC:947-1

Title	Code No.
Climate-proofing of electrical equipment	BSCP:1014
Code of practice for phosphating iron and steel	IS:6005/BS:3189
Semi-conductor converters	IEC:146
Semi-conductor rectifier equipment	IS:6619
Specification for copper rods and bars for electrical	IS : 613

Battery Charger



Battery charger shall be combined float-cum-boost type.

The charger shall be static type composed of silicon controlled rectifiers (SCRs) and diodes connected in three phase full wave half controlled bridge circuit.

The rectifier transformers for float and boost chargers shall be indoor dry type, double wound with delta-star connections. The Contractor shall ascertain if taps are required and provide adequate number of primary and secondary taps, if necessary.

The float charger shall be designed for supplying :

- i) The D.C. loads as required for the system i.e. continuous load and short-time overload.
- ii) The trickle charging current of the battery.

The boost charger shall be designed for supplying the boost charging current of the battery. If the battery and charger are to be supplied by separate contractors, the charger Contractor shall coordinate with the battery Contractor regarding the float/trickle and boost charging current and voltages required by the battery,

Performance

- i) Float Charger

The D.C. output voltage during float charging shall be stabilised within $\pm 1\%$ of the set DC bus voltage. There shall be provision for manual control if automode fails.

- ii) Boost Charger

For boost charging the discharged battery after a mains failure, the rectifier shall charge the battery at high rate limited to the maximum boost charging voltage. After a specified number of hours (adjustable) when the rated cell voltage is reached, the charger shall be returned to float charge status.

- In case of combined float-cum-boost charger, the switching and control of high rate charge and return to float charge shall be by automatic controller/regulator. There shall be provision for manual control if auto-mode fails.
- During boost charging following emergency measures shall be provided:
- If the AC mains supply fails, an arrangement shall be made to automatically connect the battery directly across the load.
- If the separate or spare float charger supplying D.C. load fails, the load shall be fed from the point of connection at the tapping of the battery via adequately rated blocking diodes.

Charger Panel and D.C. Distribution Board

- a) Battery charger panel and D.C. distribution board shall be sheet metal enclosure freestanding type with cable entry from bottom.
- b) Indications, controls and output voltage setting adjustments shall be on front panel. The Contractor shall submit a scheme for alarm and trip indication lamps on the cabinet and for fault annunciation contacts paralleled for remote annunciation.
- c) The components shall be liberally rated and housed in a well ventilated sheet metal cubicle complete with input and output terminals. Louvers shall be provided for ventilation backed

up by fine wire mesh so that the degree of protection shall be equal to or better than IP-42.

- d) Busbars shall be of copper conductor of hard drawn (HD) and high conductivity. Busbars shall be fully insulated by encapsulation in epoxy resin with moulded caps protecting all joints
- e) All printed circuit cards shall be plug-in type, interlocked to prevent insertion in a wrong slot. Each card shall have LED indication on its front plate to indicate normal condition and readily and marked test pins.
- f) All components shall be accessible to the maintenance technician for easy disassembly and replacement. Access to parts of equipment shall be with minimum danger from all hazards.
- g) All components and modules shall be clearly and unambiguously marked and all wiring colour-coded and tagged.
- h) All power and control wiring within the cubicle shall be done with stranded copper wires. The power wiring shall be adequately sized for the required rating. The minimum sizes for control wiring will be 1.5 mm² and for power wiring shall be 2.5 mm².
- i) Ground terminals with isolating links shall be provided.
- j) Cable glands shall be provided to suit the incoming and outgoing cables.

Components/Accessories

The main items are listed below. However, additional items required for completeness or to meet the specified performance or operational requirements of the charger, shall be deemed to be included in the Contractor's scope. Instead of incoming ON/OFF switches, stricker fuses and contactors, the Contractor may provide suitably rated 3 pole MCBs with overload and short circuit protection and auxiliary contacts.

- i) One (1) set - Three phase full wave half-controlled bridge rectifier circuit comprising silicon controlled rectifiers and silicon diodes complete with resistor/capacitor network for surge protection. The diodes/SCRs shall be individually protected by fuses with fuse fail indication.
- ii) One (1) Double wound, dry type, three phase suitably rated mains transformer.
- iii) One (1) set of suitably rated control transformers for electronic controller.
- iv) One (1) Electronic controller comprising of power supply card, soft start cum current limit card, auto trickle mode card with facility for setting trickle charge current and monitoring battery current, error amplifier cards and pulse generating cards for achieving the DC output voltage stabilisation of $\pm 1\%$ and also for achieving current limiting feature. The electronic controller shall have protection features with indications for under-voltage, over-voltage, set output voltage and phase failure or voltage unbalance.

The electronic controller shall be provided with following features.

- Boost current stabilisation of $\pm 2\%$ with AC input variation of voltage



and

- frequency variation
of $\pm 10\%$ and $\pm 5\%$ respectively.
- Boost charge current limiter with potentiometer to adjust the setting.
 - v) Adequately sized necessary built-in accessories shall be provided such that on failure of the controller in auto mode the voltage can be effectively controlled manually.
 - vi) One (1) Filter circuit comprising of smoothing choke and condensers complete with HRC fuse with trip indication for filter condenser circuit.
 - vii) One (1) Auto/Manual selector switch for selecting the mode of operation of the controller.
 - viii) One (1) front panel mounted potentiometer for set point adjustment of output voltage in auto mode.
 - ix) One (1) front panel mounted potentiometer for manual adjustment of voltage in manual mode.
 - x) One (1) TP AC ON/OFF switch for float charger incoming.
 - xi) One (1) set of HRC fuses complete with fuse fittings for AC input with suitable ratings and with trip indication.
 - xii) One (1) set of the pilot lamps with series resistors to indicate float charger AC Mains 'ON' condition.
 - xiii) One (1) AC contactor with suitably rated coil and three main and 2 NO + 2 NC auxiliary contacts, suitably rated thermal overload relay and ON/OFF control switch.
 - xiv) One (1) set of HRC fuses complete with fuse fittings for the DC output, and with trip indication.
 - xv) One (1) moving coil DC ammeter, with shunt, of size 96 x 96 mm and suitable range to read the float charger output current.
 - xvi) One (1) Double pole DC ON/OFF rotary switch for float charger output.
 - xvii) One (1) pilot lamp with series resistor to indicate float charger DC 'ON' condition.
 - xv) Outgoing DC Distribution Board with MCBs.

Power Electronic Components

- a) Diode and thyristors shall be of mono crystalline type silicon, capable of continuous output at specified voltages. It shall have high power efficiency.
- b) If many diode or thyristor assemblies are connected in parallel, care shall be taken to ensure that each rectifier or thyristor operates within its rating and shares the load uniformly. This may be achieved with the help of chokes. Also, care should be taken to select matched pairs of rectifier heat sink units.
- c) Each diode or thyristor built in a multi-built assembly shall be provided with a short circuit protection to avoid complete shut-down of the equipment because of a fault on single unit. Suitable fuses shall be provided such protection.



for

- d) Necessary spare capacity shall be built in the equipment to continuously supply full load even with one unit out of circuit.
- e) The diodes or thyristor banks shall be natural air cooled.
- f) The diodes or thyristors shall be protected against over voltage due to chopping surges with the aid of snubbers. It shall be ensured that normal load currents and especially fault currents are shared equally between parallel links, within the specified limits. To achieve this, great care shall be taken to design the layout of the rectifier links to ensure equal lengths of busbars and as near as possible identical contact resistance in each current path.

4.3 Transformer

Codes and Standards

The design, manufacture and performance of equipment shall comply with currently applicable statutory, regulations and safety codes in the locality where the equipment will be installed. Nothing in this specification shall be construed to relieve vendor from his responsibility.

Unless otherwise specified, equipment shall conform to the latest applicable Indian or IES standards. Equipment complying with any other authoritative standards, such as British, U.S.A., VDE etc. will also be considered if offered. The relevant Indian standards are :

Code No.	Title
IS2026/BS171/IEC76	Power Transformer
IS3639	Fittings and Accessories
IS1180	Auxiliary Transformer
IS6600/BSCP.1010/IEC354	Loading of oil immersed transformer
IS335/BS 148/IEC296	Transformer Oil
IS2099/BS223/IEC137	Bushings for > 1000V, AC
IS7421	Bushings for □ 1000V, AC
IS13947 (Part 1) / IEC947-1	Degree of Protection
IS3637	Buchholz Relay
IS 1271/BS2757/IEC85	Insulation Materials for Electrical Machinery
IS 3202/ BSCP1014/ IEC354	Climate Proofing

Code No.	Title
IS 1886	Installation & Maintenance of Transformers
IS 2705	Current Transformers

Climatic Conditions

Ambient temperature : 45 Deg. C outdoor



Performance & Characteristics

Transformer shall be capable of operating continuously and without adverse effects of overheating under all specified conditions of operation including variation in system of + 10% voltage and + 3% frequency or + 10% combined voltage and frequency unless otherwise specified separately.

Transformer shall be suitable for parallel operation with other transformers of similar characteristics.

Transformer shall be designed to withstand without any injury the thermal and mechanical stress caused by the short circuit currents of magnitude and duration specified in the data Sheet.

Transformer shall be designed for frequent direct on-line starting of motors having an equivalent rating in KVA up to CMR of the transformer and shall be capable of withstanding the forces arising from the starting current of these motors.

Operation Over Overloads: It shall be possible to operate all transformers as per loading guide IS: 6600 up to overloads of 150 %. There shall be no limitations imposed by bushing, tap changers, auxiliary equipment etc. to meet this requirement.

Constructional Features

A) General

Similar parts, particularly removable ones, shall be interchangeable. Screws, studs, nuts and bolts shall be as per Indian Standards. Nuts, bolts, pins used inside the transformers 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 is not trapped in any location. Facility shall be provided for lubrication of bearings and mechanisms. Mechanisms shall be constructed of non-corrodible material.

Material in contact with oil shall be such as not to contribute the formation of acid in oil. Surfaces in contacts 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.

B) Tank

Tank shall be made from good, commercial grade low carbon steel and shall be of 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 the following conditions:

Full vacuum of 760mm of Hg for filling with oil by vacuum.

Internal gas pressure of 0.35Kg/sq.cm (5lbs/sq. in. with oil at level).

Adequate space shall be provided at the bottom of the tank for

operating

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 sloped so that it does not retain rainwater.

Manholes with bolted covers shall be provided in the top or sides of transformer for easy access to the power ends 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 fixed base

C) Core

The magnetic circuit shall be of "core type" constructions. The core shall be built out of high grade, non-aging, low loss and 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 or windings.

All the core sections shall be bonded together with a metallic strip and connected to the tank for earthing, to ensure earth return and operation of protective gear in the event of a 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 2500 Volts 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 operation.

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.

D) Windings

Winding shall be three phase with minimum Class 'A' insulation.

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



The transformers shall be two winding type.

Winding shall be individually vacuum dried in hermetically sealed drying ovens and pre- shrunk 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 arranged 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.

Windings shall not contain sharp bends, which might damage the insulation or produce high dielectric stresses. No strip conductor wound on edge shall have width exceeding six times the thickness.

Materials used in the insulation and the assembly of the windings 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 connections shall be locked. Leads from the winding 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 connections.

E) Internal Earthing

All internal metals part of the transformers, with the individual clamping plates; shall be earthed. Core clamps and core bolts shall be insulated form the core by class B insulation unless other insulation is approved by purchaser.

The top clamping structure shall be connected to the tank by a 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 the 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 structure at one point only, through a link placed in an 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 0.25 mm 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.

F) Under Carriage

The undercarriage of the transformer shall be provided with detachable steel flanged heels 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 lubrications. 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 permitting movement in two directions. The wheels or rollers will be swiveled after jacking the transformer and they shall be lockable in the two positions.

G) Insulating Oil

Transformer oil will be mineral type (not synthetic, PCB based) conforming to IS: 331. Comparatively small transformers shall be supplied "Under Oil". For large transformers with radiator banks, it may not be feasible to ship the transformer "Under Oil", oil being supplied separately. Tested insulating oil required for filling or topping up the transformers including radiator banks and conservator shall be supplied loose, in non-returnable drums. The quantity of oil shall be sufficient for filling at site with 10% extra quantity of oil in non-returnable drums. No inhibitors shall be used in the oil.

Terminal Arrangement

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/aluminium lugs and hardware (bolts, nut, plain & spring washers etc.) 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 un-drilled removable gland plate, access cover and earthing terminals.

Separate Neutral Bushing for Earthing

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

a) Marshalling Box

For the required fittings on the transformer, a dust-tight, vermin proof and weatherproof, sheet steel (2 mm 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 a hinged door at the front.

All doors covers and plates shall be fitted with neoprene gaskets. Bottom shall be at least 600mm from floor level.

All devices mounted on the transformer and requiring electrical connections, such as Buchholz relay, oil & winding temperature indicator contacts, pressure release valve contacts, cooler fan motors and their controls, shall be wired to marshalling box.

All interconnections between these devices and marshalling boxes shall be carried out with either 1100/650V grade PVC insulated armoured 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.

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

Transformer Cooling Equipment

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 1.4 mm. They shall be so designed as to avoid pockets in which moisture may collect.

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 for each radiator.

Shut-off valves 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.

Tap Changing Gear

ON LOAD TAP CHANGING GEAR (OLTC)

The tap changer shall be suitable for connection to tapping brought out from H.T. winding (Delta Connected) covering a range of sixteen steps from + 5% to –15% making a total of seventeen positions (Taps). All taps shall be rated for maximum continuous KVA rating of the transformer and shall be suitable for operation at sustained voltage of 110% of the rated tap voltage.

OLTC gear shall be high-speed resistor transition type. Following fittings and accessories shall be provided for the OLTC. Some of the accessories may not be necessary, depending on the design and construction of the OLTC gear.

- Local Control Panel
- Remote Control Panel
- Conservator with oil level gauge, oil filling hole and cap
- Pressure wave protection device or Oil surge operated relay
- Oil drain valve and vent plug
- Silica gel breather
- Filter valves at top and bottom
- Air release plug

OPERATION

The tap changer shall change the taps by one step only at a time, when a tap change impulse is given manually or automatically. Further tap changing operation should take place only if a fresh impulse is given. Under auto-operation, the tap change should be initiated when the actual voltage deviates from the reference voltage by more than one step and remains at that level for more than a present time. (Time range : 30-180 seconds).

LOCAL CONTROL PANEL

The local control panel shall be of sheet steel weatherproof construction, mounted directly on the transformer. It shall have lockable door, neoprene gaskets at all mating surfaces and a removable gland plate at the bottom. The panel shall include the following equipment. However, the contractor shall give the detailed list of equipment provided on the panel.

- Main switch (TPN) for incoming supply, at 400-440V AC.
- A Local/Remote Control selector switch.
- HRC fuses (link type) separate for motor power and control circuits
- Contactors, auxiliary relays, timers, limit switches and other devices, required for intended operation.
- Thermal overload protection for motor
- Raise/Lower push buttons
- Electric motor drive
- Cranking handle for mechanism operation.
- Interlock between electrical and mechanical drives
- Limit switches for extreme positions
- Mechanical tap position indicator.
- Potentiometer for remote tap position indicator
- Operation counter
- 20W fluorescent Cubicle lamp with MCB
- Convenience socket outlet 15A SP & E, 230V AC controlled by



DP MCB

- Thermostat operated 50W Space heater controlled by DP MCB

REMOTE CONTROL PANEL

The remote control panel shall be of dust-damp-vermin proof 14 SWG sheet steel construction having lockable hinged door, neoprene gaskets at all mating surfaces. The panel shall be suitable for indoor installation & floor mounted type. The panel shall have undrilled gland plates at top & bottom for the cable entries. The panel shall be complete with equipment required for an automatic tap changing operation, which shall include the following. However, the contractor shall give the detailed list of equipment provided on the panel.

- Main switch for incoming supply
- Auto / Off / Manual selector switch
- Automatic voltage control relay
- Auxiliary relays, timers, required for satisfactory operation
- Tap position indicator
- Raise / Lower push buttons
- "Tap change in Progress" signal lamp for Raise & Lower
- "Supply ON" signal lamp
- Alarm hooter for OLTC trouble
- 20W fluorescent Cubicle lamp with MCB
- Convenience socket outlet 15A SP & E, 230V AC controlled by DP MCB
- Thermostat operated 50W Space heater controlled by DP MCB
- All remote indications and alarms for forced cooling systems for transformer, if called for
- Paralleling equipment, if called for, shall include the following
- Sequence selector switch
- Lockout relay
- 'Out of step' relay
- 'Out of step' signal lamp
- 'Out of step' alarm
- 'Step' correcting switch
- Voltage chart indicating tap position verses secondary voltage

NOTES FOR LOCAL & REMOTE CONTROL PANELS-

- Nameplates for the panels, labels for the devices and legend plates for the devices mounted on the door shall be provided for the control circuit.
- Two internal & two external earthing terminals each complete with one spring and two plain washers and nuts and bolts shall be provided on the opposite sides of each panel.
- The local control panel shall be painted with the paint shade similar to the transformer, but the remote control panel shall be painted with the color shade approved by the client.

FITTINGS AND ACCESSORIES

Transformers shall be supplied with fittings and accessories as indicated in the table below depending on the rating of the transformer.

R:=> Required

NR:=> Not Required

Sr.	Description	Rating of Transformer to which fitted			
		Up to 400 KVA	500 to 800 KVA	1000 to 2000 KVA	2500 KVA & above
1	Rating & diagram plate	R	R	R	R
2	Dial type magnetic oil level gauge with low level alarm	NR	NR	R	R
3	Silica Gel breather with a seal, & connecting pipe, in a transparent enclosure	R	R	R	R
4	Explosion Vent with diaphragm	NR	NR	R	R
5	Conservator with filling hole, cap and drain valve and isolating valve for conservator.	R	R	R	R
6	Double floats buchholz relay with alarm and trip contacts and				

Sr.	Description	Rating of Transformer to which fitted			
		Up to 400 KVA	500 to 800 KVA	1000 to 2000 KVA	2500 KVA & above
	level for simulating operation of buchholz relay and shut off valve on tank side.	NR	R	R	R
7	Dial thermometer for oil temperature marked in °C with alarm and trip contacts (adjustable)	NR	NR	R	R
8	Image coil with C.T. test terminals, calibrating resistors etc. for winding temperature with dial type thermometer having alarm & trip contacts (adjustable) with a maximum reading pointer (for	NR	NR	NR	R (4000 KVA & above)
9	Weatherproof marshalling box with terminal blocks complete with PVC armoured cables terminated with glands from buchholz relay, alarm/trip	NR	NR	R	R
10	Thermometer pocket (for top oil temp.)	R	R	R	R
11	Lifting lugs	R	R	R	R
12	Jacking pads – 4 Nos.	NR	NR	R	R
13	Draw eyes	NR	NR	R	R
14	Top Filter valve	R	R	R	R
15	Bottom filter valve	R	R	R	R

16	Drain valve with plug	R	R	R	R
17	Oil sampling valve	NR	NR	NR	R
18	Inspection cover	NR	NR	R	R
19	Air release vent	R	R	R	R
20	Bi-directional rollers	R	R	R	R
21	Two earthing terminals	R	R	R	R
22	Plain oil level indicator with minimum marking	R	R	R	R

NOTES

a) All instruments shall not be less than 96 mm dia or sq. b) All instruments shall be readable from ground level.

All alarm and trip contacts of instruments shall be suitable for 1A.250 Volts D.C. or 5A.250 Volts A.C.

Earthing pads : Two earthing pads of copper or other non-corrodible material on transformer tank together with clamp type terminals suitable for Purchaser earthing conductors.

Suitable earthing terminals on cable boxes and separately mounted radiator banks.

Terminal marking and rating plates shall be as per IS : 2022.

REQUIREMENTS OF FITTINGS AND ACCESSORIES

Conservator (for transformer rating as per IS : 2026). The conservator shall be of sufficient volume to maintain the oil seal from the minimum ambient temperature of –5 deg.C upto an oil temperature of 100 deg.C, with oil level varying within the minimum and maximum visible levels. The conservator shall be provided with the following accessories :

Filling plug, sump and drain valve.

150 mm diameter magnetic type oil level gauge & oil sight gauge, both provided with markings for minimum oil level, and oil level at 30 deg. C.

A bolted cover for cleaning.

Valve for shutting off oil to the transformer.

Valves

The following valves shall be fitted on the transformer tank. Main tank drain valve with flanged or threaded connection.

Top filtering valve with plug located on the same side as the main drain valve.

Bottom filter connection with plug to drain oil from the lowest part of the tank. This connection shall not be tapped through the bottom of the transformer.

Oil sampling devices at top and bottom of the main tank. These shall be distinct from other valves.

Adequate number of air relief vents.

Two plugged pipe outlets at top for applying vacuum. All valve opening plugged or blank flanged.



shall be

Valves for the cooler systems are indicated in the respective sections. These valves shall be lockable in closed or open positions and shall be provided with an indicator to show position of the valve.

Pressure Relief Devices

A pressure relief vent (explosion vent) mounted on the tank shall be provided for relieving pressure within the transformer. It shall operate for pressure less than the hydraulic test pressure for the tank. The explosion vent shall be provided with diaphragm (s) and a screen to prevent fragments of a shuttered diaphragm being sucked into the transformer under vacuum.

Equalization of air pressure in the vent may be achieved by a pipe connection to the conservator.

(This device shall be provided for all transformers rated 500 KVA and above.)

Gas And Oil Actuated Relay (Buchholz Relay)

A double float type Buchholz relay as per IS : 3637/8 shall be provided whenever called for in Data Sheet – A. All gas evolved in the transformer shall collect in this relay. The relay shall be provided with a test cock suitable for a flexible pipe connection for checking its operation. A copper tube shall be connected from the gas collector to a valve located about 1.25 M above ground level to facilitate sampling with the transformer in service. The device shall be provided with two electrically independent ungrounded contacts, one for alarm on gas accumulation and the other for tripping on sudden rise of pressure.

TEMPERATURE INDICATORS Dial type Thermometer

All transformers shall be provided with a 150 mm dial type thermometer for top oil temperature indication. The thermometer shall have adjustable, electrically independent, ungrounded alarm and trip contacts, maximum reading pointer and resetting device.

Winding Temperature Indicator

A device for measuring the hot spot temperature of the winding shall be provided.

It shall comprise of the following:

- a) Temperature sensing element. b) Image coil
- c) Current transformer
- d) 150 mm dia local indicating instrument with four adjustable electrically independent ungrounded contacts, two for control of cooling equipment and two for winding alarm and trip.
- e) Calibration device.
- f) Automatic ambient temperature compensation
- g) In addition to the above, the Analogue signal transmitter for remote indication and remote indicating flush mounted instrument for mounting on client's panel shall be provided (when specifically called for).

Painting

The interior of all transformer tanks and other oil filled chambers and internal structure steel work shall be cleaned of all scale and dust by shot – blasting unless otherwise approved. These surfaces shall be painted with not less than two coats of heat resistance, oil insoluble and insulating varnish. Steel surfaces exposed to the weather shall be thoroughly cleaned and applied a priming coat of zinc chromate. The second coat shall be of an oil and weather resistant nature, preferably of distinct colour from the prime and finish coats. The final coat shall be of glossy oil and weather resisting non fading paint of specified shade.

All exposed bolts, nuts and washers shall be of galvanized steel unless otherwise approved.

Metal parts not accessible for painting shall be made of corrosion-resistant material. Machined

finished and bright surfaces shall be coated with a suitable compound and wrapped.

Interior surfaces of mechanism chambers and knocks shall receive three coats of paint after cleaning the final coat shall be of a light-coloured anti-condensation paint.

Tests

All transformers shall be completely assembled at Works to ascertain that all parts fit correctly.

Routine Tests

Routine tests as per IS shall be performed on all transformers. The following additional points may be noted:

Resistance of winding shall be measured at principal and the two extreme taps. Impedance voltage shall be measured at principal and the two extreme taps.

No load loss and exciting current shall be measured at rated frequency at 100 % and 110 % rated voltage. These tests shall be done before and after impulse tests if the later are specified. Exciting current shall be measured on each phase and recorded.

No load loss and exciting current shall be measured and recorded with 415 V, 3 phase, 50 Hz, input on LV side (assuming LV is rated higher than 415 V).

Oil Pressure Test : All oil filled compartments shall be filled with transformer oil and subjected to a pressure of 035 Kg/cm above the pressure that would obtain under normal conditions with full head of oil. The pressure shall be maintained for 12 hours during which time no oil leakage shall occur. When heat run test is specified, the oil pressure test shall be performed immediately after the heat run. Otherwise the test may be performed at ambient temperature.

Power taken by cooling equipment shall be measured for all transformers.

Type test

Auxiliary equipment

All equipment shall be tested as per the relevant IS. Test certificates shall be submitted for bought out items. High voltage withstand test shall be performed on auxiliary equipment and writing after complete assembly.

Test Reports

Four copies of preliminary test results shall be submitted for Purchaser's approval before dispatch of transformer.

Additional bound copies as per enclosed distribution schedule of complete test results including all tests on transformer, auxiliaries, current transformer characteristics shall be furnished with the transformer.

Losses

If the measured losses on the transformer are found to exceed guaranteed loss figures by more than the + 10% tolerance permitted, following penalties shall be levied on the contractor.

No Load Loss

Indian Rupees. 2,43,731.00 for every kW in excess of the tolerance on guaranteed losses., As per CBIP Guidelines

Load Loss

Indian Rupees. 1,34,781.00 for every kW in excess of the tolerance on guaranteed losses, As per CBIP Guidelines

Rejection

Purchaser may reject any transformer if during tests or service any of the following conditions arise :

No load loss exceeds the guaranteed value by 15% or more.

Load loss exceeds the guaranteed value by 15% or more.

Impedance voltage at principal tapping not within the limits of tolerance (+ 10%) over guaranteed value.

Oil or winding temperature rise exceeds the specified value by 5 deg. C. A transformer fails on impulse test.

Transformer fails on power frequency voltage withstand test.

The rejected transformer, shall be replaced by transformers complying with the requirements to this specification at the contractor's cost.

If the commissioning of the project is likely to be delayed by the rejection of a transformer, the Engineer reserves the right to accept the rejected transformer until the replacement transformer is made available. Transporting the rejected and replacement transformers as well as installation and commissioning of both the transformers shall be at the contractor's cost.

Spares

Bidder shall quote itemwise prices for recommended spares, including the following :

- a) One (1) completely wound limb comprising HV / MV / LV winding. b) Complete set of gaskets.
- c) One bushing of each type.

- d) One CT of each type.
- e) Cooler fan / fan motor.
- f) Dial type thermometer.
- g) Oil level Gauge.

- h) Complete set of winding temperature indicating equipment.
- i) One cable sealing end of each type. j) Explosion vent diaphragms.
- k) Silica gel breather.
- l) One valve of each type.

4.4 415V BUS DUCT

CODES AND STANDARDS

Bus-duct shall be manufactured and tested according to the requirements of relevant Standards and Codes of Practices published by Indian Standards. If Indian Standards have not been published for any equipment, standard and code of practices published by following institutions shall govern- British Standards Institution International Electro-technical Commission American Standards Association Some of the relevant Standards are as follows-

Code No.	Title
IS 375	Marking & arrangement for switchgear, busbars, main
IS 2147	Degree of Protection
IS 3202	Climate- proofing of electrical equipment
IS 5082	Aluminium Busbars
IS 8081	For Non-segregated phase bus

CONSTRUCTIONAL FEATURES

GENERAL

The busduct shall be metal enclosed, non-segregated phase type, suitable for indoor/outdoor use as per layout drawing enclosed.

The busduct shall be supported from the ceiling, as required. Drawings and details for supporting arrangement shall be given by the supplier of the busduct, however actual supports will be provided by the purchaser/ contractor.

ENCLOSURE

The enclosure of the bus-duct shall be fabricated from CRCA sheet steel enclosed of minimum 2-mm thickness and shall undergo 7-tank treatment for removal of grease, rust, scale, oil by pickling followed by phosphating and 2 coats of Zinc rich primer. The sheet steel shall be further provided with epoxy based powder coating in light Green shade (shade 613 as per IS 5) from outside and Matt Black painting on the inside.

The fabrication of bus-duct shall be so designed as to offer dust-proof and vermin proof enclosure with IP 54 degree of protection for Indoor run IP 55 degree of protection for outdoor run. Adequate access shall be available for inspection/replacement/ tightening of busbars support/ fish plates / fasteners.

Rain hood / Canopy shall be provided for outdoor portion of the bus-duct. Rain

hood / canopy be designed to offer complete protection form rain.

Non-deteriorating type gaskets shall be provided at all mating surfaces. The gaskets used for out door portion of the bus-duct shall not deteriorate due to hostile climatic conditions and direct exposure to sunlight.

BUSBAR

The bus-duct shall be provided with three phase and neutral busbars. The material of the busbars shall be high conductivity electrolytic aluminium or copper conforming to relevant standards. Rating of the Neutral bus bar shall be at least 50% that of phase bus bar.

All busbars joints shall be of the bolted type. Spring washers shall be provided to ensure good contact at joints. Nut bolts of proper size and strength shall be used.

Busbars shall be air insulated with matt black painting. The clearance between phase and neutral shall be as per BS 162.

Busbar supports shall be made of high quality non-hygroscopic insulating material such as FRP, DMC or SMC. Hylam insulators are not acceptable. Surface of insulators shall be highly glazed and treated to minimize accumulation of dust, condensation of moisture ad tracing. The design of busbar supports shall be such that free thermal expansion of busbars shall be possible. In vertical run of the bus-duct, suitable clamps/supports shall be provided to retain the busbars in position and distribute loading evenly on supports.

When the busduct passes through building wall from indoors to outdoors, a wall frame assembly with seal off partition at wall to segregate the indoor and outdoor runs, shall be provided to prevent interchange of air between two sections. The seal off partition shall be of FRP with minimum thickness of 10mm.

Flanged ends shall be provided to facilitate connection of bus-duct, both at transformer and switchgear end. All hardware such as bolts, nuts, spring and plain washers shall be supplied alongwith bus-duct to connect it at both ends.

Reinforcement / stiffeners shall be provided for the covers from inside on which supporting lugs are provided.

TEMPERATURE RISE

Final temperature of the busduct when carrying the rated current under site condition.

For Enclosure	:	70°C	(final
For Busbars	:	85°C	(final
For Busbar joints	:	90°C	(final temp)

FLEXIBLE CONNECTORS

To take up mismatch of phase conductors during installation as well mechanical stresses due to thermal expansion of the busbars, braided flexible connectors shall be provided at the end terminations, both at transformer end and switchgear end and at intermediate places depending upon length and configuration of the bus-duct.

The connectors shall preferably be laminated to cater for linear expansion busbars. The material of flexible shall be same as busbars. If different

of

The busbars shall be braced for electro-mechanical stresses arising out of short-circuit condition.

Two nos. of terminals shall be brought out at ends of the earth bus to facilitate connection of earthing lead externally.

A space heater circuit comprising MCB, thermostat and a heater suitable for 230V AC supply shall be provided in the bus duct. (if called for) The space heater shall be located at a suitable location to maintain temperature of air 5°C above ambient throughout the length of the bus-duct.

A drain plug shall be provided on the busduct at the lowest point to drain condensed water in the bus- duct if specifically called for.

A cross-over chamber with sufficient number of links and supports shall be provided (if called for). The cross over chamber shall effect change of phase sequence to match with respective phase sequence in the end equipment. The links, insulators and fasteners shall be located such that access for replacement / tightening is available for all parts.

Suitable fabricated adapter box shall be provided wherever specified to interface with the termination arrangement on the end equipment connection.

PERFORMANCE

Maximum operating temperature at any point shall not exceed 85°C with the limiting ambient conditions. Eddy current heating shall be taken into account while designing the enclosure.

Busbars and insulating supports shall withstand successfully thermal and dynamic stresses resulting from the circuit currents.

DRAWINGS AND DOCUMENTS

Fully dimensioned, scale drawing showing general arrangement, assembly, installation configuration, clearances, creepage distances and interfacing details at both ends shall be submitted for approval. Calculations for bus bar capacity to carry rated current with specified maximum operating temperature.

Calculations for short time thermal and dynamic withstand capacity under specified fault level. Heat loss calculations

INSPECTION & TESTING

All routine tests as per IS shall be carried out on the completed assembly of the busduct which will be witnessed by the purchaser/his representative.

The following routine tests shall be carried out:

General Arrangement checks of the completed assembly. Insulation resistance measurement test.

High voltage test (P.F. Voltage withstand test) Milli volts drop test.

4.5 415V SWITCHGEAR

Codes & Standards

The design, construction, manufacture and performance of shall conform to latest applicable standards and comply with all currently statutes, regulations and safety codes in the locality where the equipment

equipment
applicable
will be



installed.

The relevant indian standards are :

Title	Code No.
Switchgear General Requirements	IS13947/BS5486/IEC947
Factory Built Assemblies of SWGR and Controlgear for Voltages upto and including 1000V AC &	IS8623/BS5486/IEC439
Air Break Switches	IS13947-P3 /BSEN60947 /IEC947-3
Miniature Circuit Breakers	IS8828/BSEN60898
Low voltage Fuses	IS13703/BS1362/IEC269-1
Contactors	IS13947/BS EN60947-4 /IEC947-1
Starters	IS13947/BS EN60947-4/ IEC292-1TO 4
Control Switches / Push buttons	IS6875 / BSEN 60947
Current Transformers	IS2705/BS7626
Voltage Transformers	IS3156/BS7625/IEC44, 186
Indicating instruments	IS1248/BS89/IEC51
Marking and Identification of Conductors and Apparatus Terminals	IS11353/BS159
A.C. Electricity Meters	IS722, 8530/BS5685 / IEC 145, 211
Degree of Protection	IS13947/IEC947-P1
Selection installation and maintenance of switchgear and	IS10118

Features of Construction

The switchgear shall be metal enclosed, modular type suitable for indoor floor mounting and shall have following features.

- Height shall not exceed 2300 mm
- Shall be Single front execution
- Shall have designation labels both on front and rear sides
- Shall be provided with proper gasketing for removable covers, doors, between panels and base frame and all around the perimeter of adjacent panels.

The switchgear shall be divided into distinct vertical sections each comprising :

- A completely metal enclosed busbar compartment running horizontally.
- Individual feeder modules arranged in multi-tier formation. It is essential that the modules are integral multiples of the basic unit size to provide for flexibility in changes, if any, at site.
- Enclosed vertical busbars serving all modules in the vertical section. For safety isolation of the vertical busbars, insulating barrier with cut-outs shall be provided to allow the power stab contacts to engage with vertical busbars.
- A vertical cable alley covering the entire height. The cable alley shall be minimum 300 mm wide for motor control modules and 500 mm wide for circuit breaker controlled modules.



- A horizontal separate enclosure for all auxiliary power & control buses, as required, shall be located so as to enable easy identification, maintenance and segregation from the main power buses. Tap - off connections from these buses shall be arranged separately for each vertical section.

The Switchgear shall be easily extendable on both sides by the addition of vertical sections after removing the end covers.

Operating devices shall be incorporated only in the front of switchgear

Each shipping section shall have metal sheets at both ends

Cable alley shall be provided with suitable hinged doors

Rear of single front switchgear shall be provided with removable panels with captive screws

All doors shall be with concealed type hinges and captive screws

Each vertical section shall be equipped with a space heater controlled by thermostat

Each switchgear cubicle shall be provided with interior lighting with a 20 W fluorescent tube with on/off switch.

A 240 V, 1 phase, AC plug point shall be provided in the interior of each cubicle with on-off switch for correction of head lamps

Interchangeability

All identical equipment and corresponding parts be fully interchangeable without any modifications.

Main And Auxiliary Buses

Main Buses & Taps

- a. Switchgear shall be provided with three phase or three phase and neutral busbars.
- b. Busbars shall be of uniform cross section throughout the length of the switchgear, and upto the incoming terminals of feeder circuit breaker / switch.
- c. The busbars shall be made of high conductivity copper or aluminium alloy of E91E grade as specified in the SLD
- d. Busbars shall be provided with at least the minimum clearances in air as per applicable standards for a 500 V, 3 phase system.
- e. All bus-bars, bus-taps shall be insulated with close fittings sleeve of hard, smooth, dust and dirt free plastic insulation of high dielectric strength (450 V/mil) to provide a permanent high dielectric non-ageing and non-tracking protection, impervious to water, tropical conditions and fungi. The insulation shall be non-inflammable and self-extinguishing and in fast colours to indicate phases. The joints shall be insulated in such a way as to provide for

accessibility of contact bolts for maintenance. The dielectric strength and properties shall hold good for the temperature range of 0 deg. C to 90 deg. C.

If the insulating sleeve is not coloured busbars shall be colour - coded with coloured bands at suitable intervals.

- f. Busbars shall be adequately supported and braced to withstand the stresses due to the specified short circuit currents for the associated switchgear. Busbar supports shall be made of glass reinforced moulded plastic material or DMC/SMC.
- g. Separate supports shall be provided for each phase of the busbars. If a common support is provided for all three phases, antitracking barriers shall be incorporated.
- h. Busbar joints shall be complete with high tensile steel bolts and Belleville washers and nuts. Busbars shall be thoroughly cleaned at the joint locations and a suitable contact grease shall be applied just before making a joint.

Auxiliary Buses

Auxiliary buses for control power supply, space heater power supply or any other specified service shall be provided. These buses shall be insulated, adequately supported and sized to suit specified requirements. The material of control power supply buses shall be electrolytic copper/aluminium.

The material for space heater power supply buses shall be same as that for the main power buses.

Sheet Metal Work

The switchgear frame shall be fabricated using suitable mild steel structural sections or pressed and shaped cold rolled sheet steel of thickness not less than 2.5 mm.

- a) Frames shall be enclosed by sheet steel of thickness not less than 2 mm cold rolled or 2.5 mm hot rolled, smoothly finished, levelled, and free from flaws. Doors and covers shall be made of sheet steel of thickness not less than 1.6 mm cold rolled or 2 mm hot rolled. Stiffeners shall be provided wherever necessary.
- b) All panel edges and door edges shall be reinforced against distortion by rolling, bending or by the addition of welded reinforcement members.
- c) Cut-outs shall be true in shape and avoid of sharp edges.
- d) The complete structure shall be rigid, self-supporting, free from vibration, twists and bends.

Painting

All sheet steel work shall be phosphated in accordance with the following procedure and in accordance with applicable standards.

Oil, grease, dirt and swarf shall be thoroughly removed by emulsion cleaning.

Rust and scale shall be removed by pickling with dilute acid followed by



washing and running water, rinsing with slightly alkaline hot water and drying.

After phosphating, thorough, rinsing shall be carried out with clean water, followed by final rinsing with dilute dichromate solution and oven drying.

- a. The phosphate coating shall be sealed by the application of two coats of ready mixed, stoving type zinc chromate primer. The first coat may be 'flash dried' while the second coat shall be stoved.
- b. After application of the primer, two coats of finishing paint shall be applied, with each coat followed by stoving. The second finishing coat for the exterior of panels shall be applied after completion of tests.
- c. Each coat of primer and finishing paint shall be of a slightly different shade to enable inspection of the painting.
- d. The final finished thickness of paint film on steel shall not be less than 100 microns, and shall not be more than 150 microns.
- e. Finished painted appearance of equipment shall present an aesthetically pleasing appearance, free from dents and uneven surfaces.

Motor Starters

The selection of starters shall be made according to the rating of the motor used with the equipment. The selection shall be done as follows-

<input type="checkbox"/>	Upto 10 HP	:	Direct On line Starter
<input type="checkbox"/>	11 HP to 50 HP	:	Automatic star-Delta Starter
<input type="checkbox"/>	Above 51 HP	:	Auto Transformer

All starter feeders shall have individual ammeter with selector switch. Each starters shall comprise

- One main TP Switch fuse unit/Moulded Case circuit breaker/Motor Protection Circuit Breaker (as specified in SLD)
- HRC fuses for Power & Control
- Main power contactor, auxiliary contractor/s
- Bimetallic thermal overload relay with built in single phasing preventor
- Start/Stop / Reset Push Buttons
- On, Off, Trip indication lamps, and
- terminals

Direct On-Line Starters (DOL)

Direct on-line starters shall be suitable for Class AC 3 utilisation category suitable for type –2 coordination as specified in applicable standards. Each DOL starter feeder shall be complete with Switch fuse unit, HRC fuse, contactor, Bimetallic overload relay with built in single phasing preventor, ON-OFF-TRIP indication lamps, Start-Stop-Reset push buttons.

Automatic Star-Delta Starters

- a. Automatic star-Delta starters shall comprise three sets of contactors one for the line, one for the star point and one for the delta, and a timer relay to automatically change the connections from star to delta.



- b. Star-delta contactors shall be electrically interlocked to permit starting of the motor in the proper sequence, namely star contactor closing, line contactor closing, timer energised, timer contact de-energising the star contactor, and delta contactor closing.
- c. Start delta starters shall be suitable for Class AC 3 utilisation category suitable for type – 2 coordination as specified in applicable standards.
- d. Each starter feeder shall be complete with Switch fuse unit, HRC fuse, contactor, Bimetallic overload relay with built in single phasing preventor, ON-OFF-TRIP indication lamps, Start- Stop-Reset push buttons.

Auto Transformer Starter

- a. The autotransformer shall be sheet steel enclosed.
- b. The auto transformer starter shall comprise 3phase transformer of adequate KVA rating.
- c. The type of transformer cooling shall be either ONAN or ANAN
- d. Transformer shall have Tappings at 50%, 65%, 80%
- e. For transformer sizing purpose, maximum starting duration shall be considered as 20 seconds.
- f. The transformer shall be suitable for maximum of 4 no of starts per hour.
- g. The autotransformer shall be complete with Minimum Fittings and accessories as per Statutory (IS / BS) requirements.

Thermal Overload Relays

- a. Starters shall be complete with a three element, positive acting, ambient temperature compensated, time lagged thermal overload relay with adjustable settings. The setting range shall be properly selected in accordance with the rating of the motor.
- b. Thermal overload relays shall be hand reset type.
- c. 'Stop' push button of the starter and hand reset device shall be separate from each other.
- d. Overload relay hand reset push button shall be brought out on the front of the compartment door.
- e. Overload relay shall be provided with at least one 'NO' and one 'NC' or one change-over contact.

Single Phasing Preventers

The relay shall be suitable for application to protect reversible and non-reversible motors. The relay operation shall be independent of the motor KW rating, the loading conditions prior to the occurrence of the single phasing and rpm of the motor. The relay shall be of the fail-safe type and shall operate to trip the motor when the relay internal wiring is accidentally open circuited.

Air Circuit Breakers

- a. Electrically/Manually Draw out type Air circuit breakers with microprocessor based thermal and magnetic releases (ACBs) shall be provided when called for in SLD. The ACBs shall conform to the latest application standards.
- b. ACBs in AC circuits shall be of triple pole construction arranged for simultaneous three pole electrical/manual closing and opening and for automatic instantaneous tripping on short circuit.

Operating mechanism shall be quick- make, quick-break and trip-free type. The ON, OFF and TRIP positions of the ACB shall be clearly indicated and visible to the operator when mounted as in service. Front of board operating handle shall be provided.

Moulded Case Circuit Breakers

- a. Moulded case circuit breakers (MCCBs) shall conform to the latest application standards.
- b. MCCBs in AC circuits 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 and trip-free type. The ON, OFF and TRIP positions 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.
- c. MCCBs shall be capable of withstanding the thermal stresses caused by overloads and locked rotor currents of values associated with protective relays settings of the motor starting equipment and the mechanical stress caused by the peak short-circuit current of value associated with the switchgear rating. The maximum tripping time under short circuit shall not exceed 20 milliseconds.
- d. MCCB terminals shall be shrouded and designed to receive cable lugs for cable sizes relevant to circuit ratings.
- e. All MCCBs shall be provided with Rotary handles for operational ease.

Current Transformers

- a. Current transformers shall be of the dry type resin cast.
- b. Current transformer shall have a short time withstand rating equal to the short time withstand rating of the associated switchgear for one second.
- c. Unless otherwise specified, the minimum performance requirement of current transformers are as follows :
 - Measuring CTs - 10 VA, accuracy class 1.0 and an instrument safety factor of 1.
 - Protective CTs - 15 VA, accuracy class 5P and an accuracy limit factor of 10.
- d. Test links shall be provided in both secondary leads of the CTs to easily carry out current measurement tests.
- e. All current transformers shall be earthed through a separate earth link on the terminal block to permit easy measurement of the current transformer insulation resistance.

Relays

The following clauses shall apply to the protective relays.

Relays shall be -

- enclosed in dust proof flush mounting drawout type cases.
- accessible for setting and resetting from the front

- provided with positive acting hand-reset flat indicators visible from the front.

Access to setting devices shall be possible only after the front covers are removed. Access to resetting devices shall be external to the case.

Auxiliary relays shall be rated to operate satisfactorily between 70 % and 110 % rated voltage. Each relay shall be provided with at least two separate voltage free contacts.

Indicating Instruments and Meters

Electrical indicating instruments shall be of minimum 96 mm square size, suitable for flush mounting.

Indicating instruments shall have provision for zero adjustment outside the cover. Instrument dials shall be parallex free with black numerals on a white dial.

Ammeters provided on motor circuits shall be provided with a suppressed extended scale to indicate motor starting current.

Watt-hour meters shall be electronic type.

All meters except watt hour meter shall be Analog type.

Indicating Lamps

Indicating lamps shall be :

- of the filament type and of low watt consumption / LED Type
- provided with series resistors.
- provided with translucent lamp covers of colours 'Red', 'Green' and 'Amber' as required in the control wiring diagrams.
- Bulbs and lenses shall be easily replaceable from the front.

Control and Selector Switches

Control and selector switches shall be :

- of the rotary type
- adequately rated for the purpose intended (minimum acceptable rating is 10 A continuous at 240 V AC and 1A (inductive break) 220 V DC.
- provided with escutcheon plates clearly marked to show the positions. Control switches

shall be :

- of the spring return to normal type
- provided with pistol grip type handles.

Selector switches shall be :

- of the maintained contact stayput type. Switches in ammeter circuits shall have make-before-break type contact.
- provided with oval handle.

Push Buttons

Push buttons shall be :

- of the momentary contact, push to actuate type rated to carry 10 A at 240 V AC a 1A (inductive breaking) at 220 V DC.
- fitted with self reset, 2 NO and 2 NC contacts.
- provided with integral escutcheon plates marked with its function.

'Start', 'Open', 'Close' push buttons shall be green in colour.

'Stop' push buttons shall be red in colour.

All other push buttons shall be black in colour.

'Emergency Stop' push buttons shall be of the lockable in the pushed position type and rotate to release and shall be shrouded to prevent accidental operation.

Space Heaters

Space heaters for switchgear panels shall be :

- suitable for operation on a supply system specified.
- provided with single pole MCB with overload and short circuit release.
- provided with thermostats to cut off the heaters at 45 deg. C.

Window Type Alarm Annunciators

The alarm annunciation scheme wherever specified in control wiring drawings shall incorporate the following features :

- visual indication of the fault by means of steadily lit alarm windows.
- audible alarm on the occurrence of the fault.
- red facia units to differentiate trip alarm from non- trip alarms.
- acknowledgement of occurrence of fault, incorporating audible alarm cancellation features.
- resetting the scheme after the faults have been cleared
- facility to test the healthy condition of the lamps automatically

excluding units indicating existing faults.

- prevention of maloperation of the scheme when the push buttons are pressed incorrectly or in a wrong sequence.
- initiation of the complete sequence of audiovisual alarms in the event of a new fault occurring at the time of accepting an existing fault.
- suitable for operation on a 2 wire, AC supply (voltage indicated in Data Sheet - A) with a supply voltage variation between 80 % and 110 % of the rated voltage.
- suitable for operation for fleeting (15 milli sec. duration) as well as the persistent faults.
- facility for a separate audio-visual alarm to indicate 'Alarm supply failure'.
- facility for duplicating the audio-visual alarm at a second location.

Window alarm annunciators shall incorporate the following constructional

features :

- flush mounted facia units, each of which is provided with two lamps and a series resistor and a ground glass plate in front of the inscription.
- plug in relays mounted behind the facia units

The alarm annunciation scheme shall comprise the following equipments.

- a facia unit complete with relays for each fault.
- a common alarm bell
- 'Accept' 'Reset' and 'Lamp Test' push buttons.
- Alarm supply failure, 'Accept' and 'Reset' push buttons.

4.6 Local Push Button Stations

Standards

- a. The design, manufacture and performance of the equipment to be supplied under the scope of this specification shall comply with latest revisions of relevant Indian Standards and rules.
- b. The design and workmanship shall be in accordance with best engineering practices as applicable to industrial electrical equipment enclosures.

Construction

- a. Industrial Local Control Station enclosure shall be of Cast Aluminium LM6 alloy enclosure having minimum 3 mm thickness.
- b. The enclosure shall be weatherproof, IP-55 suitable for outdoor installation. All mating surfaces of industrial LCS shall be with continuous non-deteriorating type special rubber gaskets/neoprene gaskets. An additional 2MM thick Aluminium canopy shall be provided to give adequate protection against weather.

For ease in cable terminations, the minimum distance between the terminal blocks and the cable entry gland plate shall be 50 mm for 1.5 sq.mm, size cables.

Cable Entries

Two threaded entries shall be of 20 mm shall be provided on each Local Control Stations at the bottom for fixing the cable glands. Metallic/ rubber plug shall be provided for sealing one of the cable entry.

Earthing

The enclosure shall be provided with two (2) nos. of external earthing terminals and one (1) no. internal earthing terminal each of 2.5 mm diameter complete with nut, spring washers for terminatio of 14 SWG G.I. wire.

Wiring

All internal wiring upto the terminal block in the Local Control Station shall be carried out with 1.5 sq.mm. stranded copper conductors. Wires shall be PVC insulated type of 650/1100V grade. The wire shall be terminated with crimping type lugs only and shall be provided with ferrules at both the ends.

Painting

The Local Control Stations shall be treated with two coats of epoxy primer after thorough cleaning and treating of the surfaces and shall be finally provided with two coats of epoxy paint. Shade of final paint shall be 631 to IS 1.

Name Plate

Each LCS shall be provided with name plate. Name plates shall be made from rear engraved, perspex with letters of size minimum 6 mm on black background. All nameplates shall be identical in size and shall be fixed with screws on the cover.

Component Specifications

Push Button

- a. Each push button shall be provided with 1 NO + 1 NC contacts, each rated to carry, make and break 10A at 240V AC.
- b. Colour of the actuators of "STOP" push button shall be RED and that of "START" push button shall be "GREEN". Stop Push Button actuator shall be mushroom head type and shall have stay-put feature i.e. once the "STOP" push button is pressed, it remains in pressed position until its actuator is turned in either direction. "START" push button shall be totally shrouded type to prevent accidental start of the motor.

Terminal Blocks

Voltage grade of terminal block shall be 660V. Current rating, their size and make shall be as per the requirement specified. Two nos. spare terminals shall be provided in each local control station.

Inspection & Testing

The LCS shall be routine tested at manufacturer's works in the presence of Purchaser/ his representative before despatch to site.

Specific Technical Particulars

Sr	Description	Details
1	Material of Enclosure	Die Cast Aluminium alloy LM6
2	PUSH BUTTONS	
2.1	Make – element	L & T / Teknic / Siemens
2.2	Actuator	"GREEN" for "START", "RED" for "STOP"
2.3	Type	Spring return for "START", mushroom head stayput for "STOP"
2.4	Standard to which equipments	IS 8623 & IS 4237
3.	TERMINAL BLOCK	
3.1	Make	As per List of Approved Vendors
3.2	Type	Clip-on
3.3	Size	2.5 sq.mm.
3.4	Voltage grade	660V
3.5	Current rating	10A
4.0	INTERNAL WIRING	
	SIZE	1.5 SQ.MM. Stranded copper conductor

4.7 Power Capacitors & Capacitor Control Panel

Codes and Standards

Title	Code No.
Shunt capacitors for power systems	IS : 2834
Internal fuses and internal overpressure disconnectors for shunt	IS : 12672
Metal enclosed switchgear	IS : 3427 / BSEN 60298 / IEC : 298
Code of practice for phosphating iron and steel	IS : 6005/BS : 3189
Specification for copper rods and bars for electrical purpose	IS : 613
Code of practice for phosphating iron and steel	IS6005/BS3189
Specification for copper rods and bars for electrical purposes	IS613
Control transformers for switchgear and controlgear voltage not exceeding	IS12021

Design Features

Constructional Features

- a. The capacitor banks shall be complete with all parts that are necessary or essential for efficient operation. Such parts shall be deemed to be within the scope of supply whether specifically mentioned or not.
- b. 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 galvanised.
- c. The capacitor bank may comprise of suitable number of single phase units in series parallel combination. However, the number of parallel units in each of the series racks shall be such that failure of one unit shall not create an overvoltage on the units in parallel with it, which will result in the failure of the parallel units.
 - 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.
- d. Each capacitor case and the cubicle shall be earthed to a separate earth bus in the cubicle.
- e. 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 : 2834.

Individual Capacitor Unit

- a. The power capacitor shall be self healing Mixed Di-electric type.
- b. Each unit shall be a self-contained, indoor/outdoor type unit, with a rating at 50 cycles of 5,10, 12.5, 20, 25, 50, 100 or 200 KVAR as required to give approximate bank capacitors required. Other things being equal larger sized units shall be provided.
- c. Bushings shall be porcelain type and shall be joined to the case by solder-welded or other method which ensures an adequate and permanent seal.
- d. Each unit shall be non-inflammable dielectric immersed self cooled and hermetically sealed.
- e. Each unit shall satisfactorily operate at 135 % of rated KVAR including factors of overvoltage, harmonic currents and manufacturing tolerance. The units shall be capable of continuously withstanding satisfactorily any overvoltage up to a maximum of 10 % above the rated voltage, excluding transients.
- f. A weather-proof and corrosion-proof name plate shall be provided on each capacitor unit. The nameplate shall contain the information setout in IS : 2834.

Series Reactors

The capacitor banks shall be provided with series reactors. The reactor design shall be such that they will not be overloaded due to harmonics in the supply system. The reactor shall be :

- i) Indoor or outdoor type.
- ii) Completely sealed unit.
- iii) Either dry type or non-inflammable dielectric immersed in case of indoor units.
- iv) Designed to have a linear V-I characteristic upto 150 % of rated capacitor current..
- v) Designed to have temperature rise within limits as specified in IS : 2022.

Unit Protection

Each capacitor unit shall be individually protected by an HRC fuse 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 blown fuse shall give visual indication so that it may be detected during periodic inspection. The fuse blowing time shall co- ordinate with the pressure built up within the unit to avoid explosion.

Control Requirements : Capacitor Control Panel

This shall generally conform to below mentioned specifications.

- a. The control equipment shall be mounted in a panel made of 14 gauge sheet steel. The panel shall be of indoor or outdoor type as specified.
- b. The panel shall consist of -

- Automatic power factor control relay
 - Isolating MCCB
 - Capacitor duty contactor
 - relays responsive to current/voltage/KVAR/PF as specified for automatic switching.
 - sequencing devices, timer and auxiliary relays for automatic sequential switching of the capacitors in and out of circuit.
 - Auto manual selector switches
 - Push button for opening and closing the power circuit.
 - Red and green lamps for capacitors ON/OFF indication.
 - Protective relays to protect the healthy capacitor units when one unit fails in a series connection.
- c. Contractor shall submit alongwith the bid typical control schematic for automatic switching.
- d. Data Sheets of all relays shall be submitted alongwith the bid.

Temperature Rise

The temperature rise above the specified ambient of any part of the capacitor and associated equipment shall not exceed the maximum permissible temperature limit as specified in IS :2834.

Tests and Test Reports

- a. All tests shall be conducted in accordance with the latest edition of IS : 2834 in addition to the tests specified, if any, in Data Sheet A.
- b. Type test certificates for similar capacitor units shall be furnished with the bid.
- c. Extra price, if any, shall be specified under Price Schedule for performing any of the tests.
- d. Tests on control panel as per specification shall be conducted.
- e. Routine test certificates for bought out components shall be submitted.

Spares

Contractor shall submit a list of spares recommended by him for the capacitor installation for 2 years of service. Itemwise price shall be quoted.

Rating Plate

The following information shall be given on the rating plate of each unit.

capacitor

- a) Reference to IS.
- b) Manufacgurer's name and or trade
- mark c) Manufacturer's Identification
Number
- d) Rated output in
kVAr e) Rated
Voltage
- f) Rated Frequency in Hertz
- g) Upper Limit of temperature
- category h) No. of phases
- i) Connection Symbol
- j) Discharge
- Device k) Type of
Dielectric
- l) Reference to Self Heating Design
- m) Total Weight
- n) Type of Impregnant

4.8 Power & Control Cables

Codes And Standards

Title	Code No.
PVC insulated cables (for Voltage upto 1100 V)	IS:694
HRPVC & PVC insulated cables heavy duty	IS:1554
Cross linked polyethylene Insulated PVC sheathed cables	IS:7098
Low frequency cables and wires with PVC insulation and PVC insulation and sheath of electric cables	IEC:189-1 & IEC-189-2
Polyethylene insulation and sheath for electric	IS:5831
Conductors for insulated electric cables	IS:6474
Methods of test for cables	IS:8130
	IS:10810

Specification for drums of electric cables	IS:10418
Specification for PVC insulated cables for electricity	BS:6346
Specification for PVC insulation and sheath of	BS:6746

Design Requirements of Cables

Cable shall be capable of operating satisfactory performance when laid on trays, trenches, ducts, and when laid directly buried in the ground.

Cables shall be capable of operating satisfactorily under a power supply system voltage variation of + 10% , frequency variation + 5% and a combined variation of + 10%. Cables shall normally be laid under following conditions :

- | | | | |
|-----|---------------------------|---|----------------------------------|
| i. | In air | : | Ambient temperature of 45°C |
| ii | In ground | : | Ground temperature of 35°C |
| iii | Depth of laying in ground | : | 1050 mm |
| iv | Thermal resistivity | : | 120 deg cent cm / watt |
| v | In trays | : | single layer touching each other |

The cable shall withstand all mechanical and thermal stresses under steady state and transient operating conditions.

22kV Grade XLPE Insulated Power Cables

22kV XLPE aluminium conductor cable shall be conforming to IS 7908 Part-II. The cores shall be screened by extruded semiconducting compound in combination with non-magnetic metallic tape. The inner sheath over laid up cores and outer sheath over the armour shall be extruded PVC compound conforming to the requirement of type ST2 of IS 5831 –1984 XLPE construction

- | | | | |
|-----|-------------------|---|---|
| i | Voltage grade | : | 22kV unearthed |
| ii | Conductor | : | Well compacted stranded grade H4, class 2 of IS 8130 |
| iii | Insulation | : | Cross linked polyethelene |
| iv | Insulation shield | : | This shall preferably be of the sippable triple extruded thermostat |
| v | Armour | : | Galvanised flat steel strip armoured |

1100 V grade PVC Insulated Power cables

Cables shall be insulated with extruded PVC type A. The inner sheath over laid up cores and outer sheath over the armour shall be extruded PVC compound type ST-1. The voltage rating shall be 1100

V and confirming to the latest IS: 1554 Part-I. The cables shall be of aluminium conductor, stranded grade H4 class2 as per IS 8130.

1100 V Grade PVC Insulated Control Cables

Cables shall be insulated with extruded PVC type A. The inner sheath over laid up cores and outer sheath over the armour shall be extruded PVC compound type ST-1. The voltage rating shall be 1100 V and confirming to the latest IS: 1554 Part-I. The cables shall be of stranded tinned annealed copper conductors with a minimum size of 2.5 sq.mm.

Inspection & Testing

The cables shall be tested in accordance with the IS 1554/7094. The tests shall include : Test for conductor
 Test for thickness of insulation
 Test for laying up
 Test for thickness of laying up Test for thickness of inner sheath Test for armouring
 Test for thickness of outer sheath

Test Equipments

Contractor shall ensure to use calibrated test equipment having valid calibration test certificate from standard laboratories traceable to National Standards.

4.9 Lighting System:

Codes & Standards

Electrical lighting fittings general and Safety	IS:1913/BS:4533
Code of practice for industrial lighting	IS:6665
Calculation of co-efficient of utilisation	IS:3646 (Part-III)
Industrial lighting fittings with metal reflectors	IS:1777
Decorative lighting outfits	IS:5077
Dust proof electric lighting fittings	IS:4012
Dust tight electric lighting fittings	IS:4013
Flood lights	IS:10322/BS:4533
Luminaries for street lighting	IS:10322 Part 5
Water tight electric lighting fittings	IS:3553/BS:4533, 5225
Bayonet lamp holders	IS:1258/BS:EN61184 /IEC:60061
Edison screw lamp holders	IS:10276/BS:EN 60238
Bi-Pin Lamp holders for tubular Fluorescent lamps	IS:3323
Starters for fluorescent lamp	IS:2215/BS:EN 60155
Holders for starters for tubular Fluorescent lamps	IS:3324/BS:EN60400 / IEC:60400
Ballast for use in fluorescent lighting	IS:1534 (Part 1)/BS:EN 60920 and 60921
Fittings	IEC:60082
Transistorised ballast for fluorescent lamps	IS:7027
Ballast for HP mercury vapour lamp	IS:6616
Capacitors for use in fluorescent, HPMV & LP sodium vapour discharge circuits	IS:1569/BS:EN61048 and 61049/IEC:60586
Vitreous enamel reflector for tungsten filament lamp	IS:8017
Tubular fluorescent lamps	IS:2418 (Part 1)/BS:EN 60081/IEC:60081
High pressure mercury vapour lamps	IS:9900/BS:3677/ IEC:60188
Tungsten filament general electric lamps	IS:418/IEC:60432
Cast acrylic sheets for use in Luminaries	IS:7569
Screwless terminal and electrical connections for lighting fittings	IS:10322
High pressure sodium vapour lamps	IS:9974

Emergency lighting units	IS:9583
Ignition proof enclosures, dust-tight for elect. Equipment	IS:11005
Luminaries (Part I to V)	IS:10322

Indoor lighting system

All indoor areas will be provided with A.C. lighting and the same will be available as long as A.C. supply is healthy.

Normal A.C. Lighting.

All indoor and outdoor areas will be provided with A.C. lighting and the same will be available as long as A.C. supply is healthy.

Emergency D.C. Lighting for other areas.

In other areas, at important locations, built in battery operated instalite fixtures will be provided which will come in service when A.C. supply fails.

The wiring for lighting circuits shall be done by 2:1.5 sq.mm. copper flexible (red & black colour) wires for phase & neutral and 1: 1.0 sq.mm. green wire for earthing, run in heavy duty GI conduits for indoor areas. For outdoor lighting, wiring shall be done by armoured cables.

Outdoor lighting system

All outdoor areas will be provided with A.C. lighting and the same will be available as long as A.C. supply is healthy.

Outdoor lighting shall be done with steel tubular poles of adequate height, at every 30meters to give the required illumination levels. Outdoor lighting shall be controlled from a lighting panel having a timer switch for automatic switching On & Off the street lights. In case of failure of the timer switch the panel shall have a provision by means of AUTO/MANUAL switch for Manual switching of the street lights.

Illumination levels

The illumination levels shall be as given in the clause no: 1.4.

Lighting Design & Distribution

Lighting Fixtures

The fixtures shall be suitable for operation on a nominal supply of 240V 1 ph 50Hz AC with a voltage variation of + 10% (ie 216V to 264V).

All lighting fixtures shall be with lamps and all necessary accessories for their satisfactory operation.

Each capacitor shall be suitable for operation at 240V + 10% 1 ph 50Hz with a suitable value of capacitance so as to correct the factor of its corresponding lamp circuit to the extent of 0.98 lag.

Each fixture shall be complete with 1 four way terminal block for the connection and looping of incoming & outgoing supply cables. Each terminal shall be able to accept 2-1.5sq.mm. copper stranded conductors.

Each lighting fixture shall be provided with a grounding terminal suitable for

12 SWG G.I.



connecting

wire.

Type of Fixtures

Type –A : 1 x 36W / 2 x 36W Industrial Indoor fluorescent lighting fittings :

The luminaire shall be complete with mounting bend pipe, electronic ballast & other accessories.

The luminaire shall consist of channel made from heavy gauge C.R.C.A. sheet steel. The fitting shall be powder coated and provided with detachable stoved enamelled reflector made from heavy gauge sheet steel. Accessories such as electronic ballast, P.F. improvement capacitor, and lamp holders etc. are to be wired upto a terminal block with provision for earthing.

Type –B :Emergency lighting fixtures :

Emergency lighting fixtures shall be 20W DC operated & rechargeable on AC supply. In normal case these fixtures shall be connected to AC supply & remain OFF but in case of power failure the lamp will be switched ON automatically.

Ceiling / exhaust fans:

Ceiling fans shall be 1200 mm sweep in size complete with electronic regulator.

Domestic exhaust fans shall be installed in admin block & laboratory and heavy duty industrial exhaust fans in MEP & DFG room. The fans shall be complete with mounting frame. The fan opening shall be covered by netted louvers to prevent the access of birds.

Outdoor Lighting

Street Light Pole

The material of construction of the tubular street light poles shall be either GI. The street light pole shall comply to the following-

- The pole shall conform to latest wind loading resistance.
- The pole shall have an excellent resistance to atmospheric corrosion and ground rot.
- The pole should withstand a minimum vertical load of 16kg per side at maximum wind speed.
- The pole should not deflect more than 3.5% of the above ground height under full load and maximum wind speed condition.
- The pole shall have self draining 1/4" dia. weeping hole at a height of 150mm from the ground.
- A through hole of 1/4" dia. shall be provided at a height of 300mm from the ground.

Street Light Pole Accessories

The street light pole shall be 9M long as per IS : 2713(Part –II) and flood light pole of 12 M long as per IS : 2713 (Part-II). The poles shall be provided with 2 coats of black bitumen paint from inside as well as outside and 1 coat of red oxide primer from outside. The pole shall be painted with 2 coats of silver paint after completion of erection work. The installation scope includes excavation required for pole, construction of 600x600mm concrete base for pole etc., earthing of pole, junction box & luminaire & laying of 3x2.5 AYY cable from junction box to luminaire from inside of the pole.

The street light pole erection shall be complete with -

1 no: 9M/12M long street light pole

1 no: 250W/400W luminaire with HPSV lamp

2 nos : 50mm dia. G.I. conduit sleeves for incoming & outgoing cables upto J.B.

1.5 M long 20mm dia. Galvanised MS rod earth electrode for earthing of

Loop-in-loop-out type weatherproof Junction box with terminal blocks for terminating 4X16 sq.mm. AYYFY incoming cable & fuse. The Junction

each pole
suitable
box shall



be earthed from the same rod by 25 sq.mm. G.I. stranded wire.

The lighting cable shall be laid underground at a depth of minimum 750 mm below ground level with a protection of sand & bricks.

Street Light Luminaire :

The fitting shall be single piece drawn aluminium housing with built in bright anodized reflector with a provision to control distribution of light on street side conforming to IS 10322 Part 5 / Sec1 : 1987 and complete with gasketing, heavy duty copper wound ballast & PF capacitor, die cast aluminium pole mount arrangement having aesthetic finish and hinged toughened glass lamp shield.

“U” clamps are to be provided on to the control gear housing with 2 nuts for firm gripping to the supporting pole bracket of maximum angle at which fitting can be installed.

Receptacle Units

Industrial type receptacle units of 5/15A, 15A, 30A sp/tp with switches/ MCBs shall be conforming to latest IS 3854 and sockets conforming to IS 1293. The units shall be suitable for mounting on stove enamelled sheet steel boxes generally conforming to IS 5133 Part-I.

5/15A, 5 pin convenient switch socket outlets with indication lamp & fuse mounted on a PVC surface mounting box shall be installed in administration block & laboratory area. Wiring from lighting panel to each socket is covered in point wiring.

15A single phase industrial sockets with 15A SP MCB & 2 earthing terminals shall be installed in rest of the area. 3x4 sq.mm. AYWY cable shall be laid on wall from lighting panel to socket alongwith earth wire.

4.10 Earthing System

To achieve total earth resistance to less than 1 Ω Earthing shall be carried out as per IS 3043. The scope includes supply of earthing conductors, earth electrode, installation and approval to the satisfaction of electrical inspector.

Earthing system shall be provided to ensure equipment safety, personnel safety and to facilitate designed operation of protective switching during earth fault conditions in the associated system.

Each earth pit shall be provided with Earth Pit marker.

Minimum no of earth pits for various installations/equipment shall be as follows-

4 – pole structure	:	8 nos.
HT Switchgear	:	2 Nos.
Transformer Body earthing	:	2 Nos.
Transformer Neutral earthing	:	2 Nos.
DG Body earthing	:	2 Nos.
DG Neutral earthing	:	2 Nos.
Common Earth Grid	:	As required to ensure the earth resistance to 1 Ohm

5 INSTALLATION & COMMISSIONING OF ELECTRICAL EQUIPMENTS

5.1 Power Transformer

When lifting a transformer by the lugs or shackles provided for this purpose, simultaneous use should be made of all such lugs and shackles, in order to avoid any unbalance while lifting. Before lifting, complete transformer, it should be ensured that all cover bolts are tightened fully. In case where it is necessary to use jacks for lifting, projections provided for the purpose of jacking should be used. Jacks should never be used under valve or cooling tubes.

It may be necessary under certain circumstances to place jacks under stiffening curbs on the tank base. For transporting transformers from stores to site, the transformers shall be loaded on a suitable capacity truck or trailer.

Steel ropes and stoppers on the trailer to avoid tilting of the transformers in transit due to jerks and vibrations shall properly support the transformers. At no instance, a transformer shall be kept on bare ground. Where it is not possible to unload the transformer directly on a foundation, these shall be unloaded on a properly built wooden sleeper platform. A transformer shall never be left without putting stoppers to the wheels.

Damages of any nature shall be brought to the attention of site engineer before lifting material from stores failing which it will be contractor's account. All loose items supplied along with the transformer shall be assembled. After complete assembly of the transformer, oil level should be maintained upto the conservator by topping up with oil. During topping up with oil, care should be taken so that no air bubble is formed inside the transformer. Any air accumulation in the Buchholz relay should be released.

Sample of oil from the transformer should be taken from the bottom of the tank. The sample of oil taken should pass crackle test. The transformer oil should also have a breakdown value of minimum 30 kV for transformer upto 33 kV. Breakdown value (BDV) test should be carried out as per the latest revision of IS 331.

If the transformer windings do not have high insulation resistance between the windings and between windings and earth, drying out of the transformer shall be carried out as per the latest revision of IS-1882. Normally a streamline filter will be used for transformer drying up.

Pre-commissioning check list

Before commissioning any transformer, the following points should be checked and ensured for safe energizing of the transformer.

- a. That all the accessories have been fixed properly and transformers body and neutral are properly earthed. The neutral of the transformer should be earthed to two separate earth pits. The transformer dehydration is over and results are satisfactory and approved by the Engineer-in-charge. In case transformers are idle for more than one month after dehydration. The transformer oil has been given at least two circulations.
- b. That the oil level in the transformer conservator tank is up to the marked point and the oil has been tested for break down value and acidity.

- c. That the Silica gel is in reactivated condition. The breather pipe is clear from any blocking and contains oil upto the proper level.
- d. That the explosion vent diaphragm does not have any dents and accumulation of any air has been released.
- e. That the operation of off-load and on-load tap changers on all the tap positions is satisfactory. The mechanical parts of the on-load tap changer mechanism are lubricated. Brake shoes are o.k. Motor IR value taken and tap position mechanical indicator on the transformer and tap position indicator meter on the control panel are reading the same tap positions. Tap changer limit switch are operating all right on the maximum and minimum tap positions. Oil level of tap changer tank is o.k. and oil has been tested for breakdown value.
- f. That the Buchholz relay has been tested for proper operation by injecting air through a cycle pump. All the other protective relays, alarm and annunciation relays have been tested.
- g. That all the metering equipment have been tested. Polarity test of CT/PT and transformer winding is all right. Connections have been checked for proper vector group.
- h. That the ratio test and winding resistance on all the tap position is alright.
- i. That primary injection tests have been carried out on HV and LV side panels and relay operation and respective circuit breaker tripping verified.
- j. That the winding and oil temperature thermometer pockets contain oil.
- k. That tightness of all bolts, clamps, connecting terminals, oil leakages/level, cleanliness or bushings have been checked and are all right.
- l. That the simulation tests for all the alarm, annunciation and trip circuits have been checked and are all right.
- m. That the insulation resistance of all the control circuits and IR value of the transformer windings and all the incoming and out going cables have been checked with 1000 V. megger.
- n. That all the valves in the cooling system and valve between that Buchholz relay and the conservator tank are in open position.
- o. That the transformer has been cleaned from outside. p. That the temporary earth leads have been removed.
- q. That all the tools and other materials have been removed from the transformer vicinity.
- r. That the setting of all the protective relays is at the desired value and D.C. trip supply is available.
- s. That the fire fighting equipment is in position.

Observations after commissioning:

After switching on the transformer the following points must be observed and recorded:



- a. The magnetizing in rush current and no load current
- b. Alarm if any or if any relay flag has operated.
- c. Voltage and Current on all the three phases. d. Transformer hum or abnormal noise.
- e. Circulation of oil and leakages.
- f. Record current, voltages, OLTC position, winding temperature and oil temperature readings, hourly for 24 hours.
- g. Cable end boxes for any over heating.

5.2 Switchgears

These specifications shall be applicable to HT and LT switchgear panels, motor control centres and other power and light distribution panels, instrument distribution and A.C /D.C.control supply panels of various types and capacities. Manufacturer's instructions, drawings and instruction of the Engineer-in-Charge should be studied and strictly followed during handling, erection, testing and commissioning of the switchgear. The switchgear should be handled with care by the experienced riggers under the guidance of a competent supervisor. Dragging of the panels should be avoided and use of a crane and traylor should be made for the handling purposes while transporting to various sites. The switchboards should be properly supported on the truck or traylor by means of ropes to avoid any chances of damage or tilting due to heavy vibrations. The switchboards should be lifted by making use of lifting eyes bolts only, fully tightened and after ensuring that panel supports, nuts and bolts are all in tact and tightened. When lifting panels in packed conditions, utmost care should be taken to avoid any damage to any insulators, bushings, metering and protective equipment. The panels should be preferably kept inside the packing cases till foundations are ready.

Base channels should be grouted, leveled, in cement concrete pad for H.T. and 415 V switchgear panels and other cubicle panels. Pedestal type panels and MCC's shall be erected by grouting base channels by bolts. A proper bonding surface should be made by chipping the floor while making cement concrete bearing pad for the switchboards. After cement concreting, all such foundations, grouted bolts shall be cured for a minimum period of 48 hours.

The switchboard panels should be taken from the packed cases and moved one by one to the proper place. All the panels should be assembled, aligned and leveled and it should be checked that panel to panel coupling bolts, bus bar links fit properly without any strain on any part. It should also be checked up that lowering, lifting, racking in and out operation of the breaker and all other motions are free from any obstruction. The fixing bolts should be grouted after satisfying all these equipments.

The panel shall be made dustproof and vermin proof with gaskets for inter panel joints and plugging all holes/cutouts. Tightening of bus bar/link connection and terminal connection should be carried out.

After completion of the panel erection, all the cubicles, switches, starters, C.T. and P.T. chambers, bus bar chamber, should be cleaned and checked for tightness of all the components. All the wiring connections should also be checked with drawing and tightened. Metering and protective C.T.'s alarm, indication and protective relays should be fixed up if received loose. Polarity of P.T.'s and C.T.'s should be checked. All the moving parts should be checked for easy and free movement. Hinges of panel doors should be lightly lubricated to give free and noiseless movement.



Should the switchgear be wet or having a low IR value due to bad wiring, insulators, bushings or any other insulated parts, the entire switchgear should be dried up, and the IR value should improve to a safe level for commissioning the same. Care should be taken to protect the surrounding insulation from direct local heating during the drying up process.

Earthing shall be with the proper size of the conductors as indicated in relevant drawing.

All the metering instruments, protective relays and other relays connections should be checked as per relevant drawing.

All the control wiring, P.T.s, bushings, bus bars, other alive parts of switchgear, incoming and outgoing cables should be meggered with 1000V. megger H.T. bus bars, circuit breakers, bushings on the switch gear should be pressure tested at recommended voltage as per Indian standard.

Electrical simulation tests should be carried out for all the protective, alarm and annunciation relays alongwith the manual operations of the circuit breaker.

Panels must be cleaned with vacuum cleaner.

Pre-commissioning checklist

Before commissioning any switch gear panel, circuit breaker, motor starters etc., the following points must be checked and ensured for safe energizing of the switch board:

- a. That the erection of equipment to be commissioned is complete in all respect with its auxiliaries and all other mountings including earthing.
- b. That all the openings in floor inside or outside the cubicle panels have been sealed off.
- c. That all the cubicles panel doors, gaskets are in tact and no other opening exists for vermin entry.
- d. That all the metering instruments have been checked and calibrated.
- e. That all control circuit fuses and H.T. fuses for P.T. are of proper rating and showing continuity.
- f. That all the indication lamps are healthy and in position.
- g. That the mechanical parts of breaker closing and tripping mechanism have been checked and lubricated and circuit breakers have been tested for contact travel, contact pressure and resistance and buffers are free and fully lubricated.
- h. That air vent pipe of C.B. is free and spouts/shutter mechanism is O.K.
- i. That auxiliary contacts have been checked for cleanliness and adequate contact pressure and auxiliary contacts in series with tripping circuit open with opening of breaker.
- j. That the polarity test and ratio test of all the P.T.'s C.T.'s is over.

- k. That the high voltage test of circuit breaker, bus bars and outgoing and incoming cables have been conducted and are satisfactory.
- l. That all the protective relays have been tested for primary and secondary injection tests. All thermal overload relays and the contractor coils and operation of all the current and voltage-operated relays have been tested.
- m. That the simulation tests for all protective, alarm and annunciation relays are O.K. and all the relays have been properly set.
- n. That the manual closing and tripping have been tried against shock and bouncing of the mechanism.
- o. That I.R. value have been recorded for bus bars, circuit breaker, incoming and outgoing cables, control wiring, and potential transformers. Joints resistance of high capacity busbars have been recorded and found to be satisfactory.
- p. That fire fighting equipment like C.T.C. , CO₂ or Soda Ash Extinguisher are kept ready for use.

5.3 Cables Trays

Mounting – General Notes

Unless otherwise specifically mentioned on the relevant layout drawings, all cable tray mounting works to be carried out as per notes given here.

Cable tray mounting arrangement type to be as marked on the layout drawing.

Assembly of cable tray mounting structure shall be fabricated, supplied, erected and painted by the electrical contractor.

Civil contractor, will provide plate inserts in floor slabs at 1000 mm spacing for cable tray mounting structure.

Cable tray mounting structure to be welded to the plate inserts or to structural beams.

Wherever embedded plates and structural beams are not available for welding the cable tray mounting structure, electrical contractor to supply the M.S. plate and fix it to floor slab by Anchor fasteners of minimum dia. 16 mm having minimum holding power of 5000 kg.

Spacing between cable tray mounting structures to be 1000 mm for horizontal straight runs of cable trays.

Minimum loading on a horizontal support arm to be 120 kg/M of cable run.

Width of the horizontal arms of the mounting structures to be same as the tray widths required in cable layout drawings plus length required for welding to the vertical supports (maximum tray width will be 900 mm) except where shown otherwise.

The length of the vertical supporting members, for horizontal cable tray runs, will be to suit the number of cable tray tiers required in the cable layout drawings.

Spacing between horizontal support arms of vertical cable tray runs to be 600 mm.

Cable trays will be welded to tray mounting supports.

Minimum clearance between the topmost tray tier and structural member to be 300 mm.

Minimum vertical clearance below the bottom of the lowest cable tray tier and any structural member to be 300 mm.

All structural steel supplied by the contractor and exposed surface of embedded steel for cable tray mountings and shall be painted as follows:

For indoor installation one coat of red oxide zinc chromate primer and two coats of synthetic enamel paint.

For outdoor installations – painting with two coats epoxy based paint.

Where any cuts or holes are made or welding is done on finished steel work these shall be painted by the manner specified above.

Cable Trays – Construction Notes

Cable tray of ladder and perforated types and the associated accessories such as coupler plates, tees, elbows etc. shall be hot dip galvanized fabricated from 12 gauge (2.5 mm thick) mild steel sheets. Cable tray covers shall be fabricated from 16 gauge (1.70 mm thick) m.s. sheets.

The cable trays to be supplied in standard lengths of 2500 mm and clear inside width of trays shall be as follows:

- a) Perforated type 150, 300, 450 and 600
- b) Ladder type trays: 300, 450, 600 and 900

The spacing of rungs for ladder type of trays to be 250mm unless otherwise noted.

All finished cable trays and accessories shall be free from sharp edges and corners, burrs and unevenness.

The details of accessories etc. shown are typical and do not cover the entire range of the same. Fabrication of accessories not covered here shall be done with the help of relevant project drawings.

Cable Trays – Installation Notes

Unless otherwise specifically mentioned, all cable tray mounting works shall be carried out as per approved drawings.

The type and size of tray to be used will be as mentioned in the individual layout drawings. The maximum size of cable tray when used in trenches shall be of 600 mm width.

Cable trays shall be welded to the mounting/carrier structures.

Vertical trays (raceways) and all outdoor cable trays shall be provided with removable 16 gauge painted m.s. sheet covers.

Each continuous laid out length of cable tray shall be earthed at minimum two places by M.S. flats of minimum size 25 x 3 mm (unless otherwise noted) to the main earthing grid, the distance between earthing points shall not exceed 10 meters.

The following shall be checked before laying the cables on trays.

- Check for proper painting and identification nos. of the trays
- Check for continuity of power and control cable trays over the entire route.
- Check that all sharp corners, burrs and waste materials have been removed from the tray.

5.4 Cable – Installation Notes

General

These notes in general cover cables upto and including 22 kV rating. All cables above ground shall be laid in cable trays. Where ever tray installation is not possible the cable above ground level shall be clamped along the walls/railing etc. after getting approval by the engineer in charge.

Electrical installation work shall comply with all currently applicable statutes, regulations and safety codes in the locality/country where the installation is to be carried out.

Installation of cable shall be carried out generally as per IS 1255 and as per the relevant project drawings.

Installation of cables shall include, unloading, storing, laying, fixing, jointing, termination, supply of glands and lugs and all other work necessary for completing the job.

Cables will be installed in trenches, trays, racks, conduits, duct banks or directly buried. The actual cable layouts will be shown on the relevant project drawings. Any changes, if necessary, after obtaining prior approval of the Purchaser/Engineer shall be carried out at site by the contractor and shall be clearly marked by him on project drawings and forwarded for approval of the purchaser.

Cable to each circuit shall be laid in one continuous length, cable jointing and splicing shall be done after obtaining Site Engineer's permission.

Outdoor Cable Installation

Cables laid in ground shall be laid on a 75 mm riddled earth bed. The cables shall then be covered on top and at their sides with riddled earth of depth of about 150 mm. The RCC covers shall have one hole at each end, to tie them to each other with GI wires to prevent displacement. The trench shall then be backfilled with the excavated soil and well-rammed in successive layer of not more than 300 mm in depth, with the trenches being watered to improve consolidation wherever necessary. To allow for subsidence, it is advisable to allow a crown of earth not less than 50 mm in the centre and tapering towards the sides of the trench.

Cable route markers shall be provided at every 20 meters. At least one marker shall be provided if the length of the buried cable is less than 15 meters. Buried cables in trefoil formation shall be bound by plastic tapes of 1 mm dia. Nylon cord every 750mm.

Joint markers at each joint location shall identify joints in directly buried



cables.

In each outdoor cable run, some extra cable length shall be kept at a suitable point to enable a straight through joint to be made should the cable develop fault at a later date.

Where cables cross roads and water, oil, gas or sewage pipes, the cables shall be laid in RCC hume pipes. For road crossing, the pipe for the cable shall be buried at not less than 600 mm unless otherwise noted in the drawings.

Cables In Trays/On Racks

Different voltage grade cables shall be laid in separate trays when trays are arranged in tiers. H.V. cables shall be laid in top trays and cables of subsequent voltage grades in lower tiers of trays.

Termination Clamping and Miscellaneous Details

Cable entry to motors, push button stations and other electrical devices shall be from the bottom as far as possible or from the sides. Top entry shall be avoided particularly for outdoor equipment.

Identification tags made from aluminium sheet shall be attached to each end of each cable by means of GI binding wire. Tags shall be additionally put at an interval of 30 metres on long runs of cables and in pull boxes.

All cable terminations shall be solderless crimping type. The crimping tools shall be adequate for lug sizes.

Testing and Commissioning Of Cables

Cables shall be checked for insulation resistance before and after jointing. The voltage rating of the meggers for cables of different voltage grades shall be as indicated below:

Voltage Grade of Cable	Megger Rating
1.1 kV	500 V
22 kV	2.5 kV Motorised Megger

a. High Voltage Testing

All cables of 1.1 kV grade 400 mm² and above and all HV cables shall be subjected to DC or AC high voltage test after jointing and terminating but before commissioning as per the relevant standards. Testing with DC voltage should be preferred as test equipment required is compact, easily portable and requires low power. The DC test voltages applicable in India shall be as per table 6 in IS 1251. The cable cores must be discharged on completion of DC high voltage test and cable shall be kept earthed until it is put into service.

Testing of Cable Installation

DC test voltages after installation (before commissioning) (REF IS – 1255 – 83) DC test voltage for cables is 1.5 times rated voltage. In each test, the metallic sheath/screen/armour should be connected to earth.

Continuity of all the cores, correctness of all connections as per wiring diagrams, correctness of polarity and phasing of power cables and proper earth connection of cable gland, cable boxes, armour and metallic sheath shall be checked.

5.5 Lighting

General

Electrical installation work shall comply with all currently applicable standards, statutes, regulations and safety codes in the locality/country where the installation is to be carried out.

Installation of lighting system shall be carried out generally as per the instructions in this document and typical drawings and relevant project layout drawings to be furnished by the contractor.

The scope of installation work shall include storing, unpacking, fixing of all items associated with lighting system, laying and fixing conduits, wiring, termination, testing, commissioning and all other work items necessary for completing the job. The supply of all mounting accessories hardware, consumables like fixing saddles at the fixture fixing/suspension points, connectors, jointing ferrules, all fixing brackets, screws and studs and earthing wires shall be deemed to be include in the scope of installation work.

The scope and specification of the supply items like lighting distribution boards, lighting panels, fixtures, street lighting poles, wires/cables, conduits, receptacles, switches, ceiling fans shall be as indicated separately in schedule of items and rates.

Lighting panel, distribution boards, fixtures, fans switches, receptacles etc. shall be located as per the PURCHASER'S approved layout drawings. Any changes, if necessary after obtaining prior approval of the PURCHASER/ENGINEER, shall be carried out at site by the CONTRACTOR and shall clearly marked by him on the project drawings and forwarded to for purchasre's approval.

The required conduits for lighting wiring shall be suitably routed at site by the CONTRACTOR with due considerations to a neat layout and ease of maintenance.

Unless specifically noted otherwise, lighting panels, light control switches and receptaces shall be installed at the following mounting heights from finished floor/ground levels:

- Lighting panels – 1200 mm to bottom of the panel
- Light control switches – 1200 mm
- Receptacle units – 500 mm for indoor and 1000 mm for outdoor.

Lighting Panels/Distribution Boards

All lighting panels located indoor/outdoor shall be installed by the CONTRACTOR on walls/columns by fastening to suitably grouted stud.

Lighting Fixtures

Lighting fixtures of appropriate type as per PURCHASER's drawings shall be installed by the CONTRACTOR as per the typical mounting arrangement drawings furnished to him.

Lighting fixtures installed on/under platforms/pedestals which are subject to vibrations (such as TG pedestal) shall be provided with rubber cushions to minimise vibration reaching the fixtures.

Switches and Receptacles

Exact locations shall be finalised by the CONTRACTOR in consultation



with

the site ENGINEER/ PURCHASER.

Switches/receptacles which are to be wired on the same phase and to be located close by each other shall be accommodated/housed in the same box.

Conduits

Minimum size of rigid GI conduits used for wiring shall be of 20mm in case of exposed systems and 25 mm in case of concealed/embedded systems. The conduits shall be supported by means of saddles as follows:

Rigid Metallic Conduits -

Spacing between saddles not to exceed 1 m in addition saddles shall be located on either ends of couplers/bonds or similar fittings/accessories. In such cases the saddles shall be located at a distance not exceeding 300 mm from the fittings/accessory.

Wires belonging to different phases shall not be run in the same conduit. However, more than one circuit, consisting of phase and neutral wires, of the same phase can be run in the same conduit, for every phase wire a separate neutral wire shall be run.

Wiring/Cabling

Unless otherwise stated, the mode of wiring will be as follows:

250/440V PVC insulated flexible 2 core wires used for indoor lighting wiring shall be laid in rigid GI conduits.

Outdoor lighting cables shall be directly buried in ground at a minimum depth of 600 mm or routed in the available cable trenches. Cables crossing road/rail shall be laid in RCChume pipes.

Size of wire shall be chosen to limit voltage drop to within 5%. Minimum area of conductor shall be 1.5 sq.mm copper, unless otherwise stated, and density not to exceed 2.5A/sq.mm. Generally not more than 8 to 10 points shall be wired in one circuit. For the purpose of calculating connected loads of various circuits a multiplying factor of 1.25 will be assumed to the rated lamp wattage for mercury vapour and fluorescent lamp fixtures to take into account losses in the control gear. A loading of 100 watts and 500 watts will be assumed for single-phase 5 Amps and 15 Amps receptacles respectively.

Ceiling Fans

Unless otherwise specified, all ceiling fans shall be installed not less than 2.75 m above the floor level.

In rooms having fluorescent lamp lighting fixtures and ceiling fans, the fans shall be installed with their blades at least 100 mm above the lighting fixtures.

Earthing

Lighting fixtures, receptacles, switches, conduits and junction boxes shall be properly earthed using 12 SWG. GI wire (unless otherwise specified) run along the entire length of the conduit between the fixture and the corresponding lighting panel where it will be connected to the station earth.



The earth wire for each conduit length shall be efficiently fastened to the conduit at regular intervals of not more than 750 mm.

Testing and Commissioning

Before a completed installation or an extension to an existing installation is put into service it shall be tested as per the relevant standards/codes of practices of the country where the installation is carried out. Installation shall be tested in accordance with IS-732.

5.6 Earthing

All electrical equipment must be efficiently double earthed in accordance with the requirement of IS 3043 and relevant regulations of Electric Supply Authority.

The earth pits shall be as per Indian Standard with proper arrangement for testing.

All earthing conductors shall be hot dip galvanised/electrolytic grade base conductor. The main earthing rings shall be done as per practice laid in Indian Standard.

The earthing of individual electrical equipment by two distinct strips/conductors shall be done as per practice laid in Indian Standard.

The sizes of conductors for earthing various equipment shall be as follows:

Sr.	System	Earthing conductor size & Material
a)	Main Earthing Grid	50 x 10 mm GS
b)	Transformer/HT Switchgear	50 x 10 mm GS
	LV Bus Duct	50 x 6 mm MS
	415V switchgear	50 x 6 mm MS
	Capacitor Control panel	50 x 6 mm GS
	Cable tray	30 x 5 mm GS
	Battery charger/Lighting Panel	25 x 3 mm GS
	Local Push Button Station	8 SWG GS wire
	Outdoor Street Lighting	8 SWG GS wire
c)	L.T. Motors	
	up to 11 Kw	8 SWG GS wire
	Above 11 kW upto 30 kW	25 x 3 mm GI Strip
	Above 30 kW	50 x 6 mm GI Strip
d)	Earth Electrode	40 mm diameter 3000 mm long heavy duty GI pipe electrode

All electrical equipment shall be connected to the earth bus at two points except the lighting fittings and junction boxes where single earthing shall be provided. All other equipments in hazardous areas shall be earthed at places.

Following earthing resistances shall be measured and recorded in the presence of site engineer during the dry season.

Resistance of each earth electrode with electrode isolated from the system.

Combined earth resistance of the installation measured at the substation, switchroom and any other point as directed by the site engineer.

The method of testing shall be as per clause 10.1 and 10.2 of IS-3043. The contractor shall prepare the test report and submit to the engineer in charge. The effective earth resistance of the system shall be less than one Ohm.

The 415V neutral shall be solidly earthed by means of two separate and distinct connections to earth using conductor of appropriate size. Each connection shall be connected to an independent earth interconnected between themselves and the main earthing grid to form an earthing ring. The neutral earthing leads shall be kept away from the transformer tank and protected inside wire mesh enclosure to prevent accidental contact.

Terminal joints on the equipment shall be bolted. The earthing conductors running underground shall be laid approximately 600 mm below the grade level. Removable test links shall be provided near the earth pits to facilitate testing of earth pits. The quality of galvanising shall be subject to test in the presence of site engineer. The vessels shall be earthed at two points. The vessels to be earthed shall be connected to a common earth grid of power system

For equipment earthing, suitable GI bolts with spring and plain washers to suit the thread of earth boss of vessels etc. shall be provided.

Earth pits:

The number of earth pits will depend upon soil resistivity and the voltage of the system. The earth pit together with the electrode shall be constructed as per I.S. 3043 – 1983. The minimum distance between two earth pits shall not be less than twice the length of the electrode. A bolted assembly link shall be provided in the connection between earth electrode and the main earth conductor. GI pipe for watering shall be included in the earth pit.

Earth bus and earth wires:

Framework and other non-current carrying metal work association with each system e.g. transformer, tanks, switchgear frame work etc. shall be earthed. Extraneous metal framework not associated with the power system. e.g. boundary fence, steel structure, sheaths of communication cables etc. will have to be earthed.

Each incoming and outgoing cable shall be bound to the switchboard earth so that the armour and sheathing with feeders and interconnection shall form an earth system. The complete earthing system inside a substation shall be given a coat of black asphaltic varnish.

Earthing of transformer:

Unless otherwise specified, the transformer neutral shall be directly earthed at two points through the neutral bushing provided on the transformer. Inside transformer cubicle and inside the switch rooms where the neutral connection to earth is accessible. The resistance of the earth electrode in any case shall not be more than 1 ohm.

Earthing of LT Panels:

Distribution boards and MCCs shall be provided with two visible, separate and distinct earth connections from the ring main.

A separate earth bar shall be provided throughout the length of the MCC

or

distribution board, and individual connections to various items of equipment in the distribution board or MCC shall emanate from the above bus bar in the form of a ring.

Earthing of motors, starters and push buttons:

All the motors shall be provided with separate and distinct earth connection from ring main. Where the terminal box is not part of the motor frame or where a mealing box is used, a bond shall be provided from the gland plate or armour clamp to the motor frame.

Starters and push buttons shall be double earthed.

Testing of earthing system:

Resistance of all earth electrodes and total resistance of each group shall be tested to prove that the value do not exceed that specified in the codes of practice or regulations and recorded. Earth pit resistance shall not be more than 1 Ohm.

The continuity of earthing and resistance of each earthing connection to the equipment shall be tested and recorded.

5.7 Fabrication Work

M.S. channels/angles of requisite size shall be used for cable tray supports/ push button station mounting frames, panel frames etc. The fabricated work shall be provided with two coats of zinc rich red oxide primer & 2 coats of enamelled paint of approved colour. The scope of fabrication work includes supply of necessary hardware viz. anchor fasteners, M.S. base plate etc.

6 EQUIPMENT TESTING

- All equipments shall be fully tested in accordance with the relevant clauses of applicable standards. All components and devices shall be checked for correct operation before dispatch.
- Tests to be carried out at Manufacturer's works shall be as mentioned below.
- For tests designated by symbol "A": the contractor shall furnish valid test certificates.
- For tests designated by symbol "B": Test shall be carried out in presence of the Purchaser or Purchaser's authorized representative.

6.1 High Voltage Switchgear

Sr.	Test Particulars	Type Test	Routine Test
a	Assembly inspection	-	B
b	Operation test	A	B
c	Temperature rise tests for main & auxiliary	A	-
d	Power frequency voltage tests on main & auxiliary circuits	A	B
e	Impulse voltage test	A	-
f	Verification of making & breaking capacity of circuit breaker	A	-
g	Short time current withstand test on main circuit	A	-
h	Short time current test on earthing circuits	A	-
i	Verification of mechanical endurance of circuit breakers	A	-

j	Operation tests of auxiliary electrical and pneumatic devices (as applicable)	-	B
k	Measurement of resistance of main circuit of circuit breakers	B	A
l	Verification of Wiring	-	B
J	Protection relay primary and secondary injection test.	-	B

6.2 Power Transformers

Sr.	Test Particulars	Type Test	Routine Test
a	Visual inspection	-	B
b	Measurement of winding resistance	A	B
c	Measurement of voltage ratio	A	B
d	Check of voltage vector relationship	A	B
e	Measurement of impedance voltage, short-circuit impedance and load loss	A	B
f	Short-circuit test	B (Special test)	-
g	Measurement of no-load current	A	B
h	Temperature rise test	B	-
i	Measurement of insulation resistance	A	B
j	Separate source voltage withstand test	-	B

6.3 22 kV HV Cable

Sr.	Test Particulars	Type Test	Routine Test
k	Impulse voltage test for oil immersed transformers except for 220KV class	B	-
l	Impulse voltage test including chopped waves for	B	-
m	Induced over voltage withstand test	-	B
n	Test on on-load tap-changer	A	B
o	Transformer Oil Breakdown Voltage Test	-	B

6.4 Bus-Ducts

Sr.	Test Particulars	Type Test	Routine Test
a	Assembly inspection	-	B
b	Temperature rise test	B	-
c	Short time current test	A	-
d	Power frequency voltage test	A	B
e	Impulse voltage test	B	-

6.5 415 V Switchgear

Sr.	Test Particulars	Type Test	Routine Test
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a	Assembly inspection	-	B
b	Operation test	A	B
c	Temperature rise test	B	-
d	Di-electric test	A	B
e	Short-circuit making and breaking performance test of circuit-breaker only	A	-
f	Short-time current withstand test	A	-
g	Verification of overload performance of circuit-breaker only	A	-
h	Verification of mechanical and electrical endurance of circuit-breaker only	A	-
i	Verification of operating limits and characteristics of over current opening release	A	-
j	Calibration of release	-	A
k	Verification of terminal markings and polarity of	A	A
l	Test for checking accuracy of CT	A	A

9.6 AC Motors

Sr.	Test Particulars	Type Test	Routine Test
a	Insulation resistance test	A	B
b	High voltage test	A	B
c	No-load running of motor and reading of voltage, current power input and speed	A	B
d	Locked-rotor readings of voltage, current and power input at a reduced voltage (Values of torques are to be indicated in type test)	A	B
e	Reduced voltage running-up test	A	B
f	Open-circuit voltage ratio (for slip-ring motors only)	A	B
g	Calculation of efficiency	A	-
h	Temperature rise test	A	-
i	Momentary overload test	A	-
j	Over speed test	A	-

6.7 Motor Control Centers

Sr.	Test Particulars	Type Test	Routine Test
a	Visual inspection	-	B
b	Electrical operation test	-	B
c	Di-electric test	-	B
d	Insulation resistance test	-	B
e	Short-circuit withstand and peak withstand tests on main and vertical bus bars	A	-
f	Temperature rise tests on main and vertical bus bars	A	-

6.8 Power Distribution Board

Sr.	Test Particulars	Type Test	Routine Test
a	Visual inspection	-	B
b	Operation test	-	B
c	Insulation resistance test	-	B
d	High voltage test	-	B

LIST OF APPROVED MAKES FOR ELECTRICAL EQUIPMENTS

Sr.	Equipment	APPROVED MAKES
A	Power Transformer	Voltamp/ Crompton/Bharat Bijlee/Alstom
B		LV - ELECTRICAL SYSTEM
1	LV Switchgear / Busduct	L & T/ SIEMNS/ INDUSTRIAL Switchgear & CONTROL /
2	Air Circuit Breakers	L&T / SIEMENS / ABB
3	Moulded Case Circuit Breakers	L & T / SIEMENS / ABB
4	Switch / Fuse Unit	L&T / SIEMENS / ABB
5	Contactors AC / DC	L&T / SIEMENS / ABB
6	Thermal O/L relay	L&T / SIEMENS / ABB
7	Motor Starters	L & T / SIEMENS / ABB
8	Current / Potential Transformer	ABB/KAPPA / SILKANS / GIBERT / AE / ASHMORE
9	Automatic Power Factor Correction Panel (APFCP)	ELECMECH CORPN / INDUSTRIAL CONTROL /SAVIN
10	Automatic Power Factor Correction Relay	Neptune DUCATI/ L & T
11	Power Capacitors	MALDE / PRABODHAN / SAVIN / L & T (MEHER) / ASIAN
12	Protective relays Numerical Measurement + Auxiliary (Electro magnetic & static)	ALSTOM / ABB / SIEMENS
13	Cables - HT Cable - LT Cable	CCI / POLY CAB /AVOCAB
14	Cable Gland	COMET / BRACO / 3D
15	HT Cable Termination	RAY CHEM / MAHINDRA / CCI
16	Lugs	DOWELL / 3D / BRACO
17	Indicating Meters	MECO / RISHABH / AEP / IMP
E	COMMON ITEMS	
1	Indicating lamps	L&T / SIEMENS / GEC – ALSTHOM / IEC / TECHNIK / RASS CONTROLS
2	Push – Buttons	L&T / BCH / SIEMENS / TECHNIK / RASS
3	Indicating meters	AE / IMP / MECO / RISHABH (L&T)
4	Terminal blocks	ELMEX / WAGO (C&S)/ Connectwell
5	Lighting Fixtures	WIPRO / THORN/HAVELLS
6	Lamps	WIPRO/OSRAM
7	Aluminium Steert Light poles	IDS
8	Lighting Distribution Boards	MDS / ABB/ L&T/ HAVELLS
9	Miniature Circuit Breakers	MDS / L & T / SIEMENS / S & S/ABB

Sr.	Equipment	APPROVED MAKES
10	Annunciators	MINILEC / PEACON / ICA
11	Energy Meters	ELECTRONIC: ENERCON / L & T / ALACRITY ELECTROMECHANICAL: GEC-A / SIMCO / IMP
12	Electronic TVM	ENERCON / L&T / DUKE / SIMCO
13	Breaker Control / Selector switches	EE / KAYCEE / SIEMENS / JYOTI