

- Name of Work -

**EPC Contract for Providing Irrigation Water
Facility to Filling Kelamul Village Tank by Lifting
Water from KLBMC at Ch.8.20 km of Taluka
Kadana, Dist. Mahisagar.**

Tender Document

VOLUME II – [C]

Technical Specifications for Electrical Works

Government of Gujarat
Narmada Water Resources, Water Supply
& Kalpsar Department

Index

Chapter	Title	Page
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Index	1	
1.	GENERAL	1
1.1	STANDARDS AND CODES _____	1
1.2	SAFETY & SECURITY _____	5
1.3	ENVIRONMENTAL CONDITION _____	5
1.4	ELECTRICAL SWITCHGEAR ROOM ENVIRONMENT _____	6
1.5	SYSTEM VOLTAGE _____	6
1.6	VOLTAGE & FREQUENCY VARIATIONS _____	6
1.7	PHASE SEQUENCE _____	6
1.8	VOLTAGE DROP CRITERION _____	6
1.9	COMPATIBILITY _____	7
1.10	ENCLOSURES _____	7
1.11	IDENTIFICATIONS _____	8
1.12	HARMONICS _____	8
1.13	SURGE PROTECTION _____	9
1.14	EARTHING PROTECTION _____	9
1.15	LIGHTNING PROTECTION _____	9
1.16	TOOLS & TESTING EQUIPMENTS _____	10
1.17	CUTTING, PATCHING AND EXCAVATION _____	11
1.18	DRAWINGS _____	11
1.19	PERSONNEL _____	11
2.	SCOPE OF WORK	12
2.1	SCOPE OF WORK _____	12
2.2	SUBMITTALS _____	13
3.	11 kV SWITCHYARD EQUIPMENT	15
3.1	GENERAL _____	15
3.2	STRUCTURE _____	15

3.3	GOD _____	16
3.4	ISOLATOR INTERLOCK: _____	16
3.5	INSULATORS: _____	16
3.6	ACSR CONDUCTOR: _____	17
3.7	DROP OUT (DO) FUSE UNIT: _____	17
3.8	STATION CLASS LIGHTNING ARRESTORS: _____	17
3.9	CHAIN LINK FENCING AND GRAVEL FILLING: _____	19
4.	POWER/ DISTRIBUTION TRANSFORMER	20
4.1	SCOPE _____	20
4.2	STANDARDS AND OTHER PARAMETERS _____	20
5.	HV SWITCHGEAR PANEL	34
5.1	APPLICABLE STANDARDS _____	34
5.2	TYPE & CONSTRUCTION _____	35
5.3	CAPACITY OF BRAKER _____	35
5.4	AUXILIARY RELAYS _____	35
5.5	DESIGN _____	36
5.6	RELAYS: _____	40
5.7	CURRENT TRANSFORMERS: _____	42
5.8	VOLTAGE TRANSFORMERS: _____	42
5.9	MAINTENANCE REQUIREMENTS: _____	43
5.10	EARTHING: _____	43
5.11	ANNUNCIATORS _____	43
5.12	CABLE TERMINATIONS: _____	44
5.13	TESTS: _____	45
5.14	DRAWINGS/ DOCUMENTS REQUIRED: _____	45
5.15	LIST OF TYPE TEST REPORTS _____	45
5.16	ROUTINE TEST: _____	45
6.	LV SWITCHGEAR PANEL/ 415 V MCC PANEL	47
6.1	STANDARDS _____	47
6.2	CONSTRUCTIONAL REQUIREMENT _____	48
6.2.1	GENERAL _____	48

6.2.2	FLOOR MOUNTING PANELS _____	50
6.2.3	WALL MOUNTING PANELS _____	50
6.3	SWITCHBOARD COMPONENTS & CONTROL ARCHITECTURE _____	50
6.4	PROTECTION CO-ORDINATION _____	51
6.5	COMMUNICATION ARCHITECTURE _____	51
6.6	MOULDED CASE CIRCUIT BREAKER _____	52
6.7	MULTIFUNCTION METERS _____	54
6.8	MINIATURE CIRCUIT BREAKERS (MCB) _____	55
6.9	RESIDUAL CURRENT BREAKER WITH OVERLOAD (RCBO) _____	56
6.10	CONTACTORS _____	57
6.11	INDICATING LAMPS AND CONTROL SWITCHES _____	58
6.12	PUSH BUTTONS _____	58
6.13	OPERATING COILS _____	58
6.14	TERMINAL BLOCKS _____	58
6.15	SPACE HEATER AND CUBICLE LIGHTING _____	59
6.16	INDICATING INSTRUMENTS & METERS _____	59
6.17	SWITCHBOARD ANTI-CONDENSATION HEATERS / PANEL INTERNAL ILLUMINATION _____	59
6.18	EARTHING ARRANGEMENT _____	59
6.19	SAFETY ARRANGEMENTS _____	60
6.20	AUXILIARY SWITCHES _____	60
6.21	VOLT-FREE CONTACTS _____	60
6.22	PROTECTION TRANSFORMERS _____	60
6.23	NAME PLATES, RATING PLATES AND LABELS _____	62
6.24	MOTOR STARTER _____	63
7.	APFC PANEL WITH CAPACITOR BANKS:	66
7.1	GENERAL _____	66
7.2	CAPACITOR BANKS: _____	66
7.3	CONTROL CUBICLES: _____	67
7.4	PRINCIPLE OF OPERATION: _____	69
7.5	APFC RELAY: _____	69
7.6	PERFORMANCE TESTS: _____	69

7.7	MAINTENANCE REQUIREMENTS: _____	70
7.8	DRAWINGS/ DOCUMENTS REQUIRED: _____	70
8.	HV & LV CABLES	71
8.1	SCOPE _____	71
8.2	CODES AND STANDARDS _____	71
8.3	GENERAL CONSTRUCTION OF CABLES _____	71
8.4	XLPE CABLES _____	72
8.5	PVC CABLES _____	73
8.6	CABLE ACCESSORIES _____	74
8.6.1	Installation and Termination of Cables _____	74
8.7	CABLE SUPPORT SYSTEMS _____	77
8.7.1	Trays for Power Cables _____	77
8.7.2	Cables External to Buildings and Structures _____	77
8.7.3	Metallic Conduit: _____	78
8.7.4	Non-Metallic Conduit: _____	78
8.7.5	Corrugated Flexible Conduit: _____	78
8.7.6	Conduit Fittings: _____	78
8.7.7	Conduit Fastenings: _____	79
8.7.8	Expansion Fittings or couplers: _____	79
8.7.9	Outlet and Conduit Boxes: _____	79
8.7.10	Markers: _____	79
8.7.11	Sealing Compound: _____	80
8.7.12	Packing and marking _____	80
8.7.13	Testing and inspection _____	80
8.8	WIRES & CABLES _____	81
8.8.1	General _____	81
8.8.2	415/240V System _____	82
8.8.3	Buried cables _____	82
9.	LIGHTING SYSTEM	84
9.1	SCOPE _____	84

9.2	GENERAL REQUIREMENTS _____	84
9.3	LIGHTING LAYOUT _____	85
9.4	LIGHTING FIXTURES (LUMINAIRES) _____	85
9.5	DECORATIVE LUMINAIRES _____	87
9.6	PANELS/BOARD COMPONENT EQUIPMENT _____	88
9.6.1	SWITCHES/MINIATURE CIRCUIT BREAKERS (MCB) & HRC FUSE _____	88
9.6.2	Indicating Meters And meters _____	88
9.6.3	Instruments Transformers _____	88
9.6.4	Internal Wiring _____	89
9.6.5	LABELS & DIAGRAM PLATE _____	89
9.6.6	Light Control Switch _____	90
9.6.7	RECEPTACLE UNITS _____	90
9.6.8	Drawings and Data _____	92
9.6.9	Lighting Fixture – LED lamp Set _____	92
9.6.10	Lighting Poles and Flood Light Pole Mounting _____	92
10.	EARTHING SYSTEM	95
10.1	SCOPE _____	95
10.2	GENERAL _____	95
10.3	240 V EQUIPMENT _____	96
10.4	415 V EQUIPMENT _____	96
10.5	EARTH ELECTRODE SYSTEM _____	96
10.6	EARTHING OF POWER OR MOTOR CONTROL CENTRE, DISTRIBUTION BOARDS _____	97
11.	SAFETY EQUIPMENTS	98
11.1	REQUIREMENTS AND MISCELLANEOUS ITEMS: _____	98
11.2	FIRE SAFETY: _____	98
11.3	DEGREE OF PROTECTION: _____	98
11.4	ELECTRICAL EQUIPMENT FOR HAZARDOUS AREAS: _____	99
12.	INSTALLATION, TESTING & COMMISSIONING - ELECTRICAL & INSTRUMENTATION EQUIPMENT	100
12.1	GENERAL: _____	100

12.2	POWER/ DISTRIBUTION TRANSFORMERS: _____	101
12.3	HV/ LV SWITCHGEAR CONTROL PANELS: _____	101
12.4	EARTHING AND LIGHTNING PROTECTION SYSTEM: _____	101
12.5	INSTALLATION OF CABLE RACKS AND CABLE TRAYS: _____	104
12.5.1	General _____	104
12.5.2	Cable Trays: _____	104
12.5.3	Cable Trunking – Metal: _____	105
12.6	CABLE INSTALLATION: _____	106
12.6.1	General: _____	106
12.6.2	Laying of Cables: _____	107
12.6.3	Cables Laid Direct in Ground: _____	108
12.6.4	Cables Laid in Underground Ducts: _____	108
12.6.5	Cables installed in Conduit: _____	108
12.6.6	Surface Installation: _____	109
12.6.7	Concealed Installation: _____	110
12.6.8	Cable Installed in Flexible Conduit: _____	110
12.6.9	Cable Clipped Direct: _____	110
12.6.10	Cable Installed in Internal Floor Trench: _____	110
12.6.11	Cable Terminations and Joints: _____	111
12.6.12	Cable Fixings: _____	112
12.6.13	Cable Identification: _____	112
12.6.14	Marking Locations of Underground Cables: _____	112
12.6.15	Additional Requirements for Cable Installations: _____	113
12.7	LIGHTING SYSTEM INSTALLATION: _____	115
12.7.1	Rrequirements _____	115
12.7.2	Standards _____	115
12.7.3	Lighting Fixtures: _____	116
12.7.4	Point Wiring: _____	116
12.7.5	Outdoor Lighting (Street and Flood Lighting): _____	118
12.7.6	LDB & LIGHTING PANELS _____	119
12.7.7	REQUIRMENTS _____	119
12.7.8	General Practices for lighting: _____	120

12.7.9	Earthing for lighting: _____	120
13.	INSPECTION & FIELD TEST OF ELECTRICAL EQUIPMENT'S	121
13.1	Scope _____	121
13.2	General requirements _____	121
13.3	Site Acceptance Test (SAT) _____	122
13.3.1	EHV equipment _____	122
13.3.2	Power transformer _____	122
13.3.3	High voltage switchgear _____	123
13.3.4	Medium voltage switchgear _____	124
13.3.5	H.V. cable _____	126
13.3.6	L.V cable _____	126
13.3.7	Wiring _____	126
13.3.8	Alarms _____	127
13.3.9	Earthing _____	127
13.3.10	Insulating liquid dielectric test _____	128
14.	MODE OF MEASUREMENT & PAYMENT	129

1. GENERAL

This section of the specification sets out the standard for items of electrical system to be executed by the Contractor. This section describes the basic system that has to be adopted for the electrical power distribution of pumping station. The selection of power distribution system equipment ratings and layout of the electrical equipment shall consider ease of installation, maintenance and modular addition of equipment for future expansion. All the components of the electrical system shall withstand the environmental conditions of the region as described hereafter.

The equipment shall be complete in all respects and device not included in the specifications but essential from code, regulation, statutory requirement, standard practice or operational flexibility point of view shall be included by the Contractor.

1.1 STANDARDS AND CODES

- a. Applicable standards established by the Indian Standards, International Electro technical commission (IEC) etc. govern the materials and workmanship employed in the manufacture of all equipment/items are:

Codes	Description
IS 191	Copper – Specification
IS 319	Free Cutting Leaded Brass Bars, Rods and Section Specification
IS 12615	Three phase induction motors
IS 335	New insulating oils
IS 374	Electric ceiling type fans and regulators
IS 694	PVC Insulated cables for working voltage up to and including 1100 V.
IS 722	Specification for AC Electricity Meters
IS 732	Code of practice for electrical wiring installations
IS 1079	Hot Rolled Carbon Steel Sheet and Strip – Specification
IS1169	Electric pedestal type fans and regulators
IS1248	Direct acting indicating analogue electrical measuring instruments and their accessories
IS 1255	Code of practice for installation and maintenance of power cables up to and including 33kV rating
IS 1271	Thermal evaluation and classification of electrical insulation
IS 1293	Plugs and socket- outlets of rated voltage up to and including 250 volts and rated current up to 16 amperes – Specification
IS 1544	Cotton calico
IS 1554	PVC insulated (heavy duty) electric cable
IS 1868	Anodic Coatings on Aluminium and its Alloys – Specification
IS 1897	Copper strip for electrical purposes – Specification

IS 1944	Code of practice for lighting of public thoroughfare
IS 2026	Power transformers
IS 2099	Bushings for alternating voltages above 1 000 Volts
IS 2190	Selection, Installation and Maintenance of First-aid Fire Extinguishers
IS 2253	Designation types of construction and mounting arrangement of rotating electrical machines
IS 2309	Code of practice for protection of buildings and allied structures against lightning
IS 2419	Dimensions for panel mounted indicating and recording electrical instruments
IS 2544	Porcelain post insulators for systems with nominal voltage greater than 1000 V
IS 2546	Specification for galvanized mild steel fire bucket
IS 2551	Danger notice plate
IS 2629	Recommended Practice for Hot-Dip Galvanizing of Iron and Steel
IS 2633	Methods for testing uniformity of coating of zinc coated articles
IS 2667	Fittings for rigid steel conduits for electrical wiring
IS 2705	Current transformers
IS 2925	Specification for Industrial Safety Helmets
IS 2993	A.C. motor capacitors
IS 3043	Code of practice for earthing
IS 3070	Lighting arresters for alternating current systems
IS 3156	Voltage transformers
IS 3231	Electrical relays for power system protection
IS 3347	Dimensions for porcelain transformer bushings for use in lightly polluted atmospheres
IS 3400	Methods of test for vulcanized rubbers
IS 3419	Fittings for rigid non-metallic conduits
IS 3427	A.C. Metal Enclosed Switchgear and Control gear for Rated Voltages Above 1 kV and up to and Including 52 kV
IS 3480	Flexible steel conduits for electrical wiring
IS 3646	Code of practice for interior illumination
IS 3837	Accessories for rigid steel conduits for electrical wiring
IS 3842	Application guide for electrical relays for ac systems
IS 3854	Switches for domestic and similar purposes.
IS 3975	Mild steel wires, formed wires and tapes for armoring of cables
IS 4759	Hot-dip zinc coatings on structural steel and other allied products
IS 4770	Rubber Gloves - Electrical Purposes – Specification
IS 4795	Holders for Indicator Lamps for Electronic and Telecommunication Equipment

IS 5572	Classification of hazardous areas (other than mines) having flammable gases and vapour for electrical installation
IS 5578	Guide for marking of insulated conductors
IS 5621	Hollow insulators for use in electrical equipment
IS 5819	Recommended short-circuit ratings of high voltage PVC cables
IS 5831	PVC insulation and sheath of electric cables.
IS 6229	Method for Measurement of Real-ear Protection of Hearing Protectors and Physical Attenuation of Earmuffs
IS 6600	Guide for loading of oil immersed transformers
IS 6665	Code of practice for industrial lighting
IS 7098	Cross linked polyethylene insulated PVC sheathed cables
IS 7752	Guide for improvement of power factor in consumer installation
IS 8130	Conductors for insulated electric cables and flexible cords
IS 8224	Electric lighting fittings for division 2 areas
IS 8468	On-load tap changers
IS 8478	Application guide for on-load tap changers
IS 8752	Towing hook for use between trailers of up to 5 tones gross mass and transport tractor
IS 8789	Values of performance characteristics for three phase induction motors
IS 8828	Electrical Accessories - Circuit Breakers for Over Current Protection for Household and Similar Installations
IS 9283	Motors for submersible pump sets
IS 9334	Electric motor operated actuators.
IS 9537	Conduits for electrical installations
IS 9583	Emergency lighting units
IS 9677	Guide for limits of temperature-rise of the windings of electrical equipment when tested by different methods
IS 9678	Methods of measuring temperature rise of electrical equipment
IS 9921	Alternating current disconnectors (isolators) and earthing switches for voltages above 1000 V
IS 9974	High pressure sodium vapour lamps
IS 10118	Code of practice for selection, installation and maintenance of switchgear and control gear
IS 10322	Luminaries
IS 10418	Drums for electric cables
IS 10601	Dimensions of terminals of high voltage switchgear and control gear
IS 10810	Methods of test for cables
IS 11037	Electronic type fan regulators

IS 11353	Guide for uniform system of marking and identification of conductors and apparatus
IS 11171	Specification for Dry-Type Power Transformers.
IS 12065	Permissible limits of noise level for rotating electrical machines
IS 12615	Energy efficient induction motors- three phase squirrel cage.
IS 13585	Power Capacitors of non-Self-healing Type for AC Power Systems having Rated Voltage up to 650 V – Specification
IS 13369	Stationary lead acid batteries (with tubular positive plates) in monobloc containers
IS 13383	Methods of Photometry of Luminaires.
IS 13440	Code of safety for methyl chloride
IS 13703	Low Voltage Fuses for voltages not exceeding 1000V AC or 1500 V DC
IS 13779	AC Static Watt-hour Meters, Class1 & 2
IS 13849	Specification for portable fire extinguisher dry powder type (constant pressure).
IS 13875	Digital measuring instruments for measuring and control.
IS 13925	Shunt capacitors for ac power systems having a rated voltage above 1000 V
IS 13947	Low-voltage switchgear and control gear
IS 14697	AC Static transformer operated Watt hour and VAR Hour Meters
IS 14981	Live Working-Earthing or earthing and short-circuiting equipment using lances as a short- circuiting device-lance working
IS 14927	Cable trucking and ducting systems for electrical installation
IS 14993	Saddles, pole clamps (stick clamps) and accessories for live working
IS 15086	Surge arresters
IS 15652	Insulating mats for electrical purposes – Specification.
IEC 60076	Power transformers
IEC 60335	Household and similar electrical appliances - Safety - Part 1: General requirements.
IEC 60669	Switches for household and similar fixed-electrical installations - Part 1: General requirements.
IEC 60751	Industrial platinum resistance thermometers and platinum temperature sensors
IEC 60789	Medical electrical equipment - Characteristics and test conditions of radionuclide imaging devices – Anger type gamma cameras
IEC 60896	Stationary lead-acid batteries - Part 22: Valve regulated types – Requirements
IEC 60947	Low-voltage switchgear and control gear - Part 1: General rules
IEC 61537	Cable management - Cable tray systems and cable ladder systems
IEC 61643	Low-voltage surge protective devices - Part 12: Surge protective devices connected to low-voltage power distribution systems - Selection and application principles
IEC 61921	Power capacitors - Low-voltage power factor correction banks

- IEC 62305 Protection against lightning - Part 4: Electrical and electronic systems within structures
- IEC 62271 High-voltage switchgear and control gear - Part 101: Synthetic testing.

- b. Where provisions of the pertinent codes and standards conflict with these Specifications, Drawings and Datasheets or with each other, comply with the more stringent provision.
- c. Use the latest issue of Standards. Make available at least one copy of Standards for reference during construction.
- d. It is essential that the electrical power distribution system will comply in all respects with the relevant statutory and regulatory instruments of state of Gujarat and that of India.
- e. The relevant, state and national, statutory and regulatory instruments for electrical installations are as follows:
 - i. The Indian Electricity Rules 1956
 - ii. The Electricity Act 2003
 - iii. Gujarat State Electricity Act 2003

1.2 SAFETY & SECURITY

- a. It is essential at all times to maintain a safe system of working and to comply with all enactments, regulations and working rules relating to safety, security, health and welfare of all persons who may be affected by the work.
- b. In particular, it has to be ensured that only persons who are properly trained for their duties are employed, and that the correct tools and procedures are used.
- c. Nothing which has been written into or omitted from this document shall be taken to relieve the contractor from the obligations under this clause. No clause in this specification shall prevent the executing agency from drawing the attention of the Owner to any feature of the works which is not consistent with normal safety practices nor prevent him putting forward proposals at any time which would increase the safety of the installations.
- d. The design should include all reasonable precautions and provisions for the safety of operating and maintenance personnel.
- e. Electrical works design life shall be 20 years.

1.3 ENVIRONMENTAL CONDITION

- a. All equipment shall be designed for operation in tropical humid climate having 50°C ambient temperature and a humidity of 100 percent. Maximum temperature and maximum humidity however are not likely to occur simultaneously. The derating of the equipment shall be done on the basis of the maximum ambient temperature of 50°C.
- b. Continuity of equipment operation is the first consideration and the design shall be such as to provide facilities to simplify inspection, testing, maintenance, and cleaning and general repairs at site.

1.4 ELECTRICAL SWITCHGEAR ROOM ENVIRONMENT

- a. Electrical switchgear rooms are designed to provide a non-hazardous, clean and dry location for the switchgear/motor control centers/power control centers and associated equipment. Rooms are being ventilated with air taken from non-hazardous and clean areas.
- b. No pipe work is routed in electrical rooms. If this cannot be avoided, precautions taken to ensure that no liquid from a burst pipe or leaking joint can enter the electrical room.
- c. Vehicle access is provided to equipment doors.
- d. Ventilation system shall be provided with minimum three air change in Electrical switchgear room.

1.5 SYSTEM VOLTAGE

- a. System Voltage/Incoming Power Supply of Pumping station is derived based on Load Demand.
- b. Based on Load requirement, 11 KV Power supply shall be received through GETCO from nearest GETCO Substation.
- c. Fault level has envisaged 25 kA for 3 sec at 11 kV Supply from GETCO, however contractor has to design electrical equipment confirming actual fault level at Project site.
- d. Incoming Power supply & system Voltage for all equipment's is derived in table below:

System Voltage

Sr No	System Voltage	Type
1	Incoming Voltage	11 KV based on Load demand of PS
2	Supply voltage for HV Pump Motors	415V, 3 phase, 3 wire, 50Hz
3	LV system distribution network	415V 3 phase 4 wire neutral solidly earthed
4	Motors less than 250kW	415 V, 3 phase, 3 wire, 50 Hz

1.6 VOLTAGE & FREQUENCY VARIATIONS

Electrical equipment shall function satisfactorily during voltage fluctuations within +10% and -10% of the stated voltage levels and at frequencies within +/-5% of the stated frequency.

1.7 PHASE SEQUENCE

- a. Phase sequence shall be specified in alphabetical order, each phase reaching its maximum in time sequence in this order. Bus bars shall be marked as R.Y.B. and N as seen from the front or operating side of a switchboard or panel.
- b. Cable terminals and apparatus which are to be connected directly or indirectly to supply conductors shall be marked U.V.W. The neutral and earth shall be marked as N, E respectively.

1.8 VOLTAGE DROP CRITERION

- a. The steady-state voltage drop of each circuit shall be calculated on the basis that the total load

on the circuit is equal to the sum of the nameplate full load amperes of all connected utilization devices that will be in operation under normal conditions.

- b. The normal steady-state voltage drops in the distribution system between the secondary terminals of the supply transformer and the utilization devices shall be limited to values that allow rated voltage to be supplied to each energized and loaded device.
- c. The most suitable setting for the power transformer taps changers shall be established following consideration of the supply configuration and resultant voltage drop conditions.
- d. The actual distribution of the allowable overall steady-state voltage drop across the different parts of the electrical system will depend on the circuit configurations and distances between circuit components.
- e. The voltages at all motors during start up shall be maintained at a value which ensures that there is sufficient accelerating torque developed by the motor to give a safe run up time.
- f. The maximum system transient impedance shall be used in calculating voltage drops relating to motor starting, restarting and re-acceleration requirements.
- g. Vendor requirements for special equipment requiring close voltage regulation shall be taken into account when designing the overall system to ensure that the voltage drops do not exceed those specified.
- h. During starting or re-acceleration of a motor, either individually or in a group, the voltage dip at the motor terminals shall not vary more than 15% from rated voltage when started direct on line under the worst operating scenario i.e., largest motor started with minimum number of power sources and minimum fault level.
- i. The above shall be achieved within the constraints imposed by the electrical system and as feasible with regard to process requirements, safety and economic factors.
- j. Under steady state conditions, the maximum voltage drop in various sections of electrical system shall be limited to the following:

1. Cables/bus-bar ducting between transformer and switchboard	:	0.5%
2. Cables/bus-bar ducting between generator and switchboard	:	0.5%
3. Cables between LV switchboard and LV motor	:	5%
4. Cables between LV switchboard and lighting panel	:	1%
5. Cables between lighting panel and farthest lighting point	:	4%

1.9 COMPATIBILITY

Components used with electrical switchgear, motor control gear and control panels shall be uniform throughout the works in order to reduce spare holdings. Electrical enclosures housing switchgear, motor control gear, control systems, terminations shall each be of similar construction throughout the works in order to achieve a consistent appearance.

1.10 ENCLOSURES

- a. Enclosures shall be constructed to provide an adequate level of protection from the environment. The following minimum standards shall be applied unless otherwise specified:

- | | |
|---|----------|
| 1. Switchgear and control panels located in switchgear or control rooms | - IP 54 |
| 2. Switchgear and control panels located in plant rooms | - IP 55 |
| 3. Equipment located externally in sheltered locations | - IP 65 |
| 4. Equipment located externally in exposed locations | - IP 65 |
| 5. Equipment liable to be periodically submerged | - IP 68. |

b. The IP ratings are defined by IEC 529.

1.11 IDENTIFICATIONS

- a. Each main and auxiliary item of pumping station shall have permanently attached to it in a conspicuous position a nameplate and rating plate. Upon these shall be engraved, in English, the manufacturer's name, direction of rotation, type and serial number of plants, details of the loading and duty at which the item of pumping station has been designed. All indicating and operating devices shall have securely attached to them or marked upon them designations as to their function and proper manner of use. Provision shall be made to incorporate descriptive numbering codes as indicated on the layout drawings.
- b. Such nameplates, rating plates and labels shall be of a rigid type, at least 3 mm thick, laminated and engraved plastic material, with black block capitals on a white background. The labels shall be fixed by non-ferrous or stainless-steel screws.
- c. Warning labels shall be of similar construction with black block capitals on a yellow background.
- d. Weatherproof labels for use outside the buildings shall be rigid type laminated plastic.
- e. All field items shall be tagged with 50 × 25 mm engraved labels. The label shall state the item tag number and hazardous area classification in case it falls under it and shall be attached by a corrosion resistant ring to a fixed portion of the item. The ring shall retain the tag securely but shall allow transfer to a replacement item when necessary.
- f. Warning labels shall be provided where necessary to warn of dangerous circumstances or substances. Inscriptions or graphic symbols shall be black on yellow background and to internationally recognized standards.
- g. Instruction labels shall be provided where safety procedures such as wearing of protective clothing are essential to protect personnel from hazardous or potentially hazardous conditions. These labels shall have inscriptions or graphic symbols in white on a blue background.

1.12 HARMONICS

- a. The limits for harmonics in the power system as a result of non-linear loads are to be limited to those standards imposed by the power supply company i.e., GETCO & UGVCL.
- b. No significant non-linear loads are proposed therefore the existing background harmonic content of the supply will be unaffected. There is no evidence of problems at present with harmonic content of the power supply.

1.13 SURGE PROTECTION

- a. Surge protection shall be provided on power system equipment fed from overhead line systems. Usually this will apply to HV overhead supplies feeding to sites. In this case the surge protection shall be provided by the contractor near to the point of common coupling.
- b. Surge protection shall be provided on at each end of long LV cables e.g., such as those feeding the switchboards at longer distance.
- c. Surge protection shall be provided at the main control panel end of instrumentation cabling connecting equipment located external to buildings.

1.14 EARTHING PROTECTION

- a. The electrical installation shall where required be connected to the general mass of the earth by an earthing conductor as per IS 3043.
- b. Where the earth electrode system is not provided by the power supply authority or where a requirement for a standby or base load generator is specified the installation shall comprise one or more earth electrodes, earthing strip network, mesh or a combination of these in order to obtain the required earth electrode resistance.
- c. Earth electrodes where used shall be of galvanized iron. The rod shall penetrate a minimum of three meter below ground level. Where multi-rods are used, they shall be separated by a distance of not less than the driven length.
- d. Earth rods shall have hardened tips and caps and be extendable. Bare galvanized iron strip buried at a minimum depth of 600 mm shall be used for interconnection of rods.
- e. Where soil conditions make the use of rod type electrodes impracticable a grid configuration may be used comprising horizontally buried bare galvanized iron strips as per IS 3043. Strip shall be buried at a minimum depth of 600 mm.
- f. Each earth electrode rod if used shall be provided with an approved non-ferrous clamp for the connection of the earthing conductor or tape as required. These connections shall each be housed in individual concrete inspection chamber set flush to the finished ground level and shall allow disconnection for testing of individual electrodes.
- g. All materials used for the earth electrode installation shall be purpose made for the application and shall be suitable for the site and soil conditions.
- h. Unless otherwise stated all excavation of trenches for the installation of the earth electrodes and the inspection pit shall be carried out by the Contractor.
- i. The Contractor shall demonstrate that the resistance of the electrodes to earth and the continuity of the earth network are within the limits specified. Any additional earth electrodes and test instruments required for the tests shall be provided by the Contractor.
- j. Marker posts and plates shall be provided to mark the route of buried strip electrodes. The markers shall be similar to those provided for cable routes.

1.15 LIGHTNING PROTECTION

- a. Lightning Protection system shall be provided for protection against atmospheric discharges on

the all-new buildings. This shall consist of an air termination network of horizontal and/or vertical conductors. The air termination network shall be connected to earth electrodes by an adequate number of down conductors. The earth electrodes shall be connected to the pumping station earthing system.

- b. The lightning protection system shall be designed and installed in accordance with IS 2309 and IEC 62305 Standards. The normal air termination shall be tinned copper strip. All metallic ducts, antennae, hand railing, etc. shall be bonded to the air termination.
- c. The earth electrode resistance of the lightning protection earth electrode system alone shall not be more than ten ohms. Each lightning protection system should be bonded locally to the power earth at not less than two points.

1.16 TOOLS & TESTING EQUIPMENTS

- a. The work shall be performed using tools and testing equipment designed and approved for the purpose.
- b. The following tools and testing equipment's are recommended for carrying out the electrical installation work. The contractor shall bring tools and equipment which may be necessary to carry out / complete the work, in addition to the tools and equipment suggested hereunder, if asked for by Owner.
 - 1. 5000 volts constant pressure type motorized insulation tester (megger)
 - 2. 1000 volts constant pressure type insulation tester (megger)
 - 3. 500 volts constant pressure type insulation tester (megger)
 - 4. Relay testing kit
 - 5. High voltage test kit
 - 6. Universal Earth Tester
 - 7. Welding Sets
 - 8. Cutting Tools
 - 9. Derricks, if required
 - 10. Jacks
 - 11. Electric Blower
 - 12. Drilling Machines (different sizes)
 - 13. Grinding Machine
 - 14. Cable Crimping Tool
 - 15. H.V. and L.V. Cable termination and jointing kits.
 - 16. Tong Tester
 - 17. Portable Voltmeter
 - 18. Pipe bending machine
 - 19. Phase sequence indicator
 - 20. Portable test lamps with prongs
 - 21. Tachometer (0-1500 rpm)

- 22. Constant pressure type continuity tester
- 23. Wiremen kits
- 24. Fitter's tools
- 25. Vices
- 26. Die sets with difference dies
- 27. Ladders (different sizes)
- 28. Cable laying tools

1.17 CUTTING, PATCHING AND EXCAVATION

The Contractor shall do all excavation and cutting required for the installation work and shall be responsible for any damage that may be caused to the work of others. He shall, where possible, keep the excavation, cutting and patching to a minimum. If the contractor fails to perform his work in the proper manner or at proper time and due to this, additional excavation, cutting and patching is required, the Contractor shall do such additional cutting and patching without any extra cost.

1.18 DRAWINGS

- a. The Contractor shall submit four prints of each drawing after award of contract for approval.
- b. One set of drawings shall be kept as record drawings. All deviations of the actual proposed installations as shown on the drawings should be marked in red on these drawings. On completion of the project, as-built drawings shall be prepared by the contractor incorporating these changes and four sets of such drawings shall be handed over to the Owner at the time of final handing over.
- c. The contractor shall also submit one set of CD each to Owner containing all drawings. Sketches etc. in AutoCAD 2018 or latest version and data in MS Office/ WINDOWS 10 or latest.

1.19 PERSONNEL

All work shall be performed by contractor under the direct supervision of a qualified person appointed by him and regularly engaged in the installation of electrical equipment. The contractor shall place in charge of the work at all the times during the construction. A qualified and experienced Contractor's Electrical Engineer who shall be responsible for keeping liaison and co-ordination between Owner's personnel and his own men at site. he shall also submit progress reports every fifteen days. Anyone not deemed capable shall be replaced immediately upon such advice.

2. SCOPE OF WORK

2.1 SCOPE OF WORK

1. The Electrical scope for pumping station is briefly described below, but not limited to it,
2. Design, supply, installation, testing(Factory Acceptance Test(FAT) and Site Acceptance Test(SAT)), Pre-commissioning, Commissioning and Operation & Maintenance of 11 kV outdoor type Air Insulated Switchyard (AIS) comprising of equipment i.e. Substation structure, Lightning arrestor, circuit breaker, Current and potential transformer, Isolator, Bus bar assembly, Power and Auxiliary transformer with tap changer, NGR, Marshalling box, Cable containment & necessary fire protection/ fighting system arrangement.
3. Outdoor switchyard illumination, lightning and earthing protection system for outdoor switchyard and electrical panel building and pumping station.
4. All Architectural and Civil work comprising equipment and substation structure foundation, soil treatment, fencing, gates, Gravels, cable trenches, Storm water drain system, Oil drainage system, approach road, buffer wall, rail track HDPE, RCC pipe etc.
5. Design, supply, installation, testing Factory Acceptance Test (FAT) and Site Acceptance Test (SAT), pre-commissioning, commissioning and operation and maintenance of 11 kV Control and Relay panel, RTCC, Battery and battery charger, PDB, MLDB etc.
6. Design, supply, installation, testing Factory Acceptance Test (FAT) and Site Acceptance Test (SAT), pre-commissioning, commissioning and operation and maintenance of 415 V Switchboard, 415 V Capacitor bank and APFC panel, 415 V Digital soft starter, 415 V XLPE insulated power cable battery charger, LDB etc.
7. Design, supply, installation, testing Factory Acceptance Test (FAT) and Site Acceptance Test (SAT) pre-commissioning, commissioning and operation and maintenance of 415 V Switchboard, 415 V Capacitor bank and APFC panel, 415V XLPE insulated power and control cable etc.
8. Indoor illumination and electrification for Electrical panel room and pumping station;
9. Outdoor street illumination using lamps/ street light/ flood lights.
10. Reactive power compensation, Harmonic mitigation, switching surge protection in line with utility norms, OEM recommendation and confirming to Indian Standards and latest IE Rules.
11. Supply and delivery of Personal Protective Equipment (PPE) in line with utility norms and confirming to Indian Standards and latest IE Rules.
12. 11 kV control and relay panel room; ventilation of electrical panel building and Pumping station as per OEM recommendation.
13. All work to be performed and supplies to be affected as a part of contract shall require specific review and approval of Client or his authorized representative as per vendor data requirement.

14. Design, supply, installation, testing (Factory Acceptance Test (FAT) and Site Acceptance Test (SAT), pre-commissioning, commissioning and operation and maintenance of DG set of 415V, Min. required capacity as per price bid complete with AMF panel.
15. To obtain clearance for energizing the complete electrical facilities covered under this tender and approval of installation / drawings and documents from Central Electrical Authority / Gujarat state electricity Inspectorate and any other concerned approving authority and follow up with electricity board for getting power approved by Client. Any other requirements as necessary by the statutory regulations which are not shown in typical installation shall be complied by the contractor.
16. To supply and deliver commissioning spares.
17. To make the provision of all testing instruments / kits for testing and commissioning of the system.
18. The contractor shall arrange technical experts of equipment from OEM as and when necessary, until the commissioning and guaranteed run of the plant is completed.
19. The Contractor shall also include in the project any other work/activity which is not specifically listed but is necessary for completeness of electrical system.

2.2 SUBMITTALS

- a. Following submittals shall be part of scope of work but not limited to following list.

1. Design Calculations
2. Equipment Lists covering list of Bearings and Seals
3. Equipment Data Sheet
4. Electrical Single Line Diagrams
5. Schematic and Control Diagrams
6. General Arrangement Drawings of electrical equipment
7. Earthing Layout
8. Illumination layout
9. Lightning Protection layout
10. Equipment Dimensional Drawings.
11. Electrical Equipment Weights.
12. Cable Schedules and Cable Routing Drawings.
13. Transformer, Motor, switchgear etc. Performance Curves
14. Noise and Vibration Test Certificates.
15. Factory Test Reports and Performance Test Certificates.
16. Construction Power Supply Requirements

17. Protection co-ordination Settings
 18. Interface or Inter-Connection Diagrams / Lists
 19. Quality control document
 20. Firefighting system layout & test reports
-
- b. Submit to Inspection Authority and the Power Supply Authority the required copies of relevant drawings and specifications for examination and approval prior to commencement of work.
 - c. Neatly assemble and submit operating and maintenance data containing booklets, “AS BUILT” drawings, instruction sheets, etc., issued by the suppliers and relating to the equipment intended to be installed under this section and necessary or desirable for the maintenance, repair or operation of the equipment along with “AS BUILT” drawing.
 - d. The contractor shall submit to the department such as QAP / data sheets / drawings / catalogues etc. and any other supporting documents (each 3 sets) of equipment / items of electrical system before start of manufacturing and approval of Engineer-in-charge to be obtained. Before shipping of such items, the contractor shall obtain inspection release note / dispatch clearance from the Engineer-in-charge.

3. 11 kV SWITCHYARD EQUIPMENT

3.1 GENERAL

The design, material, construction, manufacture and testing of substation equipment shall comply with all currently applicable standards/ statutes, regulations and safety codes in the locality where the equipment will be installed. In case of conflict between the standards and this specification, this specification shall govern. The following equipment shall be provided in the Switchyard.

3.2 STRUCTURE

- a. Two/ four pole structures in switchyard to receive 11KV power supply from electric supply authority shall conform to the latest applicable standards specified as under.
- b. A two/ four pole structure shall be of a rolled steel joist of minimum ISMB 150 (150mm x 75mm) for 6-meter pole/ ISMB 175 (175 mm x 90 mm) for 9/ 11meter pole with 400 mm x 400 mm x 8 mm thick base plate welded at bottom end of all the poles of structure.
- c. Mild steel cross members of minimum ISMC 100 mm x 50 mm x 6 mm size channels of 3.5 m in length, 8 Nos. shall be provided with cross bracing angles of minimum ISA 50 mm x 50 mm x 6 mm size of 4.5 meter in length.
- d. Side clamps, stay clamps, cleats etc. shall be fabricated from minimum 50 mm x 6 mm size MS flats as per actual requirements. All bolts, nuts, washers, etc. shall be of minimum 15 mm size.
- e. All the members of two/ four pole structure should be galvanized.
- f. Excavation of pits even in hard soil shall be done up to a depth of about 1/ 6 the length of pole and refilling the same after erection of structure and concreting work. Compacting the bottom of pits, providing cement concrete to suit at bottom and side of poles up to at least 150 mm above FGL curing and making it hard as per requirement.
- g. Erection of RSJ poles and fixing of all structural members as per requirement shall be in line, level and properly facing the incoming and outgoing lines. Cross members shall be firmly tightened.
- h. All members shall be fabricated to suit mounting/ fixing of Gang Operated Disconnectors/ Isolators, Lightning Arrestors, Pin/ Post insulators, cable end termination Kit/ Box etc.
- i. All MS parts shall be painted with two coats of red oxide and two coats of aluminum paints.
- j. Earthing terminals shall be provided by welding 15 mm size bolts or cleats of 50 mm x 6 mm size MS flat shall be welded in each joist with a hole of 15 mm size and galvanized nuts, bolts, washers shall be provided as earthing terminals.
- k. Necessary stay sets & hardware as required for completeness shall be supplied and erected.
- l. All drawings/ documents such as GA drawing of two/ four pole structure showing all equipment mounted on the structure, technical particulars & Bill of Material etc. shall be prepared and submitted to Purchaser/ Purchaser's representative for approval. Obtaining the approval from CEIG/ IMPD (GOG) and getting power released from supply authority are also included in the

scope of work.

3.3 GOD

Gang operated offload disconnectors (GOD) with earth switch:

- a. The double break type isolator (GOD) shall be manually operated and suitable for the specified site conditions and shall be able to-
 - i. Carry rated current without excessive temperature rise.
 - ii. Withstand the short circuit forces developed during fault.
 - iii. Carry the inrush current of the transformer.
 - iv. Interrupt small inductive and capacitive currents.
- b. The operating rod shall be extended up to the operating level and shall have a handle with 'lock and key' arrangement. The operating handle shall be at a level of 1.0 meter from finished ground level.
- c. The operating handles shall be mounted on the base of supporting structure. Guide bearings shall be provided, if necessary, at appropriate height above ground level. Necessary accessories viz. brackets, angles, guides, guide bearings for attaching the operating mechanism and operating handles to the structure and part of the isolator, rust proof pins, ball or roller type bearings shall be provided and installed. All bearings shall be protected by means of covers and grease retainers. Bearing's pressure shall be kept low to ensure long life and ease of operation.
- d. The operating mechanism design shall be such that, as soon as the moving blades reach the sparking distance during operation of isolator, springs shall take over to give a quick snap action closing so that the isolator closing is independent of manual effort. Similarly, the springs must assist during opening operation to give quick breaking feature.
- e. All copper parts shall be Silver or Tin plated. All ferrous parts shall be hot dipped galvanized to assure long protection against tropicalized weather.
- f. The contacts shall be of silver faced copper ensuring sufficient contact pressure. The male and female contacts shall be of self-aligning type to ensure trouble free operation during opening and closing of isolator. Mild steel arcing horn capable of breaking the magnetizing current shall be provided. Earth mesh below GOD to be provided

3.4 ISOLATOR INTERLOCK:

- a. Electrical interlock arrangement shall be provided among double break isolator (GOD) and respective 11 KV indoor type breakers.
- b. Interlocking arrangement shall be robust, heavy-duty type and sturdy in construction.
- c. Mechanical interlock between Isolator & Earth Switch shall be provided.

3.5 INSULATORS:

- a. Insulator shall be properly glazed with smooth surface without cracks etc. and dielectric property shall be properly coordinated with isolator voltage class. Porcelain used for the manufacturer of insulator shall be uniform, brown color, free from blisters, burns and other

similar defects. Insulators of the same rating and type shall be interchangeable.

- b. Porcelain and metal parts shall be assembled in such a manner that any thermal expansion differential between the metal and porcelain parts throughout the range of the temperature variation shall not loosen the parts or create undue internal stresses which may affect the electrical or mechanical strength and rigidity. Each cap and base shall be of high-grade cast steel or malleable steel casting and they shall be machine faced and smoothly galvanized. The cap and base of the insulators shall be interchangeable with each other.

3.6 ACSR CONDUCTOR:

- a. Aluminum conductor steel reinforced shall be hard drawn from 99.5% pure electrolytic aluminum rods. The Contractor shall specify the conductivity.
- b. Chemical composition of the material shall comply with the requirements of relevant standards.
- c. The surface of conductor shall be clean and dry and free from any excess grease that may be used in its fabrication. The surface strands shall be smooth and free from burrs and other projections which may be a cause for increasing corona losses.
- d. The Contractor shall provide necessary treatment for the bus conductor to make it free from corrosion.
- e. The steel wire strand of conductor and steel conductor shall be hot dip galvanized. Zinc coating shall be evenly and uniformly for heavily coated wires.
- f. The steel core and inner layer of aluminum wires where more than one aluminum layer exist shall be protected with special grease in order to provide additional protection against corrosion due to salinity. The grease shall fill the whole space between wires within circumscribed cylinder at inner aluminum layer or at steel core if the conductor has only one aluminum layer.
- g. The grease shall be chemically neutral with respect to aluminum, zinc and steel. It shall withstand weather conditions given elsewhere and temperature of 85 degree centigrade without alternation of its properties.
- h. Bare conductor shall be covered in Alkathene pipes of suitable insulation to avoid accidental contact.

3.7 DROP OUT (DO) FUSE UNIT:

- a. Drop Out Fuse shall be of approved make suitable for 11 kV supply and shall be mounted on two pole structures complete with 3 fuse elements of required ampere suitable for continuous current rating and shall offer protection against fault level of suitable ampere at 11 kV.
- b. The fuse link shall consist of iron channel base to stack insulators per phase, fuse carrier Bakelite tube, heavy duty non-ferrous metal parts and spring-loaded phosphor bronze contacts.
- c. The insulator shall comply with impulse voltage in accordance with relevant IS.

3.8 STATION CLASS LIGHTNING ARRESTORS:

- a. The design, material, construction, manufacture, inspection and testing of lightning arresters shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed.

- b. In case of conflict between the standards and this specification, this specification shall govern.
- c. The equipment covered in this specification shall conform to the latest edition of the following standards.

IS: 3070 (Part-3) Lightning arresters for AC system – Specification (Metal Oxide Lightning Arrester without Gaps)

IEC: 60099-4 Metal Oxide surge arresters without gaps for AC system

d. Constructional Features:

- i. Lightning arrester shall be station class heavy duty and non- linear resistance type. The elements shall be in hollow cylindrical form, stacked together. Lightning arrestor shall be of class II, having non – linear voltage – current characteristic and having high discharge capability.
- ii. The entire arrester unit shall be housed in a porcelain insulating casing of high strength, made from brown glazed wet process porcelain, with metallic cover plates and terminal assemblies. The end castings shall be hermetically sealed and leak tested to protect the unit from moisture or breathing.
- iii. Pressure relief diaphragm, vent pipe, etc. shall be provided on the LA for the escape of gases formed. In the event of failure of L.A., the pressure relief directional aperture should be directed away from adjacent apparatus to prevent damage, due to arc transfer.
- iv. All hardware such as clamps, screws, bolts, nuts, washers etc. shall be electro galvanized.

e. Insulators:

- i. The porcelain insulators used shall be made from wet process, and shall be homogenous, free from lamination, cavities and other flaws, which may impair its mechanical or dielectric strength. They shall be thoroughly vitrified, tough and impervious to moisture.
- ii. The glazing of porcelain shall be uniform brown colour, free from blisters, burns, cracks and other defects. The glazing shall cover all the porcelain part of the insulators except that area which serves as support during firing or are unglazed for the purpose of assembly.
- iii. The minimum creepage distance shall be as stipulated in data sheets. The petticoats shall be spaced for natural cleaning action by wind and rain and avoid concentrated hot spots where local stress can precipitate flashover.
- iv. All live metallic parts shall be suitably painted. All joints shall be fluid – tight and air tight. The design of insulators shall be such, as to produce uniform compression pressure joints.
- v. All insulators of identical rating shall be interchangeable.
- vi. Each bushing shall be provided with aluminum/ bimetallic terminal connectors suitable for inter – connection with aluminum tubular Bus bars or ACSR conductor as specified in data sheet.

f. Accessories: Each lightning arrester shall be furnished complete with the accessories as listed below:

- i. Anti-contamination and pressure relief diaphragm complete with vent pipe.
- ii. Two (2) grounding pads.

- iii. Base plate suitable for mounting on GI/ steel structure or concrete structure.
- iv. Line side terminal suitable for specified conductor.
- v. Other standard accessories which are not specifically mentioned but are usually and provided with lightning arrester of similar type and rating for efficient and trouble-free operation.
- vi. Name plates fixed on lightning arresters giving full technical details.
- vii. The clamps and connectors on arrester terminals for connection to Purchaser's line conductor and the connection between incoming transmission line and LA will be in the Contractors scope.
- g. Drawings/ documents to be furnished for Purchaser's approval:
 - i. Technical Particulars
 - ii. GA drawing of LA indicating weight and overall dimensions
 - iii. GA drawing of insulating base, discharge counter, terminal assembly
 - iv. Bill of Material
 - v. Mounting arrangement (base plate details) on the structure
 - vi. QAP for Lightning Arrester

3.9 CHAIN LINK FENCING AND GRAVEL FILLING:

- a. The work of erecting chain link fencing includes excavation, brick wall construction, erection of angle/ channel supports, providing chain link mesh on angle/ pipe frame barbed wire fencing at the top, concreting of support members, painting the complete structure and white washing the walls. All materials, hard wares, labours etc. are in the scope of Contractor.
- b. Fencing height shall be minimum 2.0 meter & shall be complying with CEA guide lines/ requirements.
- c. Gate for entry in the fenced compound shall be fabricated from pipes of heavy-duty class. Design of gate shall be got approved from the engineer in charge before starting the fabrication work. All necessary hard wares, fittings, stoppers, locking arrangements with brass pad locks of 100 mm size are in the scope of gate works. Gates shall be self-supporting type.
- d. Gravel Filling

4. POWER/ DISTRIBUTION TRANSFORMER

4.1 SCOPE

This specification covers the design, construction, manufacture, assembly, testing of performance of transformers packing, supply delivery & commissioning of 11/0.433 kV power Transformers complete with all fittings, accessories and associated equipment which are required for efficient & trouble-free operation.

4.2 STANDARDS AND OTHER PARAMETERS

A. APPLICABLE STANDARDS

Transformer shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed. The equipment shall also conform to the latest applicable standards and codes of practice specified as under. In case of conflict between the applicable reference standards and this specification, this specification shall govern.

Transformer	:	IS 1180-2014, IS 2026, BS 171, IEC76, CBIP Pub No.317
Fittings & Accessories	:	IS 3639
Climate proofing	:	IS 3202 BS-CP-1014 IEC 354
Loading of oil immersed	:	IS 6600 BS-CP-1010 IEC 296
Oil	:	IS 335 BS-148 IEC 137
Bushing for > 1000 V, AC	:	IS 2099 BS-223 IEC 144
Bushing for < 1000 V, AC	:	IS 7421 BS-223 IEC 144
Degree of protection	:	IS 13947 IEC 76
Tests	:	IS 2026 BS-171 IEC 76
Tolerance on guaranteed Particulars	:	IS 2026
Buchholz relay	:	IS 3637
Electrical insulation classified by thermal Stability	:	IS 1271 BS 2727 IEC 85
Auxiliary Transformer	:	IS 1180
Code of practice for selection, Installation & Maintenance of transformer	:	IS 10028

- B. This specification is for complete design, manufacture, testing at manufacturer's works, supply, packing, forwarding and delivery from place of storage/ manufacturer's works to erection site including transit insurance, storage at site, shifting from the place of storage to place of installation, installation, testing and commissioning for two winding, three phase, 50 Hz, outdoor type, distribution transformer of (*) kVA, 11/ 0.433kV, ONAN cooled, connected in Dyn11 with OCTC/ OLTC on HV winding & other accessories as specified.

- C. The values of Load- losses and No-load losses shall be as given in relevant IS or as per applicable standard.
- D. The Purchaser reserves the right to reject the transformer if the same does not meet the specification requirement as follows:
- No load loss exceeds the guaranteed value by 10% or more.
 - Load loss exceeds the guaranteed value by 10% or more.
 - Impedance value differs the guaranteed value by +10% or more (zero negative tolerance)
 - Oil or winding temperature rise exceeds the specified value by 5 deg C
 - Transformer fails on impulse test.
 - Transformer fails on power frequency voltage withstand test.
 - Transformer is proved to have been manufactured not in accordance with the agreed specification.
- E. The rejected transformers shall be replaced by transformers complying with the requirements of this specification at the Contractor's cost.
- F. If the commissioning of the project is likely to be delayed by the rejection of a transformer, the Purchaser 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
- G. Transformer Protections: The following protections shall be provided for a distribution transformer:

Over-current protection – Instant (50/ 51)	Trip (Relay in HV Panel)
Earth fault protection – Instant (50N)	Trip (Relay in HV Panel)
Buchholz protection relay (63) [For transformers of 500 KVA & above]	Alarm + Trip
Oil temperature indicator (OTI - 49O)	Alarm + Trip
Winding temperature indicator (WTI - 49W) [for transformer of 800 KVA & above]	Alarm + Trip
Magnetic Oil level gauge (MOG)	Alarm
Oil Surge Relay (OSR) [For transformers with OLTC]	Trip – For OLTC
Pressure relief device (PRD) [For transformer	Trip

of 800 kVA & above]	
Stand by Earth fault protection (51NS) with CT in transformer neutral [For transformer of 1600KVA & above]	Trip (Relay in HV Panel)

- H. In case of 11kV Cable feeder, an air insulated cable box with disconnecting chamber shall be provided on 11 kV side of transformer.
- I. For the pole mounted transformers (i.e., transformers ≤ 100 kVA, 11/ 0.433 kV rating), suitable orientation of HV porcelain bushings shall be ensured for direct termination of ACSR conductor from 11 kV Double Pole Structure.
- J. For transformers above 100 kVA rating, elevated foundation/ plinth of suitable height shall be provided.
- K. All the Civil works such as, transformer foundation, Oil Soak Pit, burnt oil pit as per CEA guidelines & IS 10028 requirements shall be considered in Contractor's scope.
- L. Ambient temperature of 50°C shall be considered for transformer design. Temperature rise shall be 40°C for Oil temperature and 45°C for winding temperature. Hot spot temperature limits shall be complying with IS 2026, IS 6600 & IEC 60076-2:1993 & it shall be limited to 98 Deg. C.
- M. The limits of hot spot temperature mentioned above will have to be satisfied by the manufacturer by carrying out the heat run test at the lowest negative tap. This test shall be carried out by feeding 1.1 times the total losses at 75°C at highest current tap.
- N. Neutral of LV winding shall be 50% rated.
- O. Suitable dial type instruments/indicator with alarm and trip contacts shall be provided for monitoring of following parameters for the transformer. The settings shall be site adjustable.

Winding Temperature Indicator (WTI)	1 No local + 1 No remote on RTCC
Oil Temperature indicator (OTI)	1 No local + 1 No remote
Magnetic oil level gauge (MOG)	1 No local

- P. The bushing CT required in neutral connection for back up earth fault protection shall be provided before bifurcation of neutral.
- Q. Accessories listed below shall be provided for the transformer unless noted otherwise.

- a. Anti-earthquake clamping device
- b. Marshalling Box
- c. All interconnection cables, cable accessories for connection between the transformer marshalling box & other devices mounted on the transformer and inter-connection cables for all the associated equipment/ panels including cable termination accessories such as glands, lugs etc.
- d. Foundation bolts & hardware, mounting channel & support structures for marshalling boxes, junction boxes etc.
- e. All MS components including steel bolts & nuts shall be hot dip galvanized.
- f. Automatic self-resetting type pressure relief device with trip contacts wired up to marshalling box.
- g. Additional neutral bushing.
- h. Conservator with lifting lugs (for transformers 50 KVA and above with rated voltage up to 11 kV, and all rating above 11kV with oil filling hole with cap and a drain plug.) Conservator shall be complete with plug, sample and drain valve and a shut-off valve on the pipe connection between the transformer tank and conservator to permit removal of the conservator
- i. Bushing Terminals or cable boxes complete with connectors for the Purchaser's external conductors or cable.
- j. Neutral bushing terminal complete with connector for earth conductor.
- k. Four plain rollers in place of fixing channels. The rollers shall be bidirectional, with suitable corrosion-free bearings, suitable for 90-degree rotation & lockable in both directions and of the detachable type.
- l. Inspection covers (for transformers of 1000 KVA and above).
- m. Rating and terminal marking plates
- n. Two earthing terminals for body earthing
- o. Drain cum sampling valve with plug or cover plate.
- p. Dehydrating Silica Gel Breather equipped with a silica gel dehydration capsule and oil seal to eliminate constant contact with the atmosphere.
- q. Thermometer pocket with mercury in glass bulb thermometer.
- r. Radiator with air release plug, lifting lug, drain valve and with shut off valves.
- s. Conservator with lifting lugs, oil filling cap & drain plug.
- t. Prismatic oil level gauge (on conservator) with minimum level marking.
- u. Jacking Lugs (Transformers weighing above 3000 Kg)
- v. Filter Valves
- w. Explosion vent with diaphragm/ pressure relief valve (for transformers 50 KVA and above). The device shall be rain-proof after operation. For transformers of 500 KVA and above an equalizer pipe connecting the pressure relief device to the conservator shall be supplied
- x. Base channels for fixing on a platform or plinth

- y. Lifting lugs for top cover & active part.
- z. Lifting lugs for lifting complete transformer with oil.
- aa. Lifting lugs for lifting core & coils.
- bb. Pocket for O.T.I & W.T.I.
- cc. Neutral C.T with terminal box.
- dd. Earthing bar with insulator support.
- ee. All indicating lamps shall be multichip LED Type.
- ff. Dial type thermometer (150 mm Dia.) with two contacts for oil temperature 'high' and 'very high' alarms. Each contact shall be electrically independent and brought out to separate terminals, rated 220 VDC; minimum 0.5A.
- gg. Magnetic oil level gauge (150 mm dia. 240-degree scale) with low oil level alarm contact for transformers fitted with conservator. Contact rating suitable for 220V DC, minimum 0.5A.
- hh. Gas actuated Buchholz relay, double float type with a valve between the relay and the conservator.
- ii. Gas sampling device at an accessible height and an air release cock for Buchholz relay.
- jj. Winding temperature indicator, consisting of:
 - i. Temperature sensing element. Separate PT100 for digital signal shall be provided as temperature sensor
 - ii. Turret mounted CT.
 - iii. Local Winding temperature indicating instrument (150 mm Dia.) with electrically independent contact (potential free contact) brought out to separate terminals for winding temperature 'high' and 'too high' alarms. Contacts shall be suitable for 220V DC, rated minimum 0.5A.
- kk. All digital outputs for control / remote annunciation shall be provided with at least two change-over contacts for alarm & two change-over contacts for trip conditions. Auxiliary relays, if required, to provide change-over contacts suitable for Purchaser's equipment are deemed to be included in the Contractor's scope.
- ll. Valves: Valves shall be of Gun Metal material & of suitable diameter for their intended purpose. Following valves shall be provided for each oil immersed transformer.
 - i. One (1) top filter valve with blanking plate.
 - ii. One (1) bottom filter valve with blanking plate
 - iii. One (1) bottom sampling valve with blanking plate
 - iv. Two (2) Shut-Off/ Gate Valve for OLTC Part of Conservator (on both sides of Oil Surge relay)
 - v. Two (2) Shut-Off/ Gate Valve for Main Conservator (on both sides of Buchholz relay)
 - vi. One (1) Drain valve with blanking plate for Conservator
 - vii. One (1) bottom drain valve with blanking plate for complete Transformer
 - viii. One (1) top sampling valve with blanking plate

- ix. Radiator shut off valves with blanking plates between radiator head & tank.
- x. Oil filling valve with blanking plate for Main & OLTC conservator.

R. General Constructional Features of Transformer: All material used shall be of best quality and of the class, most suitable for working-under the conditions specified and shall withstand the variations of temperature and atmospheric conditions, overloads, over-excitation, short-circuits as per specified standards, without distortion or deterioration or the setting up of undue stresses in any part, and also without affecting the strength and suitability of the various parts for the work which they have to perform. The transformer construction shall be suitable for Seismic Data (As per latest edition of IS 1893) or elsewhere in the specification.

a. Tanks:

- i. The exterior of tank and other steel surfaces exposed to the weather shall be thoroughly cleaned and have a priming coat of zinc chromate applied. 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 a glossy, oil and weather resisting non- fading paint of specified shade. The interior of the tank shall be cleaned by shot blasting and painting with two coats of heat resistant and oil insoluble paint.
- ii. Steel bolts and nuts exposed to the atmosphere shall be galvanized.
- iii. Vacuum & Pressure Tests
- iv. Various Vacuum & Pressure Tests for tank, conservator, radiator, pipes etc. shall be as per mentioned in the CBIP Manual on Transformer – Publication no. 317: 2013 & latest edition thereof.
- v. The material used for gaskets shall be cork neoprene or approved equivalent.

b. Core:

- i. The magnetic circuit shall be constructed from high grade cold-rolled non-ageing grain-oriented silicon steel laminations and shall be of 'core' type.
- ii. The insulation structure for the core to bolts and core to clamp plates shall be such as to withstands BIL & Lightning Impulse Voltage.
- iii. Each lamination shall be coated with insulation which is unaffected by the temperature attained by the transformer during service.
- iv. Core laminations shall be annealed and burrs removed after cutting. Cut edges shall be insulated.

c. Windings:

- i. Windings shall be of electrolytic grade Copper of 99.9% purity unless specifically approved by the Purchaser.
- ii. Windings shall be of insulated Copper wire or Copper strip.
- iii. Windings and insulation shall be so arranged that free circulation of oil is possible between coils, between windings, and between winding and core.

- iv. Winding shall be subjected to a shrinking and seasoning process, so that no further shrinkage occurs during service.
 - v. The completed core and coil assembly shall be dried in vacuum and shall be immediately impregnated with oil after the drying process to ensure elimination of air and moisture within the insulation.
 - vi. High voltage end-windings shall be suitably braced to withstand short circuit stresses and stresses caused up by surges.
 - vii. Materials used in the insulation and 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.
 - viii. Varnish application on coil windings may be given only for mechanical protection and not for improvement in dielectric properties. In no case varnish or other adhesive, be used which will seal the coil and prevent evacuations of air and moisture and impregnation by oil.
 - ix. Permanent current carrying joints in the windings and leads shall be welded or brazed. Clamping bolts for current carrying parts inside oil shall be made of oil resistant material which shall not be affected by acidity in the oil. Steel bolts, if used, shall be suitably treated.
 - x. Terminals of all windings, and if stated also of stabilizing windings, shall be Brought out of the tank through bushings for external connections.
 - xi. Windings shall be of copper and the conductors shall be transposed at sufficient intervals in order to minimize eddy currents and equalize the distribution of currents and temperatures along the windings.
 - xii. The sequence and orientation of HV/ LV side phase and neutral bushings shall be as specified in the latest edition of relevant IS.
 - xiii. Transformer shall operate without injurious heating at the rated KVA and at any voltage up to $\pm 10\%$ of the rated voltage of any tap. Transformer shall be designed for 110 % continuous over-fluxing withstands capability.
- d. Internal Earthing: The framework and clamping arrangement of core and coil shall be securely earthed inside the tank by copper strap connection to the tank.
- e. Terminations:
- i. Transformers shall be fitted either with bushing insulators or with air insulated cable boxes/ air insulated cable box with disconnecting chamber, as per requirement based on transformer HV incomer.
 - ii. The neutral of the star-connected winding shall be brought out to a separate bushing terminal. The neutral bushing shall be provided on the tank side to facilitate lead of the earth conductor down to the ground level. For transformers 1000 KVA and above, tank mounted insulators shall be provided for supporting the neutral earthing bar of specified section, along its run from the neutral bushing to ground-level.

f. Bushings:

- i. Bushings shall be designed and tested to comply with the applicable standards specified in the specifications.
- ii. Bushing rated for 400A and above shall have non-ferrous flanges and hardware.
- iii. Fittings made of steel or malleable iron shall be galvanized.
- iv. Bushings shall be supplied with terminal connector clamp suitable for connecting the bushing terminal to the specified conductor/ cable.

g. Bushing Current Transformers:

- i. Whenever applicable, bushing shall be supplied with current transformers.
- ii. Secondary leads, including tapings, shall be brought to a weatherproof terminal box near the bushing.
- iii. Bushing CT nameplate shall be mounted on the tank adjacent to the terminal box.

h. Cable Boxes and Disconnecting Chamber:

- i. The cable boxes, wherever required as per the prescribed criteria, shall be complete with cable joint fittings or sealing ends as required, tinned copper lugs to suit specified cable, compound and all other accessories including compression type glands, armor earth clamps and body earth terminal.
- ii. For Cable type of terminations, disconnecting chamber shall be provided to enable the transformer to be removed without unsealing the cables or draining oil from the main tank. The disconnecting chamber shall be air insulated and complete with seal-off bushings, removable flexible connectors/ links and removable covers.
- iii. Cable boxes shall be designed to accommodate all cable joint fittings or sealing ends as required, including stress/ cones or other approved means for grading voltage stress on the terminal insulation of cables operating at voltages of 22 kV and above.
- iv. Phase to phase and phase to ground clearances within the chamber shall be such as to enable either the transformer or cable to be subjected separately to HV tests.

i. Marshalling Box:

- i. Whenever fittings such as OTI/ WTI, temperature indicators with auxiliary contacts, Buchholz relay, bushing CTs etc. are provided the marshalling box shall be provided to marshal in it all the contacts/ terminals of electrical devices mounted on the transformer.
- ii. It shall be in the Contractor's scope to provide interconnection cabling between the marshalling box and the accessory devices by either PVC insulated, FRLS wires in GI conduits and/ or XLPE insulated, inner & outer extruded PVC, armored cable and necessary compression type brass cable glands at the marshalling box for the above-

- mentioned cables as well as for terminating the incoming cables from remote panels.
- iii. The marshalling box shall be tank mounted (at easily accessible location), outdoor type, IP-55 protected, weather-proof, sheet-steel (2.0 mm thick) enclosed, with hinged door having padlocking facility and painted as per paint shade approved by the Purchaser. All doors, covers and plates shall be fitted with Neoprene gaskets. Bottom shall be at least 600 mm from floor level and provided with gland plate and cable glands as required. Top surface shall be sloped.
 - iv. The marshalling box shall be provided with glass window so as to make the WTI and the OTI dials visible from the outside without opening the door.
 - v. All contacts for alarm, trip and indication circuits shall each be potential free, wired for auxiliary DC supply as specified and brought out to separate terminals at the terminal blocks in the marshalling-box. Terminals shall be rated for 10A. Wiring shall be 1.1 kV grade, with multi-stranded, copper conductors of sizes not smaller than 1.5 sq.mm for control and 2.5 sq. mm for CT circuits. CT terminals shall be provided with shorting facility and earthing.
 - vi. The marshalling box shall house the winding temperature indicator (WTI, 150 mm dial), the oil temperature indicator (OTI, 150 mm dial), terminal block, 60W anti-condensation heater, 5/ 15A industrial type five pin socket and a 10W CFL with fixture, suitable for operating on 240 V AC. Contacts of Buchholz relay, WTI, OTI, magnetic level gauge, PRD, OSR shall be wired up to the terminal block.
- j. Noise level of transformers shall be as per latest NEMA standard.
- k. Oil - Transformers shall be supplied complete with transformer oil. Transformer oil shall be as per IS-335:1993, BS 148 or IEC 296. 10% extra oil shall be supplied with transformer in non-returnable drums.
- l. Transformer losses at 75° c shall be as follows.

Transformer Rating	No load loss (kW) with Tolerance as per IS 2026	Load loss (kW) with Tolerance as per IS 2026	% Impedance
1600 kVA	8.4 kW	57 kW	8.35%

S. Maintenance Requirements for Transformers & Associated Equipment:

- a. The construction of the transformer & location of the accessories like CTs, lower ends of bushings, terminals, tap-changers etc., shall be such as to afford easy access & permit replacement of auxiliaries without removing the tank cover.
- b. Instruments & wiring in the local marshalling box (cabinet) shall be completely accessible & sufficient working space shall be made available in the cabinet. Instrument s, wiring & accessories in the cabinet shall be accessible from the front & the rear as well.

- c. The rating plate of the transformer shall be supplied as per latest version of IS: 2026.
- d. Transformer shall be capable of being used with any make of transformer oil complying with IS: 335.
- e. As far as practicable, transformer & accessories shall be so designed that no special tools are necessary for installation & maintenance. However, if special tools are required, the Contractor shall supply one complete set of such tools along-with transformer.

T. Performance Tests:

- a. In addition to the routine tests specified in the latest edition of IS: 2026, tests listed out shall be carried out on the transformer and these shall be included in the quoted prices.
- b. The tests shall be carried out in the presence of the Purchaser/ Purchaser's representative. The following tests shall be carried out on the assembled transformer during inspection at the manufacturer's works;
 - i. Measurement of resistance of windings at principal and extreme taps.
 - ii. Ratio at each tap, polarity and phase relationships
 - iii. Measurement of impedance voltage at principal and extreme taps
 - iv. Measurement of no load current and no-load losses at rated frequency and at both the rated voltage and 110% rated voltage
 - v. Measurement of efficiency at $\frac{1}{2}$, $\frac{3}{4}$ and full load
 - vi. Measurement of insulation resistance
 - vii. Induced over voltage withstand test
 - viii. Separate source voltage withstand test
 - ix. Magnetic balance test
 - x. Vacuum & Pressure Test for the tank.
- c. In addition to the above tests, lightning impulse withstand test shall be carried out on one limb of HV winding of the transformer if impulse test has not been already carried out on transformer of similar or higher capacity in the last five years. Similarly heat run test shall also be carried out if the same has not been already carried out on transformer of similar or higher capacity in the last five years. Type test certificate shall be submitted along with the bid. if such a test has not been already carried out then same has to be carried out & witnessed by third party (such as CPRI) at the Contractor's expense.
- d. All tests required by the specification including repeated tests and inspection that may be necessary owing to the failure to meet any tests specified, shall be carried out at the Contractor's expense.
- e. Guaranteed Full Load Losses (No load & Load) shall be performed at CPRI/ERDA or NABL accredited lab prior to Final inspection call.
- f. If the transformer fails to pass the tests specified, the Client shall have the option to reject the unit. Additional tests shall be conducted to locate the failure and after rectification, all tests shall be repeated to prove that the rebuilt transformer meets the specification in all respects, all at the Contractor's expense.

- U. Drawings/ Documents Required: Contractor shall submit the following drawings/ documents for Purchaser's approval:
- General arrangement drawing of the transformer, showing plan, front elevation and side elevation complete with all accessories and fittings, detailed dimensions, net weights, quantity of oil, crane lift for untacking, size of lifting lugs and eyes, clearances between HV terminals, between LV terminals, between HV and LV terminals, between HV & LV terminals and ground etc.
 - Rating, diagram and terminal marking plates, complete with polarity and vector group
 - Foundation drawing with position of foundation bolts and depth. In case of Soak pit/ Burnt oil pit requirements, the same shall also be included.
 - General arrangement of HV cable box with air insulated disconnecting chamber.
 - General arrangement of LV Cable Box or Bus Duct arrangement.
 - General arrangement of marshalling box & wiring diagram.
 - General arrangement of OLTC/ RTCC & wiring diagram
 - Guaranteed Technical Particulars for Transformer
- V. Off Circuit Tap Changing Mechanism (OCTC) for Transformer <1000 KVA: OCTC shall be with + 5% to –10% taps in steps of 2.5 % on HV winding of transformer; It shall comprise:
- Operating handle or wheel, accessible from ground level. Tap changer operating switch mounted on the top of the transformer tanks will not be acceptable
 - Tap position indicator.
 - Pad locking arrangement without interfering with visual tap position indicator shall be provided.
 - The tap-changer connections and contacts shall be accessible through an excess hole having a bolted gasketed cover.
- W. On load Tap Changing Mechanism (OLTC) for Transformer ≥ 1000 KVA: OLTC shall be with +5% to - 15% taps in steps of 1.25 % on HV winding of transformer; It shall have following technical features:
- The OLTC gear shall be designed to complete successfully tap changes for current equal to 120% of current at minimum tap position of the transformer. Also, OLTC over loading capability shall be compatible with that of transformer specified in IS/ IEC specification "Guide for loading of oil immersed transformers". Devices shall be incorporated to prevent tap change when the through current is in excess of the safe current that the tap changer can handle. The OLTC gear shall withstand through fault currents without injury.
 - When a tap change has been commenced it shall be completed independently of the operation of the control relays and switches. Necessary safeguard shall be provided to allow for failure of auxiliary power supply or any other contingency which may result in the tap changer movement not being completed once it is commenced.

- c. Oil in compartments which contain the making and breaking contacts of the OLTC shall not mix with the oil in other compartments of the OLTC or with transformer oil. Gases released from these compartments shall be conveyed by a pipe to a separate oil conservator or to a segregated compartment within the main transformer conservator. An oil surge relay shall be installed in the above pipe. The conservator shall be provided with a prismatic oil level gauge.
- d. Oil, in compartments of OLTC which do not contain the make and break contacts, shall be maintained under conservator head by valved pipe connections. Any gas leaving these compartments shall pass through the oil surge relay before entering the conservator.
- e. Oil filled compartments shall be provided with filling plug, drain valve with plug, air release vent, oil sampling device, inspection window with view glass.
- f. OLTC driving mechanism and its associated control equipment shall be mounted in an outdoor, weather proof cabinet conforming to degree of enclosure protection IP55. The finish shall match with that of the transformer on which it is mounted. The cabinet shall include:
 - i. Driving motor (415 V, 3 phase, 50 Hz, AC squirrel cage)
 - ii. Mechanically & electrically interlocked motor starting contactors with thermal overload relay, isolating switch and MCCBs.
 - iii. Duplicate sources of power supply with automatic changeover from the running source to the standby source and vice versa will be provided in transformer marshalling box and one no. outgoing feeder extending to OLTC Driving Motor cabinet, with appropriate provision for receiving the same.
 - iv. Control switch: Raise/ off/ lower (spring return to normal type) or independent push buttons.
 - v. Emergency 'OFF' push button (maintained type).
 - vi. Remote/ Local selector switch (maintained contact type).
 - vii. Mechanical tap position indicator.
 - viii. Limit switches to prevent motor over-travel in either direction or final mechanical stops.
 - ix. Appropriate scheme/ device to permit only one tap change at a time on manual operation.
 - x. Emergency manual operating device (hand crank or hand wheel).
 - xi. A five-digit operation counter.
 - xii. Space heaters with thermostat and MCB.
 - xiii. Control transformers with MPCB/ MCBs on primary and secondary sides for each supply.
 - xiv. Interior lighting fixture with lamp, door switch/ ON-OFF switch and MCB.
 - xv. Gasketed and hinged door with locking arrangement.
 - xvi. Terminal blocks, internal wiring, earthing terminals and cable glands for power and control cables.

- xvii. Necessary relays, contactors, current transformers etc.
- xviii. Transducers or any other appropriate device for remote tap position indication.

g. Control Requirements for OLTC: The following electrical control features shall be provided:

- i. Positive completion of load current transfer, once a tap change has been initiated, without stopping on any intermediate position, even in case of failure of external power supply.
- ii. Only one tap change from each taps change command even if the command is maintained.
- iii. Cut-off of electrical control when manual operation is resorted to.
- iv. Cut-off of a counter impulse for a reverse tap change until the mechanism comes to rest and resets the circuits for a fresh operation.
- v. Cut-off of electrical control when it tends to operate the tap beyond its extreme position.

h. Remote Control Equipment: The OLTC remote control equipment shall be housed in an indoor sheet steel cubicle to be located in a remote-control room. It shall conform to degree of enclosure protection IP42 or better and shall comprise the following:

- i. Control switches; Raise/ Off/ Lower (spring return to normal type) or independent push buttons.
- ii. If automatic operation is specified, auto / manual selector switch (maintained contact type) and other items as listed.
- iii. If parallel operation is specified, Master / Independent / Follower selector switch (maintained contact type) with 'out of step' annunciation.
- iv. Tap position indicator.
- v. Facia type alarm annunciators with "accept", "lamp test" facilities and hooter / buzzer for alarms as listed.
- vi. Necessary auxiliary relays.
- vii. Lamp indications for:
 - Tap change in progress
 - Lower limit reached
 - Upper limit reached
 - Transformer cooler control apparatus (if applicable)
- viii. Cable glands for power and control cables.
- ix. 240 V rated panel space heater with thermostat.
- x. CFL type interior lighting fixture with lamp and door switch.
- xi. MCBs.
- xii. Terminal blocks.
- xiii. Internal wiring.
- xiv. Earthing terminal.

- xv. Hook up for the remote operation of tap lower and raise operation and contact/ signal for tap position indication to Purchaser's DCS shall be incorporated in the panel.
- i. Automatic Control of OLTC: Automatic voltage regulator (AVR) for auto control of OLTC shall include:
 - i. Voltage setting device
 - ii. Voltage sensing and voltage regulating devices
 - iii. Line drop compensator with adjustable R and X elements.
 - iv. Timer 5-25 seconds for delaying the operation of the tap changer in the first step for every tap change operation.
 - v. Adjustable dead band for voltage variation.
 - vi. Additional features as required when parallel operation with other transformers is specified.
- j. Alarms: The following alarms shall be provided:
 - i. A.C. supply failure
 - ii. Drive motor auto tripped
 - iii. Other protective purpose considered essential by the Contractor.
 - iv. Out of step operation when paralleled transformers supposed to operate on the same tap are operating at different taps.
 - v. Tap changes delayed
 - vi. AVR failure (if AVR is specified)
 - vii. For the all specified above an "OLTC trouble" group alarm to be provided in DCS which is located in control room.
 - viii. Others, as specified.
- k. Tests:
 - i. Routine Tests: Routine tests as per IS: 8468 shall be performed on all OLTC's & Motor drive mechanisms. Over and above, Pressure and Vacuum tests shall be conducted as per IEC: 60214.
 - ii. Type Tests: Type tests as per IS: 8468 shall be carried out on OLTC & Motor drive mechanism when called for. The bidder shall indicate in his price schedule extra price, if any, for carrying out these tests. If type tests are not called for, type test reports for tests conducted (not older than 5 years) on a similar or higher rating OLTC & Motor drive mechanism shall be submitted for Purchaser's approval.
- l. Additional Requirements, if any: Tap position indicators and OLTC control switch shall be supplied loose if Purchaser decides to mount the same in the power transformer control panel.
- m. The finish and dimensions of the panel shall be as specified so as to match with the other panels in remote control room.

5. HV SWITCHGEAR PANEL

5.1 APPLICABLE STANDARDS

- a. The design, material, construction, manufacture, inspection and testing of switchgear shall conform to the latest applicable standards & comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed.
- b. The equipment shall also conform to the latest standards specified below. In case of conflict between the standards and this specification, this specification shall govern.

Circuit Breakers	IS: 13118/ IEC: 56, 694, 62271
Vacuum Contactors above 1kV and up to	IEC: 60470, 529, 721 12kV
Metal Enclosed Switchgear	IS: 3427/ BSEN: 60298/ IEC: 298/ IEC 265
Current Transformers	IS: 2705/ BS: 7626
Voltage Transformers	IS: 3156/ BS: 7625/ IEC: 186
Arrangement for switchgear bus bars, main connections and auxiliary wiring	IS: 5578, 11353
Busbar Support Insulators	IS: 2544/ BS: 3297/ IEC: 273
Degree of Protection	IS: 13947 (Part 1)/ IEC: 947-1/ IEC: 60529
Electrical Relays for power system protection	IS: 3231, 3842/ BS: 142/ IEC: 255
Electrical Indicating Instruments	IS: 1248/ BS: 89/ IEC: 51
High Voltage Fuses	IS: 9385/ BS: 2692/ IEC: 282
AC Electricity Meters	IS: 722, 8530/ BS: 5685/ IEC: 145, 211
Specification for copper rods and bars for electrical purposes	IS: 613
Code of practice for phosphating iron and steel	IS:6005/ BS:3189
Alternating current switches for voltages above 1000 V	IS: 9920/ IEC: 129, 265 & 298
Low Voltage Fuses	IS: 13703/ BS: 1362/ IEC: 269
Toggle Switches	IS: 3452/ BS: 3676
Code of practice for selection, installation and maintenance of switchgear and control	IS: 10118
gear Control Switches	IS: 6875/ BSEN: 60947/ IEC: 947
HV Cable Termination	IEC: 62329

5.2 TYPE & CONSTRUCTION

The switchgear shall be metal enclosed, indoor type with vacuum circuit breakers fully drawn out. Circuit breakers of same rating shall be completely inter-changeable with one another. Separate metal enclosed compartment for (a) control, metering & relay devices, (b) circuit breaker, (c) phase bus bars, (d) instrument transformers & (e) input/ out power cable terminations and each section shall be in conformance with loss of service continuity LSC 2B.

5.3 CAPACITY OF BRAKER

The rated capacity of the breaker & switchgear configuration (no. of incomer & outgoing breakers, minimum rating, protections, indications, annunciations, instruments etc.) shall be as per reference electrical Single Line Diagram & this specification given in table below:

Sr. No.	Description	Rating	
a)	Rated voltage (kv)	11	0.433
b)	Bus bar rating (A)	* A (As per SLD)	
c)	Short circuit rating (kA for 3 Sec)	26.3	26.3
d)	Type of Breakers	VCB	VCB
e)	One minute power frequency withstands capacity (kV rms)	28	20
f)	Basic Insulation Level (kVp)	75	60
g)	Bus bars material	Electrolytic Copper (Silver plate at Joints)	
h)	Degree of Protection (Indoor/ Outdoor)	IP4X/ IP5X (As minimum)	

5.4 AUXILIARY RELAYS

Auxiliary relays for multiplication of contacts for following transformer protections shall be provided for oil type Transformer feeders:

- Buchholz Protection Alarm & Trip
- Winding Temperature Alarm & Trip
- Oil Temperature Alarm & Trip
- Pressure Relief Device Trip
- Oil level gauge (MOG) Alarm
- Oil Surge Relay (OSR) Trip

5.5 DESIGN

1. The circuit breakers should be able to carry the rated current continuously under site conditions without exceeding the permissible temperature rise for design ambient temperature outside the switchgear cubicle as specified.
2. Bus bar material for switchgear panel shall be electrolytic Copper/ electrolytic Aluminium. Bus bars shall be fully insulated, supported on insulators capable of withstanding dynamic stresses due to short circuit. Maximum temperature of the main bus bars and bus bar connections, under operating conditions, when carrying rated normal current at rated frequency shall not exceed 90/ 105°C for non-silver plated/ silver plated joints as per IEC 60694. Bus bar temperature limits shall be adhered to without forced cooling method. The continuous current ratings of the droppers in each switchgear cubicle shall at least be equal to the corresponding breaker rating. However short time current rating shall be same as the short time current rating of the bus-bars.
3. The circuit breaker shall be fully drawn-out type in horizontal with test, service and isolated positions. In test position, the circuit breaker shall be capable of being tested for operation without energizing power circuits. Additional 2 (Two) normally open (NO) contacts of test and service positions shall be available for Client's use, after meeting all the interlocks / permissive.
4. Switchgear shall comprise rigid welded structural frame enclosed completely by sheet steel - minimum 2.5 mm thick (hot rolled) or 2.0 mm thick (cold rolled), smooth finished, levelled and free from flaws. Switchgear cubicles shall be provided with bottom sheet steel plates of 2.5 mm thickness. Cable compartments shall be fitted with removable plates of minimum 3 mm thickness for fixing cable. Cable gland shall be double compression type for single core cable, removable plates of non-magnetic material shall be provided.
5. The switchgear panel shall be powder coated with shade RAL-7032 with minimum thickness 80 microns with structured finish and height not exceeding 2300 mm.
6. For vacuum circuit breakers necessary hardware for surge suppression shall be provided to take care of switching surge.
7. Circuit breaker shall be provided with a minimum of 6NO + 6NC contacts per pole exclusively for the Client's use. All spare contacts of the circuit breaker shall be wired up to the terminal block.
8. The breaker closing coils, tripping coils, indications, annunciations shall be rated for 24/ 30V or 110V DC. The spring charging motor shall be suitable for 240V AC. Space heater, power socket, panel illumination lamp shall be fed from 240V, 50 Hz, 1 phase raw power supply. All lamp test facility shall be provided with push button.
9. The current transformers shall be mounted in the fixed portion of the switchgear expansion panel. The CTs shall withstand momentary and short time current ratings of the associated

- switchgear. CTs & VTs shall be of the cast resin type and completely encapsulated. Adequate space shall be available for termination using heat shrinkable type cable termination in CT compartment.
10. The switchgear shall have complete interlocking arrangement at the fully inserted and fully drawn-out position of the breaker. Withdrawal of circuit breaker shall not be possible unless it is in open position and operation of circuit breaker shall not be possible unless it is fully in service position, or is fully drawn out. Comprehensive interlocking system to prevent any dangerous or inadvertent operation shall be provided. Breaker trolley if required shall be provided with breaker.
 11. Automatic safety shutters shall cover live parts when the breaker is withdrawn and all other standard safety features shall be provided.
 12. All the High Voltage compartments i.e., Circuit Breaker, Bus Bar, and Cable Compartments shall be separated from each other by metallic partitions in line with IEC-62271-100/200. These compartments must have pressure relief flaps for exit of gas due to internal arc to ensure operators safety. All the HV design must ensure conformity to IEC-62271-100/200 and must be type tested for Internal Arc Tests.
 13. All non-current carrying metal work of the switchgear panel shall be effectively bonded to the earth bus. Earth bus-bar shall be extended outside the switchboard at the ends. All hinged doors & bolted joints in the body of switchgear shall be earthed through flexible copper earthing braid of adequate cross section.
 14. Terminal blocks shall be of stud & nut type, 1100V volts grade, 10 amps rated complete with insulated barriers. Terminal blocks for CTs and VTs shall be provided with test links and isolating facilities and CT terminals with short circuiting and earthing facility. All spare contacts and terminals of cubicle mounted equipment and devices shall be wired to terminal blocks with 20% spare terminals. All terminals of different control voltages shall be separate from each other. Stud type terminals and ring type lugs shall be used for control cables.
 15. The sizes of wire for CT circuit shall be minimum 2.5 mm² multi-stranded copper conductor PVC insulated and for others minimum 1.5 mm² multi-stranded copper conductors PVC insulated. Ring type lugs suitable for termination of 2.5 sq mm copper wires shall be used. Colours of the secondary/ auxiliary wiring should conform to IS 375/ 1963 and latest amendments thereof.
 16. All wiring shall be neatly run and group of wiring shall be securely fixed with clips so that wiring can be checked without necessity of removing the clamps. Ferrules with number shall be provided on both end of the wiring, i.e., straight + cross ferruling shall be done. Printed ferrules (tubular type- cut to size after printing) white with black lettering shall be provided. Printing shall be done with the indelible ink.
 17. All protective relays shall be in draw out cases with built in test facilities. All auxiliary

relays and timers shall be supplied in non-draw out cases. Externally operated hand reset indicators shall be provided on all electro-mechanical relays and timers. Timers shall be of electromagnetic or electronic type only. All spare contacts of all relays/ timers shall be wired to terminal block. All relays shall be of self-reset type, unless otherwise specified.

18. Main Protection relays shall be numerical type and shall be supplied with latest version software without any extra cost. Relays and protection shall be enabled for SCADA with IEC 61850 protocol & Modbus RS-485.
19. Breaker control switches shall be of pistol grip type and selector switches shall be oval or knob. Breaker control switches shall be 3 position spring returns to neutral.
20. Indicating lamps shall be panel mounting type of the colour specified and of multi-chip/ cluster LED type only.
21. Each circuit breaker panel shall be complete with the following:
 - a. T-N-C control switch, spring return to neutral position.
 - b. Key operated local/ remote selector switch stay put type.
 - c. Red, green, amber, white and blue colored clustered type LED indicating lamps for breaker- ON, OFF, auto trip, trip circuit healthy and spring charged and breaker in Test/ Service position shall be provided.
 - d. Push Button for all lamp test facility.
 - e. 8 window (for Incomer Panel) or ICOG/ 16 window [for each Outgoing (transformer feeder) panel] annunciator with all associated accessories as per detailed in electrical specification.
 - f. Double pole control supply switch with MCB.
 - g. Electrical anti pumping relay.
 - h. Panel illumination lamp (CFL) with MCB/ switch.
 - i. Space heater with adjustable thermostat, MCB.
 - j. 5/ 15A, 1 phase receptacle with MCB.
 - k. Potential indicating multichip/ clustered type LED lamps (R, Y, and B) for incomer/ICOG breaker.
 - l. Components as per electrical SLD.
 - m. Emergency trip push button (ETPB- Mushroom type, red colored catchable type)
 - n. Test Terminal Block (TTB)
 - o. Mechanical trip push button to trip the breaker when control supply is lost. The pushbutton shall be shrouded type. Mechanical close push button provided shall be accessible only after opening of the front door.
 - p. The panel front of the circuit breaker truck shall have following devices/ indications:
 - i. Mechanical push button for breaker open.
 - ii. Mechanical indications for spring charge / discharge.

- iii. Mechanical indications for breaker test/ service position.
 - iv. Mechanical indication for breaker ON/ OFF.
 - v. Operation Counter.
 - vi. Device for manual charging of closing spring.
- q. analogue indicating meters shall be 96 x 96 mm size taut band with 240° Scale. All indicating meters shall be provided as per enclosed electrical Single Line Diagram.
22. All analogue indicating meters shall be 144 x 144 mm size taut band with 240° Scale. All indicating meters shall be provided as per enclosed electrical single line diagram.
23. Multi-Function Meter (MFM) shall be micro-processor based electronic meter and shall have facility for on line monitoring, reading display of each parameter and shall be provided with RS- 485 to communicate the data to PLC/ SCADA. Analogue Ammeter & Voltmeter shall also be provided as per electrical 'Single Line Diagram'.
24. No extra charges shall be payable to Contractor in the event of any change in the contact configuration of relays i.e., from normally open (NO) to normally closed (NC) and vice versa. All wiring and necessary hardware for the completeness of the schemes shall be included in the scope of Contractor.
25. All operating switches shall be accessible without opening the compartment door.
26. All transformer outgoing feeders shall be suitable for interrupting transformer magnetizing currents. The breaker shall be electrically interlocked with downstream LV breaker such that if HV breaker trips, LV breaker shall also trip, and LV breaker cannot be closed until HV breaker is closed.
27. Withdrawal or engagement of circuit breakers or disconnecting switch shall not be possible unless it is in the open position.
28. Operation of circuit breaker or disconnecting switch shall not be possible unless it is fully in service position, or in test position or in fully drawn-out.
29. It shall be entirely responsibility of the Contractor to ensure that characteristics of CTs, VTs and all other devices offered by him/ her are such as to be suitable for the purpose for which they are intended.
30. Switchgear shall be suitable for easy extension on both the sides. It shall be possible at a later stage to add cubicles on both the sides of the switchgear by extending the bus-bars.
31. All power and control cables entry shall be from bottom/ top to suit the site condition. The cable compartment shall house all power cable connections along with associated cable terminations.
32. All control cabling/ wiring shall be done using 1.1kV grade, multi-stranded, Cu conductor,

- PVC insulated FRLS cables. Panel wiring shall be securely supported, neatly installed by lacing, and tying, readily accessible and connected to equipment terminals and terminal blocks. All the accessories such as cable troughs, cable ties, covers etc. shall be of fire-retardant material.
33. Breaker handling trolley shall be provided if required. This shall be complete with all necessary accessories.
 34. Earthing Switch shall be provided for bus-bar earthing for incomer panel and for cable earthing on the outgoing breaker panel with necessary interlocks. The panel earthing shall be extended up to cable alley for armor earthing.
 35. Required suitable Cable/ extension adopter boxes for power cables shall be a part of HV panel. The termination kit shall be heat shrinkable type only. Cable lugs for all power, control & instrumentation cables connections shall be supplied. The lugs shall be tinned copper/ Aluminum depending on cable conductor and of solder less crimping type.
 36. Padlocking facilities shall be provided for locking the shutters positively in closed position in all the panels. All door locks shall be provided with special keys to ensure opening by authorized personal only.
 37. Caution name plate, "Caution Live Terminal" shall be provided at all the points where the terminals are likely to remain live and isolation is possible only at remote end i.e., incomer to the switchboard.
 38. Danger notices in three languages (Hindi, English & Gujarati) and in line with the requirements of IS 2551 shall be riveted & not pasted at appropriate locations of the switchgear.
 39. Feeder and board name plates to be provided at front and rear of switchboard.
 40. Panel illumination lamp shall be 9/ 11W CFL with fixture & shall be provided with door limit switch.

5.6 RELAYS:

1. All relays as indicated in electrical 'Single Line Diagram' shall be mounted on the switchgear panels. The relays shall be in draw-out case, flush mounted type.
2. All the unit protection relays such as 51NS shall be separate relays & elements (50/50N, 51/ 51N, 51NS etc.) available in numerical relays shall not be used for this purpose.
3. In case the primary protection relays offered by Contractor do not have adequate number of contacts for protection/ interlock schemes. Contractor shall supply suitable contact multiplying auxiliary relays as required. Also, all necessary auxiliary relays as required to

meet the Purchaser's final control/ protection/ interlock schemes shall be provided by the Contractor.

4. Relays shall be Numerical type. Test terminal block for testing shall be provided. Relays shall be suitable for 1/ 5A CT secondary rating as indicated in respective Single Line Diagram. Relays shall be suitable for SCADA with IEC 61850 protocol & Modbus RS-485.
5. Relay & Metering used shall be as per following Make & model Nos. "OR equivalent" shall be construed as Equivalent from the approved Makes mentioned elsewhere in the specifications.

Relays	
Over-current & Earth Fault protection [IDMT & Instant.] (50/50N, 51/51N)	Approved Make
Master Trip/ Lock out Relay (86)	Approved Make
Stand by Earth Fault Relay (51NS)	Approved Make
Temperature rises tripping Relay	Approved Make
Contact multiplication relay	Approved Make
Trip Circuit Supervision Relay	Approved Make
Comprehensive Motor Protection relays	Approved Make
Instantaneous under voltage relay	Approved Make
Auxiliary relay for anti-pumping device	Approved Make
Metering	
Analogue Ammeter	Approved Make
Analogue Voltmeter	Approved Make
Multi-Function Meter (MFM)	Approved Make

- a. Lockout relay-86 shall be having minimum 6 NO + 6 NC contacts.
- b. All relays shall have clear identification on the associated panel by well-written inscription plates. Where indications are provided by flag relays or LEDs, these shall also be specifically identified by permanently fixed inscription adjacent to them.
- c. The final relay ranges of each relay shall be decided at detailed engineering stage, if it is found that the offered relay range is not suitable for the intended application, the Contractor shall change the relay of appropriate range without any commercial /delivery implications whatsoever. The relay shall be subject to approval of Client's representative.
- d. Contractor shall furnish recommended relay settings with backup calculations & approval for the same has to be obtained from Purchaser/ Consultant. Entire Relay co-ordination shall be carried out in ETAP 12.5 version or latest available during detailed engineering. The

Contractor shall obtain all interface data from all concerned.

- e. All relay/ auxiliary relay coils shall operate satisfactorily between 85% to 115% of rated control voltage.
- f. It is responsibility of the Contractor to include accessories like auxiliary CTs, VTs and all other necessary devices as required for satisfactory performance of relay and protection scheme even if not indicated in drawings/ data sheets. Testing facilities like test switches / test plugs shall be provided for testing of each individual relays.
- g. Performance tests shall be conducted at site and also supervised by Contractor for all the equipment's to prove the guarantee.
- h. Prices quoted shall include the cost of all routine tests specified in relevant standard & as mentioned below. As regards type tests, copies of the earlier test certificates carried out on equipment of similar or higher ratings but not older than five (5) years shall be furnished along with the offer.

5.7 CURRENT TRANSFORMERS:

Current Transformers shall satisfy following requirements:

- 1. Current transformers for metering & protection shall be double core cast resin (class of insulation or better). The CT ratios/ protection class shall be as shown in 'Single Line Diagram'.
- 2. Rated VA burden for metering/ protection CTs shall not be less than 15VA or 120% of total VA burden whichever is higher.
- 3. The accuracy class for metering CT shall be 0.5 or better.
- 4. It shall be responsibility of Contractor to ensure that CTs are suitable for correct and satisfactory operation of the instruments/ relays connected across them.
- 5. Short time current rating and momentary withstand rating of CTs shall be as per breaker short time current withstanding capacity.
- 6. All CTs shall have secondary rating of 1A or 5A.

5.8 VOLTAGE TRANSFORMERS:

Voltage Transformers shall satisfy following requirements:

- 1. Potential transformers for metering/protection shall be suitable for operation on 11kV, 50 Hz system. The VT ratios shall be as shown in respective electrical Single Line Diagram.
- 2. Rated VA burden for metering/ protection VTs shall not be less than 100VA or 120% of total VA burden whichever is higher.

3. The accuracy class for metering VT shall be Class 1.0/ 3P as required.
4. It shall be responsibility of Contractor to ensure that VTs are suitable for correct and satisfactory operation of the instruments connected across them.
5. Fuses on primary side shall have rupturing capacity equal to the switchgear rating.
6. For VT's MCB shall be provided on secondary. MCB trip contact to be wired up for annunciation.

5.9 MAINTENANCE REQUIREMENTS:

1. Contractor shall supply maintenance tools including special tools (if required) for attending to the equipment supplied at no extra cost. As far as practicable, the equipment and accessories shall be so designed that no special tools are necessary for installation and maintenance of the equipment. However, if special tools are required, the Contractor shall supply one complete set for each type of equipment for the purpose.
2. Contractor shall include supply of start-up and essential spares.
3. Contractor shall furnish detailed inter-panel diagrams, terminal connection wiring diagram, and detailed component layout drawings to carry out maintenance work.
4. Contractor shall ensure the use of calibrated test equipment having valid calibration test certificates from standard laboratories traceable to national standard.

5.10 EARTHING:

1. An earthing bus shall be provided at the bottom and extend throughout the length of the switchgear. It shall be bolted / welded to the frame work of each unit and each breaker earthing bus.
2. All non-current carrying metal work of the switchgear shall be effectively bonded to the earth bus. Hinged doors shall be earthed through flexible earthing braid of adequate size.
3. Positive earthing of the circuit breaker frame shall be maintained both in service and test position.

5.11 ANNUNCIATORS

1. Microprocessor based alarm annunciators shall be provided for generating audio visual alarms for each abnormal condition. Facia annunciators, suitable for operation on 24/ 30V or 110V DC (as applicable) shall be provided.
2. Each alarm shall initiate the operation of both visual and audible devices equipped with 'Mute', '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.
3. Annunciator shall be of facia type with translucent plastic window for each alarm point. Annunciator facia plates shall be engraved in block lettering with respective alarm inscriptions. The inscriptions shall be clearly readable and visible when the respective facia light is lighted provided with two lamps connected in parallel on each facia window with series resistors. Lamps shall be clustered LED type.
 4. All facia annunciator points shall be suitable to accept external contacts of either 'NO' or 'NC' self or hand reset type for initiating the annunciation sequence.
 5. Annunciators shall be suitable for accepting fleeting faults of duration as less as 15 milliseconds annunciating subsequent faults with the specified sequence immediately after acknowledging the previous fault.
 6. Facia Window shall be of minimum size of 35 mm x 50 mm.
 7. During lamp test, if a fault occurs, the corresponding lamp circuit shall be automatically disconnected from the "lamp test" circuit and shall start flashing.
 8. The sound intensity of each audible device shall be suitable for the maximum sound level of it environment.
 9. The sequence of alarm should be user selectable by dip switch. The operation or acceptance of one alarm shall not inhibit the operation of the audible device or the flashing of the appropriate alarm indicator if a future alarm condition occurs.
 10. Annunciator shall be designed for an operating sequence indicated below:

Alarm Condition	Fault Contact	Audible Alarm	Visual Alarm
Normal	Open	Off	Off
Abnormal	Closed	On	Flashing
Acknowledge	Open	Off	Steady on
Reset	Open	Off	Off
Lamp Test	Open	Off	Steady on

5.12 CABLE TERMINATIONS:

1. 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.
2. Cable lugs for all power and control cable connections shall be supplied. The lugs shall be tinned Copper/ Aluminium depending on cable conductor and of solder less crimping type.
3. All necessary materials required for terminating the power cables such as tapes, fillers, binding wires, armor clamps, brass glands etc., shall be supplied.

5.13 TESTS:

1. Routine tests and acceptance tests as per the applicable IS / IEC standards shall be carried out in the presence of Purchaser/ Purchaser's representative.
2. Type test certificates for internal arc test, SC withstand & Impulse test shall be furnished with the Bid (not older than five (5) years) from CPRI or other Govt Approved Lab.
3. The test equipment, meters, instruments etc. used for testing shall be calibrated at recognized test laboratories at regular intervals and valid certificates shall be made available to the Client / Client's representative at the time of testing. The calibrating instruments used as standards shall be traceable to national/international standards.

5.14 DRAWINGS/ DOCUMENTS REQUIRED:

The following drawings/ documents to be furnished by the Contractor for Purchaser's approval

- a. Technical Data Sheet
- b. General Arrangement Drawing
- c. Wiring Schematic
- d. Bill of Quantities
- e. Quality Assurance Plan

5.15 LIST OF TYPE TEST REPORTS

- a. Impulse Test& PF withstand test
- b. Temperature rise Test
- c. Short circuit Test
- d. Internal Arc Test
- e. Short circuit test duties
- f. Mechanical Endurance test
- g. Degree of IP Protection

5.16 ROUTINE TEST:

Routine tests shall be carried out by the contractor on all complete arrestors and also on proportionate prorated sections as per IEC recommendations. Certified copies of routine test reports shall be submitted to the Owner for approval along with the acceptance test reports.

Sr. No	List of routine test Reports
1	Visual inspection, Dimension check
2	Bill of material verification
3	Mounting arrangement of component

4	CT ratio by primary injection test
5	CT polarity marking
6	Voltage ratio of potential transformer
7	Mechanical and electrical operation of VCB
8	High Voltage Test on Power and Control Circuits.
9	IR test before and after HV test
10	Primary/Secondary current injection test to check the operation of meters and relays.
11	Operational check of VCB <ul style="list-style-type: none"> 1. Close & Open at 100%, 110% and minimum voltage 2. Time/Speed measurement 3. Power frequency on main & auxiliary contact 4. Contact resistance measurement
12	Paint shade verification & Paint thickness measurement
13	Operational Test (Electrical & Mechanical) of Circuit Breakers.
14	Rack IN & Rack Out operation
15	Milli volt drop test of VCB
16	Interchangeability of VCB
17	Earth continuity test
18	Interlock check
19	Pick-up & Drop-off voltage test for shunt trip and closing coil.

6. LV SWITCHGEAR PANEL/ 415 V MCC PANEL

1. The specification covers the design, manufacture, testing at manufactures works, supply, delivery, storage at site; erection, testing and commissioning of 0.415 kV Switchgear, Motor Control Center (MCC) and Power distribution Board (PDB) complete with instrumentation controls and safety devices.
2. The scope of supply shall include spares for 10 years of operation & maintenance of the pumping station, special tools and testing devices, all parts accessories etc. which are essential for construction, operation and maintenance of the switchgear. Components of the Switchgear and associated equipment and spares shall be of the same material, dimensions and finish and shall be interchangeable.
3. LV Switchgear Panel shall be Partially/ Total type tested as per latest IEC 61439-1 & 2.

6.1 STANDARDS

The design, manufacture and performance of the equipment shall comply with all Indian Standards, I.E. Rules, Statutory Regulations and Safety Codes currently applicable in the locality where the equipment will be installed.

Unless otherwise specified, the equipment shall confirm to the latest applicable Indian Standards and, in particular, the following:

LV switchgear panel IS codes

Sr.No.	IS codes	Description
1	IS 2147	Degree of Protection provided by enclosure for low voltage switchgear and control gear.
2	IS 13947	Specification for low voltage switchgear and control gear.
3	IS 2705	Specification for current Transformers.
4	IS 3156	Specification for voltage transformer.
5	IS 1248	Specification for direct acting indicating analogue electrical measuring instrument and their accessories.
6	IS 8623	Specification for low voltage switchgear and control gear assemblies
7	IS 3231	Specification for electrical relays for power system protection.
8	IS 5578	Guide for marking of insulated conductors.
9	IS 11353	Guide for uniform system of marking and identification of conductors and apparatus terminals.
10	IS 13703	Specification for Low-voltage fuses not exceeding 1000V AC or 1500V DC.

6.2 CONSTRUCTIONAL REQUIREMENT

6.2.1 GENERAL

- a. Panels must confirm to Totally Type Tested (TTA) as per IEC 61439-1/2. Panel assembly must be manufactured and tested in OEMs factory (as per IEC 61439-1 & 2) manufacturing facility. The enclosures shall be designed to take care of normal stress as well as abnormal electro-mechanical stress due to short circuit conditions. All covers and doors provided shall offer adequate safety to operating persons and provide ingress protection of IP 54. Ventilating openings and vent outlets, if provided, shall be arranged such that same ingress protection of IP 54 is retained. Suitable pressure relief devices shall be provided to minimize danger to operator during internal fault conditions.
- b. For operator safety IP2 X (touch proof) protection to be available even after opening the feeder compartment door. The compartmentalization to be achieved by using metal separators, use of PVC sheet / Hylem sheets shall not be allowed.
- c. Degree of Protection shall be IP54 Up to 2000A and IP42 above 2000A.
- d. All identical equipment and parts shall be interchangeable.
- e. Switchboard panels and cubicles shall be fabricated with CRCA Sheet Steel of thickness not less than 2.0 mm and shall be folded and braced as necessary to provide a rigid support for all components. The doors and covers shall be fabricated from CRCA sheet steel of thickness not less than 2 mm. Joints of any kind in sheet metal shall be seam welded and all welding slag ground off and welding pits wiped smooth with plumber metal.
- f. LT Panel shall be ready with Ethernet (TCP/IP) communication i.e. All (Breakers & Cradle position) Status, release metering data and multi-function meters (MFM) data shall be on Ethernet communication inside the LT Panel), which is reliable, faster communication and easy in integration.
- g. The switchgear shall consist of indoor, floor-mounted, metal-enclosed, compartmentalized (if not indicated specifically in data sheet), modular type, totally front side operated vertical sections.
- h. It shall be dust and vermin proof and shall be easily extensible on both sides.
- i. All doors and removable covers shall be gasketed all around with neoprene gaskets.
- j. Each vertical section shall comprise the following:
 1. Metal-enclosed bus bar compartment, running horizontally throughout the length of the switchgear.
 2. Individual feeder modules in multi-tier formation.
 3. Shrouded main and vertical bus bars and individual feeder connection.
 4. Vertical cable alley and bus bar alley with doors or covers covering the entire height of the feeder module panel.
 5. Horizontal wire way for control wiring.
 6. Space heater with thermostat and MCB in each vertical panel.
 7. Sheet steel barrier between two adjacent vertical sections except for horizontal bus bar compartments.

8. Separate door for each feeder module.
 9. 20% additional space in the panel (in terms of vacant feeder compartments of various sizes), to accommodate the future requirement, if any.
 10. Totally front operated panel, i.e., cable and bus bar alleys of suitable sizes (minimum 300 mm width) shall be on the panel front side only.
 11. Each vertical panel should be divided into the distinct zones for bus bars, feeders, power cabling, control cabling and power & control terminals.
- k. The switchgear shall be provided with removable cable gland plate (of minimum 3 mm thickness), with pack hole for cable entry, as indicated in the data sheet.
- l. Separate metal labels shall be provided for switchgear modules, relays, instruments, switches, etc. Approval for the type of label shall be taken from the Owner.
- Control switches, push buttons, indicating lamps, meters and relays shall be mounted on the front door. Current Transformers (CTs) and Voltage Transformers (VTs) shall be mounted on the fixed portion. For fully draw out / semi draw out execution, all other equipment shall be mounted on withdraw able chassis with suitable guides for easy withdrawal.
- m. Painting shall be done by surface coating comprising pre-treatment, electrostatic powder spraying and curing. The surfaces to be coated shall be chemically de-rusted and degreased at a temperature of 700C to 800C, zinc phosphatized and then passivated at about 60 0C and, after proper drying, subjected to spraying of powder charged at about 90 KV through electrostatic guns. Curing shall be done in stoving oven at 180o to 200o C for 12 to 15 minutes ensuring a uniform and continuous coating. The colour of the shade shall be 631 of IS 5.
- n. Feeder control and motor control equipment not incorporating circuit breaker shall either be of fully draw out, semi draw out or fixed type execution, as specified in the drawing/data sheet.
1. In the case of fully draw out type withdraw able chassis; all electrical power and control connections shall be of plug-in type.
 2. In the case of semi draw out type withdraw able chassis; all electrical power connections shall be of plug-in type. All control connections shall be of screwing-in type.
- o. 300 mm clearance shall be provided between the finished floor and the bottom of the lower most feeder compartment.
- p. Panel lifting lugs shall be of removable type and to be fixed with panel using bolts and nuts.
- q. Fixed type-both power and control connections shall be of bolted/screwed type.
- r. All feeders name plate shall be provided. Name plate shall have white letter with Black background with rear engraving. Name plate shall have following details:
1. Feeder rating with type of feeders.
 2. Feeder description.
 3. Feeder Module No.
- s. The MCCs shall be divided into convenient shipping sections not exceeding 2.5 meters.
- t. Complete panel shall be mounted on a base frame made out of ISMC 100 x 50 sections.

- u. Every panel shall have independent vertical bus bar chamber / alley.
- v. The panel shall be divided into following compartment: -
 - 1. Bus bar Chamber
 - 2. Connector Chamber
 - 3. Main Incomer feeder
 - 4. Individual switch - disconnecter fuse chamber with motor starters etc.
- w. Each chamber shall be divided into two by 16 SWG cold rolled steel plates.
- x. Door opening shall be away from the cable alley and be provided with interlocking arrangement. Suitable keys shall be provided. Door interlock defeat arrangement shall be provided.
- y. Each vertical panel shall be provided with maximum six modules. Minimum height of motor feeder shall be 300 mm and SFU feeder shall be 250 mm.
- z. Switchgear shall be provided with removable minimum 3 mm thick cable gland plate. Brass cable glands and crimping type copper cable lugs for cables shall be provided if specified in data sheet.
- aa. The cable alley shall be provided with hinged doors for easy access to cables inside the cable alley. The compartment door shall be as far as possible, open away from the cable alley.
- bb. Doors with half round knob (No screws) for easy opening and closing.

6.2.2 FLOOR MOUNTING PANELS

Floor mounting panels, shall have rear access doors which shall have a flush appearance. The doors shall be fitted with lockable handles and shall have lift off type hinges so arranged that one shank engages before the other to permit ease of fitting.

6.2.3 WALL MOUNTING PANELS

Wall mounting panels shall have hinged front doors fitted with lockable handles. The doors shall be of rigid construction and made of sheet steel of thickness specified above. The fixing details for the wall-mounted panels shall preferably comprise externally welded brackets. The panels shall be of pre-fabricated type with modular construction and powder coated as per (a) above.

6.3 SWITCHBOARD COMPONENTS & CONTROL ARCHITECTURE

- a. This section covers specification of Low Voltage Switchboards incorporating items of switchgear like Air Circuit Breaker, Molded Case Circuit Breaker, Contactor's, Relays, Metering etc.
- b. All switchgear (ACB, MCCBs, MCB, RCBOs etc.) and control gear (Contactor, MPCBs etc.) shall be designed in compliance to latest environmental directives like RoHS (Restriction of Hazardous substance) & WEEE (Waste Electrical and Electronic Equipment) for easy de- assembly and recycling at end of life. All components shall be pollution degree

6.4 PROTECTION CO-ORDINATION

- a. It shall be the responsibility of the Contractor to fully co-ordinate the overload and short circuit tripping of the circuit breakers with the upstream and downstream circuit breakers/fuses/motor starters, to provide satisfactory Total discrimination. LV Switchgear manufacturer shall submit Coordinated & Discriminated solution for LV network protection devices i.e., ACB, MCCB, MPCB & MCB for all incoming and outgoing devices for all Panels/ DB`s with the help of published discrimination tables/charts and let through energy curves.
- b. Total discrimination shall be provided up to the service short circuit breaking capacity of most downstream circuit Breakers.

6.5 COMMUNICATION ARCHITECTURE

- a. The installation switchboard shall be equipped with a communicating system (MCBs, RCBOs, MCCBs, ACBs, Auxiliaries, Energy Meter and other modular device) that makes it possible to:
 - Monitor modular protection and control units and provide the centralized management system (DCS, supervisor, management software, etc.) with information on their status.
 - transmit orders from the centralized system to the switchboard control units.
 - meter and transmit installation power consumption data to the centralized system.
- b. The communicating system components (MCBs, RCBOs, MCCBs, ACBs, Axillaries, Energy Meter and other modular device) shall be communication ready to indicate the status of the device (On/Off/Trip), Control wherever necessary, Number of on/off cycles and Number of Tripping (or History) over universally open Modbus and Ethernet (TCP IP) protocol so as to have seamless connectivity with any Energy and Building Management System.
- c. Connectivity interface selection will be decided by client at the time of detailed engineering so that seamless and fast connectivity is done, as required to interface other equipment. Ethernet will be preferred.
- d. Complete communication system to be tested in switchboard at OEMs manufacturing facility.
- e. All individual components of control equipment associated with any item of plant shall be contained in a single control circle/ module or panel. Where a number of similar such items of plant are specified a composite cubicles or panel shall be provided.
- f. All instruments, relays, switches, lamps, pushbuttons and the like shall be arranged on the cubical in a neat, functional and logical manner. The arrangement shall be subject to Engineer's approval. Spare contacts of relays and auxiliary devices shall be wired to terminal blocks.
- g. Similar items shall be of the same type, style, pattern or appearance throughout. Control and changeover selection switches for various functional shall be of the same type but with a

handle of different shape for each specific function.

6.5.1.1 Main bus bars

- a. Main bus bars shall be of uniform cross section in aluminium or copper as specified in the drawing/data sheet.
- b. Wherever aluminium to copper connections is required, suitable bimetallic connections/clamps shall be provided.
- c. Maximum temperature of the bus bars and the bus connections shall not exceed 85°C.
- d. The bus bars shall be provided with heat shrinkable sleeves and colour coded for identification.
- e. Separate supports shall be provided for each bus bar. If common support is provided for all bus bars, anti-tracking barriers shall be incorporated.
- f. In order to avoid any accidental hazards, bus bar compartments shall be protected with 3 mm thick hylem / bakelite sheets.
- g. The size of the neutral bus bar shall be similar to that of phase bus bars in the case of Main L.V. Panels, PCCs, PMCCs, PDBs, Main and Sub Lighting DBs. However, the neutral bus bar shall be of half size that of phase bus bars in the case of Motor control centre.

6.6 MOULDED CASE CIRCUIT BREAKER

- a. All MCCBs shall be current limiting type with features of load line reversibility and suitable for Horizontal/Vertical mounting without any derating MCCBs shall have positive isolation as per IEC 60947-2. The MCCBs shall be used with terminal spreaders, where ever required. The MCCB should employ the double break arc chute system which would help to speed up the arc extinction in the event of fault so that lesser let through energy is exerted on the system.
- b. The MCCB shall be employ maintenance free minimum let – through energies and capable of achieving discrimination up to the full short circuit capacity of the downstream MCCB. The manufacturer shall provide both the discrimination tables and let through energy curves for all.
- c. MCCB should be of Class - II front face devices for operator safety.
- d. The MCCBs shall confirm to the latest applicable standards (IEC 60947-2).
 1. The circuit breakers shall comply with latest IEC/IS standards.
 2. The breaking capacity performance certificates shall be available for category A to the above-mentioned standards. The test shall be carried out under the breaking performance during the ultimate breaking capacity (ICU). Certificate for all the sequences should be available.
 3. All circuit breakers shall have a rated operational voltage of 415V AC (50Hz).
 4. Rated impulse withstand voltage shall be 8 KV.
 5. Thermal overload release adjustment can be done from a single point. MCCB cover need

not be opened for doing such adjustment.

6. MCCB till 250A can be thermal magnetic type (adjustable overload & fixed short circuit) and above 250A should have microprocessor release.
 7. Earth Fault module can be provided as inbuilt feature or add on module. User should be able to check Healthiness of ground fault protection module locally without tripping the MCCB.
 8. The breaker shall be maintenance free.
 9. It shall either be 3 poles or 4 poles.
 10. Production site organization shall be certified to comply with ISO 9001 standard.
- e. All MCCBs shall be suitable for pollution degree 3 requirements as per IEC 60664-1.
- f. MCCBs of 100A and above rating in main LT panel shall be with plug-in base; this is to ensure easy & faster replacement of MCCB and continuity of supply during maintenance in main LT panel.
- g. Construction
1. Operating mechanism shall be of the quick make quick break type, with the speed of operation independent of the operator, and mechanically trip free from the operating handle so as to prevent the contacts from being held closed against short-circuit and overload conditions (Conformity to positive isolation as per IEC 60947. The operating mechanism shall be constructed to operate all poles in a multi-pole breaker simultaneously during opening, closing and tripped conditions.
 2. It shall not require any external power supply to operate the tripping mechanism.
 3. The breakers shall be operated by a toggle which shall clearly indicate the three fundamental positions ON, OFF and TRIPPED.
 4. If required, the breaker will be equipped with rotary handles.
 5. The breaking and extinction of the electrical arc shall be achieved by means of non-welding contacts and an arc chute surrounding these contacts.
 6. If required all electrical accessories should be fitted by manufacturer to avoid tampering at site.
 7. Accessories should be common for entire range.
 8. MCCB should have cross bolted termination for easy connection on busbars.
 9. Each MCCB shall have a facility for padlocking in the off position.
 10. MCCBs shall have spreader links with phase barriers as standard feature.
- h. Operation
1. The breaker shall be provided with the facility for padlocking and door interlocking.
 2. The molded case circuit breakers shall be equipped with a "push to trip" button in front to test operation and the opening of the poles.
 3. The circuit breaker rating, the "push to trip" button, outgoing circuit identification and the contact position indication must be clearly visible and accessible from the front, through the front panel or the door of the switchboard.

4. Fault differentiation should be there between overload, short circuit & earth fault & should be wired up to panel door.
5. It should be possible to terminate Aluminium cable of required size for the defined current carrying capacity. The requisite size should be made available by means of extended terminals (as a standard offer) in case the direct terminals are not of adequate size. Adequate phase to phase clearance has to be ensured in case of extended terminations.
- i. The instantaneous short circuit release shall be so chosen by the Contractor as to operate at a current in excess of the peak motor inrush current and a range of settings shall be provided for the Employer's Engineer selection.
- j. MCCB terminals shall be shrouded and designed to receive cable lugs for cable sizes relevant to circuit ratings.
- k. Minimum 2 no. of additional auxiliary contacts (for purchaser's use) shall be provided.

6.7 MULTIFUNCTION METERS

Multifunction meters at main HT Panel & LT panel incomers

- a. Meters shall confirm to standard IEC 62053 for active and reactive energy. It should be compliant with PMD standard IEC61557-12.
- b. Multifunction meter shall have four-line LCD display, Two DI/DO, RS 485 / Ethernet connectivity ports, 0.5s accuracy, 64 samples/cycle rate, 4 nos. time in day metering, individual harmonic measurement up to 31st harmonics, Current per phase, Voltage Total, per phase L-L and L-N, Frequency, Real, reactive, and apparent power. Total and per phase Signed & Four Quadrant, True Power Factor Total and per phase Signed & Four Quadrant, Displacement PF Total and per phase Signed, Four Quadrant % Unbalanced I, VL-N, VL-L, Min/max of instantaneous values plus phase identification, Energy values, Accumulated Active, Reactive and Apparent Energy - Received/Delivered, Net and absolute, Time Counters.
- c. Multifunction meters at main LT panel outgoing and SDBs incomers (where ever specified)
 1. Meter shall have following features.
 2. LED panel for setup and 2 columns of LEDs for parameter identification.
 3. True RMS electrical parameters: per phase voltage, current, demand, W, VA, VAr.
 4. Integrated parameters: KWh, VAh, VArh.
 5. Neutral current, frequency, Power Factor, % Load, % Unbalance (V&I), Phase angle.
 6. On hours, Run hours & Interrupts.
 7. 4 Quadrant energy: bi-directional, absolute & net.
 8. Class 1.0 accuracy.
 9. 64 samples/cycle and individual harmonics up to 15th.
 10. Meter with RS485 communication port.

6.8 MINIATURE CIRCUIT BREAKERS (MCB)

- a. MCBs shall comply with and be type-tested to IEC 60898 or EN 60898.
- b. MCBs shall meet the following requirements:
 1. Number of poles: single-pole, double-pole, triple-pole or four-pole as specified.
 2. Protection against external influences: Enclosed-type,
 3. Method of connection: Bolted or Clip-on type and should have bi-connect facility to terminate fork type busbar and wires simultaneously,
 4. Rated operational voltage: 240 / 415 V AC,
 5. Rated current: 6 A, 10 A, 16 A, 20 A, 25 A, 32 A, 40 A, 50 A, 63A as specified. Above 63A, MCCB as specified above must be used.
 6. MCB's shall be used for out-going feeders. For incoming feeders irrespective of the ratings MCCB will be deployed in all Lighting Distribution Board.
 7. Rated frequency: 50 Hz,
 8. Range of instantaneous tripping current: MCB's shall be current limiting Type Energy Class 3 with range of instantaneous tripping current B, C or D type as appropriate or as specified,
 9. Rated short-circuit breaking capacity: not less than 10 kA unless otherwise specified,
 10. I_{2t} characteristic: suitable for load and circuit being protected,
 11. Degree of protection: IP-20 for MCB's
 12. Reference ambient temperature: 50°C.
- c. MCB's shall have minimum power loss (Watts) per pole as per the IEC and should be proven by published value by manufacturer.
- d. Slide latch release feature will also be considered.
- e. the manufacturer shall guarantee the following performance levels, defined by IEC60947-2 standards:
 1. suitability for isolation (section 7.2.7)
 2. rated insulation voltage (section 4.3.1.2) - 500 V (Preferred)
 3. pollution degree (Part 1, section 6.1.3.2) - 3
 4. Rated impulse-withstand voltage (section 4.3.1.3): 6 kV
 5. Discrimination for power continuity – Validation with Standard Tables in catalogue
 6. Validated Cascading tables as per standard IEC 60947-2
- f. The material used to manufacture MCB shall be 100% recyclable and must comply with RoHS and REACH standards.
- g. MCBs shall be suitable for field-fit-table Protection auxiliaries (viz. Over-voltage release, Under-voltage release, Shunt trip) and Indication Auxiliaries (like Auxiliary Contact, Trip alarm contact).
- h. The circuit breakers shall be communication ready to indicate the status of the device (On/Off/Trip), Number of on/Off cycles and Number of Tripping over universally open

Modbus and Ethernet (TCP IP) protocol so as to have seamless connectivity with any Energy and Building Management System.

- i. The load handling contacts shall be silver/tungsten and the contacts and operating mechanism shall be designed so as to give a wiping action both at make and break. The breaker operating mechanism shall be of trip-free type. The breaker operating dolly shall be clearly indicated for the "ON" and "OFF" positions. It should be of Quick make and Quick break type.
- j. Circuit protection against overload and short-circuit conditions shall be provided by means of thermal-magnetic device. Double-pole, triple-pole, and four pole MCBs shall be integral units and interlocked internally so that an overcurrent through any pole shall trip all the poles of the MCB simultaneously. An assembly of two or three or four single-pole units mechanically strapped together is not acceptable.
- k. Housing shall be heat resistant and having high impact strength. All DP, TP and FP circuit breaker shall have a common trip bar and should be mechanically coupled through a pin. It shall have an electrical endurance of the order of 10000 operation cycle for current rating of up to 50A.

6.9 RESIDUAL CURRENT BREAKER WITH OVERLOAD (RCBO)

- a. RCBOs shall be double pole or four-pole current-operated, housed in a totally enclosed
- b. RCBOs shall meet the following requirements:
 1. Number of poles: double – pole or four – pole as needed.
 2. Rated current(In): As per the load and rating of each outgoing MCB.
 3. Rated residual operating current: 30 mA.
 4. Rated voltage: 240 / 415 VAC.
 5. Rated frequency: 50 Hz.
 6. Rated short – circuit capacity: not less than 10 kA unless otherwise specified.
 7. Operating characteristics in case of residual currents with DC components: as specified.
 8. Method of mounting: distribution board type.
 9. Method of connection: connection shall be made with proper size of thimbles and number ferruling for circuit identification.
 10. I₂t characteristic: suitable for equipment and circuit being protected.
 11. Degree of protection: IP 3X to IEC 60529 or EN60529.
 12. Reference ambient temperature : 50 °C.
 13. The tripping mechanism shall be of trip-free so that the unit cannot be held closed against an earth fault. Provision shall be made for testing the automatic earth-leakage tripping by an integral test device. A device shall be fitted for prevention against reclosing after the device has tripped on earth leakage.
 14. The rated earth- leakage tripping current shall be as indicated on the Board Details.
 15. RCBOs shall be equipped with an auxiliary connection wire that must be connected to

the earth bus bar of the distribution board. This either enables the device to detect the missing neutral of the supply, causing the device to trip, or provides an alternative supply path for the tripping circuitry, enabling it to continue to function normally in the absence of the supply neutral.

6.10 CONTACTORS

- a. Contactors shall comply with IEC 60947-4-1 or EN 60947-4-1.
- b. Contactors shall be electro-magnetically controlled, double air-break type. Contactors shall be four – pole, triple – pole, double – pole or single – pole as required and to be specified by Independent Engineer at the time of pre-design approval.
- c. The mechanical endurance of the contactors shall not be less than 3 million no-load operating cycles.
- d. Contactors shall be silver or silver - faced.
- e. The contactor should be modular in design with minimum inventory requirements and built – in mechanically inter locked. They should be suitable for the addition of auxiliary contacts and other electrical auxiliaries without any compromise on the performance or the operation of the contactors.
- f. The contactors for other applications shall have a non – interrupted rated duty and utilization category of at least AC3 at 415V and 50Hz. The contacts should be off as opening and fast closing type.
- g. The making and breaking capacity values of the contactors should be as follows (as per IEC 947-4).
- h. For AC3 duty
 1. Making capacity equal to or more than 10 I_e
 2. Braking Capacity equal to or more than 8 I_e
 3. For AC4 duty
 4. Making capacity equal to or more than 12 I_e
 5. Braking Capacity equal to or more than 10 I_e
- i. The contactors should be capable of frequent switching and should operate without derating at 60°C for AC3 applications. They should be climate proof. The coil of the contactor should have class H insulation to support frequent switching. The Contactors shall operate satisfactorily between 85% to 110% of the rated voltage. The Contactor shall drop out at 70% of the rated voltage.
- j. The rated voltage of the contactor and the rated insulation voltage shall be 690V. The rated impulse voltage of the contactor should be at least 8 KV.
- k. The control and power terminals should be at separate layers preferably with colour coding (black/Gray for power and white for control). All contactors power connection shall be finger safe (IP 2X).
- l. Contactors should be capable of being integrated into automated system (PLC's) without any interposing components in the minimum operating conditions.

- m. All Motor starters should qualify Type 2 coordination chart requirement as per IEC 60947-4& backed up by manufacturers selection chart.

6.11 INDICATING LAMPS AND CONTROL SWITCHES

- a. Indicating lamps shall be rated to withstand 20% continuous over voltage and shall be provided with series resistors designed to give adequate illumination. Indicating lamps in the form of LEDs are preferred.
- b. Lamps shall be well ventilated and the design shall permit removal of lamp glasses and bulbs from the front of the unit. Switches, for control selection, motor control and other purposes shall have pistol grip type or alternative shape handles. Switches shall have adequate number of normally open/ normally closed (NO/ NC) contacts for functional use and spare sets of contacts.

6.12 PUSH BUTTONS

- a. Push buttons shall be colored as follows:
 - 1. START-green, STOP-red. All other buttons shall be black "Start" push buttons shall be effective only in selected circuits.
 - 2. Emergency stop push buttons shall be provided and positioned in the immediate vicinity of the associated motor drive in all cases where,
 - i. there is no direct line of sight between the motor and the controlling starter or
 - ii. Where the distance between the motor and the controlling starter exceeds 5 meters.
- b. Emergency stop push buttons shall be connected in control circuits such that they are effective under all conditions and shall have red mushroom headed pushes of the stay-put pattern. A deliberate reset action shall be required before the drive can be put back into service but resetting of the pushbutton shall not restart the drive. These pushbuttons shall be lockable type in pushed-in condition. All push button shall have adequate number of contacts to suit their functional requirements.

6.13 OPERATING COILS

Where practicable all fine wire operating coils and wire wound resistors shall be vacuum impregnated with an approved insulating varnish.

6.14 TERMINAL BLOCKS

- a. Terminal boards or blocks shall be of approved barrier pattern, screw or stud type having covers of transparent, insulating material, which does not sustain combustion. Pinch screw type terminal blocks are not acceptable. Terminal blocks at different voltages shall be segregated into groups and distinctively labeled and the voltage grouping and terminal strip layout shall correspond with the wiring diagrams.
- b. Terminals which may be alive when the main equipment is isolated from the mains supply shall be suitably labeled to reduce the risk of accidental contact. All terminals shall be a permanent identification number or letter.

- c. Terminal strips shall be located adjacent to the point of cable entry adequate space being allowed for terminating the cable tails on site.

6.15 SPACE HEATER AND CUBICLE LIGHTING

- a. Adequately rated anti-condensation space heaters shall be provided, one for each vertical cubicle of switchgear, for each separate control panel, for each distribution board, for each switchboard, and for marshalling kiosks. Space heaters shall be of the industrial strip continuous duty type, rated for operation on a 240 V, 1-phase, 50 Hz, AC system. Each space heater shall be complete with single pole MCB with overload and short circuit release in the phase, link in the neutral and a control thermostat to cut off the heaters at 450C.
- b. Each switchgear cubicle, control panel, control cabinet, and marshalling kiosk shall be provided with interior lighting, by means of a 20 W fluorescent tube lighting fixture. A lighting fixture "ON-OFF" switch shall be provided. The lighting fixture should be suitable for operation from a 240 V, 1-ph, 50 Hz, AC supply.
- c. A 240 V, 1-phase, 5/15 A, 5 pin AC plug point shall be provided in the interior on each cubicle with an on-off switch for connection of hand lamps.

6.16 INDICATING INSTRUMENTS & METERS

- a. Electrical indicating instruments shall be either 144 mm square with 2700 scale or 100 mm square with 1400 scale. Taut band types of instruments are preferred. Taut band moving coil instruments for use on AC systems shall incorporate built-in transducers.
- b. Instrument dials shall be white with black numbers and lettering.
- c. Normal maximum meter reading shall be of the order of 60% normal full-scale deflection. Ammeters for motor feeders shall have suppressed scale to show current from full load up to six times the full load current.

6.17 SWITCHBOARD ANTI-CONDENSATION HEATERS / PANEL INTERNAL ILLUMINATION

- a. Each switchboard or cubicle shall incorporate wiring for supplies to anti-condensation heaters. The wires will be energized from a single-phase supply obtained from a separate distribution board. The heater circuit shall be controlled by a rotary type ON/ OFF switch, HRC fuse and adjustable type thermostat. Multitier cubicles shall have cubicle heater and thermostat for each vertical panel section.
- b. The heaters shall be located in cable alleys where such alleys are available or shall be located in the bottom portion. Panels/ panel sections shall be provided with fluorescent lamp lighting fixture of 20 w rating protected by H.R.C fuse and a switch. Alternative arrangement for panel internal illumination, if proposed, shall be subject to Engineer's approval.

6.18 EARTHING ARRANGEMENT

A continuous GI earth bus-bar of 65 mm x 10 mm size shall run the entire length of each switchboard/ MCC/ Panel and shall be bonded to the metal cladding or armoring of all incomings

and outgoing cables, to the station earthing system, and components/ devices mounted within/on the panels. Earth bus bars of other size shall be subject to Engineer's approval.

6.19 SAFETY ARRANGEMENTS

- a. All terminals, connections, relays and other components which may be "live" when front access doors are open shall be adequately screened/shrouded. It shall not be possible to obtain access to an adjacent cubicle when any door is opened. Components within the cubicles shall be adequately labelled to facilitate testing.
- b. Where several outgoing circuits occupy a common termination chamber all bus work, cable lugs, terminations and terminal boards shall be fully screened or insulated to enable work on any one circuit to be carried out with other circuits live. Isolators, clearly labelled, shall be provided in such position and connected so that maintenance can be carried out with maximum safety. Screened or insulated to enable work on any one circuit to be carried out with other circuits live. Isolators, clearly labelled, shall be provided in such position and connected so that maintenance can be carried out with maximum safety.
- c. This particularly applied to control circuits fed from a remote position. Where it is necessary to maintain certain components in a cubicle in a live condition' when the isolator is in the "off" position, such apparatus shall be so screened and labelled as to eliminate the possibility of accidents. Additionally, a system of removable insulated links or isolating type terminal blocks shall be provided to enable particular components to be isolated for maintenance purposes whilst retaining other essential circuits energized.

6.20 AUXILIARY SWITCHES

- a. Auxiliary switches/ devices shall be supplied as required for indication, protection, metering, control, and interlocking and supervisory purposes. They shall be readily accessible and enclosed in a transparent dust-proof cover.
- b. Adequate secondary disconnects shall be included to enable the auxiliary switch to be wired to the fixed portion of the equipment.

6.21 VOLT-FREE CONTACTS

"Volt-free" contact on any equipment, e.g., Contactor starter, etc. shall comprise a pair of contacts operated directly by the equipment but electrically separated such that no potential derived from the equipment appears at the contact. Volt-free contacts will be used to complete external control alarm or indication circuits, the supplies for these circuits being obtained from an external source. Unless otherwise stated these supplies will be from low voltage AC or DC sources.

6.22 PROTECTION TRANSFORMERS

a. Current Transformer

1. Current transformers shall conform to IS: 2705. All current transformers shall have a

short- time current rating of not less than that of the switch panel in which they are incorporated. Identification labels shall be fitted giving type, ratio, rating, output and serial numbers and duplicate rating labels are to be fixed, on the exterior of the mounting chambers, suitably located to enable reading without the removal of any cover or metal sheeting forming part of the structure of the switchboards. Current transformers shall be of cast resin type and insulation class shall be "F" or better. Magnetization characteristics, calculated performance and protection setting shall be furnished by the Contractor.

2. Current transformers for use in conjunction with metering shall have accuracy class 0.5. Protective current transformer shall be of accuracy class 5P and accuracy limit factor not less than 10. CT parameters selected by the Contractor shall be subject to the Engineer's approval.

b. Voltage Transformers

1. Voltage transformers shall be supplied where required. They shall have a winding ratio a three-phase voltage between lines of 110V on the secondary. They shall have a rated burden, at the stated accuracy, in accordance with the requirements of all connected instruments, meters and relays and of any instruments or meter to which they may be connected via test blocks.
2. The primary circuit shall be protected by H.R.C. fuses/ MCBs having a short-circuit rating of not less than that of the switchgear. The connections between the fuses/ MCBs and the switchgear primary conductors shall be capable of withstanding the short time current of the switchgear.
3. The secondary circuit shall be protected by MCB mounted as closely as possible to the secondary terminals.
4. Voltage transformers shall conform to IS: 3156. Windings for metering circuits shall have accuracy class 0.5 and those for protective circuits shall have accuracy class 3P.

c. Polarity

The polarity of all apparatus shall be arranged as follows:

- i. For two pole apparatus the phase or 'live' pole at the top (or left-hand side) and the 'neutral' or 'earthed' pole at the bottom (or right-hand side).
- ii. For three or four pole apparatus the phases in order red, yellow, blue and neutral reading from top to bottom or left to right in the case of horizontal and vertical layouts respectively, as viewed from the front. Panel Internal Wiring
 1. FRLSH Cables shall be as specified in Chapter-2 MV Cables (BS 6724-multicore cable and BS 7211 for single core cable) of this Specification. All internal and control wiring shall be Low Smoke Zero Halogen (LSZH) copper conductor wires rated at 450/750 V complying with BS EN 50525 for this Specification. Insulation shall have a glossy finish, be resistant to oil and be incapable of supporting combustion.
 2. Inside switch gears, motor control centre, annunciation panels, etc. the wiring for

control, signaling, protection and instruments shall be done with PVC insulated copper conductors of minimum 1.5 sq.mm size. Wiring for CT circuits shall be with 2.5 sq.mm copper conductor. The insulation grade for these control wires shall be 650 volts. Inter panel wiring shall be enclosed in PVC wire ducts. Stranded copper conductor shall be used for control wiring.

3. Each wire shall be terminated at a separate terminal. Termination of two outgoing wires at a single terminal will not be acceptable.
4. Wiring for three phase circuits shall be colour code red, yellow and blue for identification of relevant phases. For single phase AC circuits white colored wires shall be used for phase conductor and black colored for neutral conductor. Grey colored wire shall be used for DC circuits and green colored wires for earth connections.
5. Circuits in which the operating voltage exceeds 110 volts shall be physically segregate from all other wiring. All wiring shall be neatly and securely fixed by insulated cleats or run-in insulated wiring troughs, wiring shall be so arranged that access to any apparatus or connection point is not impeded.
6. Wiring carrying low level DC signals shall be segregated from AC circuits and screened if recommended by the manufacturer of associated equipment/ instruments. Spare contacts available on relays/ devices etc. shall be wired up to terminal blocks.
7. Wires shall not be joined or tied between terminal points. Shorting links shall be provided for all CT terminals.
8. Each wire shall be identified at both ends by yellow colour PVC ferrules marked with black letters/ numbers. The letters/ numbers used for marking on ferules shall correspond with the appropriate wiring diagram.
9. Ferrules of other colours, if used, shall be subject to Engineer's approval.
10. Rubber grommets shall be provided so that metal parts should not come in contact with any power or control wires/ cables.
11. Minimum size of terminals for internal wiring shall be 6 sq.mm.
12. Stranded conductor shall be provided with copper lugs at both ends before connections are made.

6.23 NAME PLATES, RATING PLATES AND LABELS

- a. Where appropriate, each item of plant shall have permanently attached to it in a conspicuous position, a label or labels upon which shall be engraved or stamped the manufacture's name, type and serial number of plant and details of the loading and duty at which the item of plant has been designed to operate. A label denoting the plant or function identification number shall also be attached. Such label shall be of non-hygroscopic material to be approved by the Engineer. Labels shall also be provided to identify every instrument, relay or item of control equipment mounted externally and internally.
- b. Externally fitted panel labels shall be of Perspex or other approved transparent material with letters and numbers rear engraved and filled with black. The back surface of each label shall be finished with a coat of paint of colour to be specified by the Engineers. Internally fitted

panel labels shall be finished white with engraved letters or by other approved means wherever necessary to designate panel or panel sections, to describe or identify circuits or circuit components, to provide warnings or reminders of dangerous or potentially dangerous circumstances and wherever called for elsewhere in this specification.

- c. Danger labels, e.g., "DANGER 415V. AC" shall be colored red with white lettering.
- d. Caution labels, e.g., "CAUTION- ISOLATE BEFORE REMOVING COVER" shall be white with red lettering.
- e. Details of proposed inscription shall be submitted to the Engineer for approval before any labels are manufactured.

6.24 MOTOR STARTER

- a. Contactor
 - 1. Contactors shall be air brake, double break, single throw, electromagnetic type.
 - 2. Main contacts shall be of silver faced copper.
 - 3. Minimum Two 'N.O.' and two 'N.C.' auxiliary contacts shall be provided for each power contactor. However, additional nos. of auxiliary contactors should be added in the control scheme as per the requirement.
 - 4. The auxiliary contacts shall be wired to the terminals.
- b. Direct-on-line (DOL) starter
- c. DOL starters shall be suitable for AC3 utilization category as per IS: 13947(Part-4 /Sec-1). It shall be comprised of: -
 - 1. FSU
 - 2. Power Contactor
 - 3. Auxiliary Contactor(s)
 - 4. O/L relay with built-in SPPR.
 - 5. Separate SPPR.
 - 6. Mushroom Headed stop push button type. Red Stop PB.
 - 7. Start Push Button.
 - 8. O/L Relay reset push button on door
 - 9. Red, Green & Amber indicating Lamps (LED) for ON, OFF & Trip indications respectively.
 - 10. Set of selector switches as per various control requirements.
- d. Automatic star-delta starter
 - These starters shall comprise of following: -
 - 1. FSU
 - 2. Set of power Contactors (3 nos.).
 - 3. Auxiliary Contactor(s)

4. O/L relay with built-in SPPR.
 5. Separate SPPR.
 6. Timer.
 7. Mushroom Headed stop push button type. Red Stop PB.
 8. Start Push Button.
 9. O/L Relay reset push button on door
 10. Red, Green & Amber indicating Lamps (LED) for ON, OFF & Trip indications respectively.
 11. Set of selector switches as per various control requirements.
- e. Starters shall be suitable for AC3 utilization category as per IS: 13947 (Part-4 /Sec-1)
- f. Reversing starter
1. Forward and reverse contactors shall be mechanically and electrically interlocked.
 2. Reversing starters shall be suitable for AC4 utilization category as per IS: 13947(Part-4/Sec- 1).

6.24.1.1 Microcomputer motor protection relay

- a. Starters shall be complete with Microcomputer based Motor protection relay for the motors of 15KW and above rating.
- b. The relay shall have over current protection (with medium tripping characteristics), Under current protection, Instantaneous short circuit protection, Single phasing protection, Current unbalance protection - for all the ratings of motors and for motors above 55 KW ratings, in addition to the above standard protections, the relay should be provided with Stator Ground Fault Protection, over temperature protection and locked rotor protection.
- c. The relay shall be Auto / hand reset type. A hand reset push button separate from the stop push button shall be brought out on the front of the compartment door for all starter feeders of all ratings.

6.24.1.2 Single phasing preventer

Separate single phasing preventer shall be provided in the starters along with inbuilt SPP provided with over load relay. The relay shall be current operated and hand reset type with separate hand reset push button.

6.24.1.3 Instrument transformer

- a. CTs and VTs shall conform to the requirement of IS:2705 and IS:3156 respectively. The ratings specified are indicative only and it shall be Vendor's responsibility to ensure that the ratings offered are adequate for the relays/meters provided considering lead resistance, etc.

- b. CTs and VTs shall be of dry air insulated type.
- c. Facility shall be provided in the terminal blocks for shorting and earthing the CTs and terminal blocks.
- d. VTs shall be provided with adequately rated primary and secondary fuses.

6.24.1.4 Inspection

- a. The Owner or his authorized representative reserves the right to witness all the following tests at vendor's place of manufacturing. contractor shall give two weeks' notice prior to the proposed date of inspection to the Owner or his authorized representative.
- b. All apparatus, instruments, etc. required for tests shall be provided by the vendor and shall have been checked and tested for accuracy during the twelve months prior to the test, bearing tag of competent authority.

6.24.1.5 Testing

- a. Contractor shall test the switchgear to confirm to IS: 4237 with all components assembled and fully wired.
- b. The following routine tests shall be carried out on all the components and the assembled switchgear, as per relevant standards: -
 - 1. Mechanical and Electrical Operation tests by simulating operating conditions as at site.
 - 2. Secondary wiring conformity test with a low voltage (6 Volt) tester.
 - 3. High voltage test (2.5 KV for one minute).
 - 4. Test for verification of calibration of releases thro' primary injection test.
 - 5. CT Polarity test.
 - 6. Insulation resistance test before and after HV test.
 - 7. Earth continuity test with a low voltage (6 volts) tester.
 - 8. Test for verification of calibration of protective relays thro' secondary injection test.

7. APFC PANEL WITH CAPACITOR BANKS:

7.1 GENERAL

Scope of this specification covers design, manufacture, testing at manufacturer's works, supply, packing, forwarding and delivery from place of storage/ manufacturer's works to erection site including transit insurance, unloading, storage at site, assembly, erection, testing, installation, commissioning and performance demonstration of the following equipment with associated accessories.

7.2 CAPACITOR BANKS:

- a. The type of capacitors shall be All Polypropylene type double layer conforming to IS 13585 - 1994 & having following specifications:

Supply	3 phase, 3 wire
Rated voltage	415 V
Rated frequency	50 Hz.
Permissible over voltage	1.1 Vn
Permissible over current:	1.5 In
Temperature category:	50° C

- b. The capacitor shall be vacuum impregnated with liquid dielectric having high thermal stability.
- c. The capacitors shall have Low Dielectric Loss of $\pm 0.5 \text{ W / kVAr}$.
- d. Each capacitor bank shall be provided with the 7% detuned filter.
- e. * kVAr is net reactive compensation required to maintain 0.99 PF at 415 V Bus, i.e., excluding compensation required for detuned filters.
- f. Bushing should have high mechanical strength & method of fixing should be proper so that no leakage occurs.
- g. Auto/ Manual switch shall be provided in the APFC panel. For manual switching, every capacitor bank feeder shall be provided with ON & OFF push buttons along with the ON & OFF indications.
- h. Minimum current rating under site conditions, of circuit breakers, contactors and cables shall be at least 150% of rated capacitor current, to take care of harmonics.
- i. Contactor for switching of capacitor banks shall have AC-6b utilization category according to IEC 60947-4-1 & sized accordingly.
- j. All the components shall be suitable for capacitor duty application.
- k. 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. Capacitor shall be designed to improve the power factor to 0.99 lagging

- l. It shall be complete with the required capacitors along with the supporting post insulators, steel rack assembly, Al/ Cu bus bars, Al/ Cu connecting strips, foundation channels, fuses, fuse clips, etc. The steel rack assembly shall be hot dip galvanized.
- m. 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 over voltage 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.
- n. Each capacitor case and the cubicle shall be earthed to a separate earth bus.
- o. Capacitor shall conform to IS 2834.
- p. The units shall be capable of continuously withstanding satisfactorily any overvoltage up to a maximum of 10 % above the rated voltage, excluding transients.
- q. 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 upon disconnection, in accordance with the provisions of the latest edition of IS:2834.

7.3 CONTROL CUBICLES:

- a. Capacitor and capacitor control shall be housed in a metal enclosed cubicle. Capacitor shall be housed in the lower compartment and capacitor control unit at the top compartment, the two compartments being segregated. Control cabinets shall be free standing floor mounted type and shall meet the requirements of Metering, Protection & related provisions for APFC panel as tabulated below:

Panel Name	Breaker Type	Protection	Metering	Indications	Other
APFC Panel					
Incomer	ACB (TPN, MDO/ EDO) OR MCCB (TPN, Fixed Type)	TM based O/L, S/C release, APFC Relay, E/F Relay with CBCT & Shunt Trip	Analogue A, V	R Y B, On, Off, Trip	ETPB, A/M SS, Annunciator
Outgoing	MCCB (TP, Fixed Type)	TM based O/L, S/C release	A, AS	On, Off, Trip	Start, Stop Push Buttons

- b. APFC panel shall have Al/ Cu bus bars sized for appropriate SC rating for 1 sec & to carry continuous rated current.
- c. All CTs/ VTs shall be cast resin type.
- d. All the MCCB's shall be current limiting type. Necessary auxiliary contact block required is

included in Contractor scope.

- e. One contact of power factor correction relay shall be provided for annunciation “POWER FACTOR LOW”. The relay shall switch-on/ off capacitor banks for loads from 5% to 100%. The annunciation window shall be with test, accept and reset push button & hooter.
- f. Capacitor switching and automatic power factor correction panel shall be designed in such a way that power factor of 0.99 lagging shall always be maintained. Timings to cut in capacitors shall be provided in such a manner to facilitate capacitor discharging before next switching and shall also avoid hunting due to temporary fluctuations of load. The timer shall be provided in both auto and manual mode.
- g. The Automatic power factor correction panel and capacitor panel are integral type, prewired including power connections. Due consideration shall be given for adding/removal of capacitor or other components and maintenance considerations. Contractor shall submit General Arrangement drawings of capacitor and capacitor control panel, with description of power factor control panel with its components.
- h. For control circuit 415/ 240/ 110V AC control transformer shall be considered. VA burden to be decided by the Contractor.
- i. Minimum clearance between live parts shall be phase to phase 25.4 mm & phase to neutral 20 mm.
- j. Bus bars shall be sleeved with colored heat shrinkable sleeves. All the Bus bar supports shall be SMC type only.
- k. Degree of protection shall be IP-42 for the enclosure, epoxy painted, powder coated with colour shade RAL-7032 for exterior & interior with minimum thickness 80 micron.
- l. All necessary auxiliary contactors are included in scope.
- m. Contractor shall note that verification of double layer construction shall be done on any one of the capacitor banks during inspection by opening the capacitor bank at no extra cost.
- n. The cubicle shall be fabricated out of 2.0 mm thick cold rolled sheet steel & shall comprise of:
 - i. Isolating ACB/ MCCB
 - ii. Contactors with overload element
 - iii. Sequencing devices, timers and auxiliary relays for automatic sequential switching of capacitor units in and out of circuit.
 - iv. Auto-manual selector switch
 - v. Microprocessor based Automatic Power Factor Correction (APFC) Relay – minimum 10 stage relays.
 - vi. Push button for opening and closing the power circuit
 - vii. Red and Green lamps for capacitors ON/ OFF indication
 - viii. Protective relays to protect the healthy capacitor units when one unit fails in a series connection
 - ix. Space heater and cubicle lighting & receptacles.

7.4 PRINCIPLE OF OPERATION:

On deviations from set power factor, the power factor controller shall release command signals to switch on/ switch off capacitor bank stages and maintain the set power factor.

7.5 APFC RELAY:

APFC relay shall have following standard features:

- a. The Automatic Power Factor Correction relay shall be of microprocessor-based type and shall automatically switch ON/ OFF the capacitor banks to attain the value of “pf” close to the set value.
- b. Switching shall follow first in first out (FIFO) method to ensure uniform use of all capacitor banks. At least eight steps shall be provided for switching.
- c. To measure/ monitor power factor and VAR continuously. Status of switching step shall be displayed through LED.
- d. Following adjustment shall be available in APFC Relay.
 - i. Power factor
 - ii. Dead band capacitive region with respect to set power factor (PF).
 - iii. Inductive region with respect to set PF
 - iv. Operating time for programmable switching steps.
 - v. Auto/ manual selector switch.
 - vi. Manual step control.
- e. All control knobs, LEDs for display and selector switches shall be mounted on the front face of relay casing/ panel.
- f. It should be fully programmable. There should be a choice for customer to select operating sequence up to 4 to 5 which will have maximum number of steps of capacitors equal to fourteen (14). The sequence shall be arithmetic 1, 2, 3....13, 14.
- g. Operating time selection of time interval designation between switching stages shall be possible using time selector switches. The device shall take care that any stage which has just been switched out will only be reconnected by the pulse counter, after 60 sec. has elapsed so that it has safely discharged. This is a requirement for 415 V capacitors
- h. Loss of voltage element- This would prevent abnormal switching surges on loss of supply. Also, it would control the switching on/ Off surges.
- i. Dead band features- Relay response sensitivity adjustable using dead band so that hunting is prevented.
- j. Auto/ Manual control- This would help testing and commissioning at site as well as ease in operation when either mode fails during service time.

7.6 PERFORMANCE TESTS:

- a. Contractor shall carry out all routine tests as specified in relevant IS/ IEC standards on all

major components and furnish copies of test reports for Purchaser's approval. Wherever required, Contractor shall conduct the necessary type tests in the presence of Purchaser/ Purchaser's representative.

- b. Contractor shall also carry out all routine and functional tests as specified in the relevant IS on the assembled switchgear panels in the presence of the Purchaser's representative at works before dispatch and furnish copies of test reports for approval. If required stage inspection will be carried out by the Purchaser.
- c. During inspection, Contractor shall furnish copies of routine test report for all bought out items for Purchaser's approval.
- d. Primary Injection Test for various currents & time settings shall be provided in routine test.
- e. All the components shall be tested for their entire operating range & certification for the same shall be provided at the time of inspection.

7.7 MAINTENANCE REQUIREMENTS:

- a. As far as possible the switchgear shall be so designed that no special tools are necessary for installation and maintenance. However, if special tools are required, the Contractor shall supply one complete set of such tools along-with the equipment.
- b. Contractor shall furnish detailed inter panel wiring diagrams, internal wiring diagrams, detailed component layout drawings to carry out maintenance work.

7.8 DRAWINGS/ DOCUMENTS REQUIRED:

- a. Dimensioned general arrangement drawings of capacitor and capacitor control panel.
- b. Justification for number of steps for switching.
- c. Fully dimensioned general arrangement drawings of capacitor and capacitor control panel with elevation side view, sectional view and foundation details.
- d. Complete schematic and wiring diagrams for capacitor control panel.

8. HV & LV CABLES

8.1 SCOPE

This specification covers requirement of XLPE Cables for High Voltage Systems and XLPE/PVC Cables for Medium Voltage systems.

8.2 CODES AND STANDARDS

Unless otherwise specified cables shall confirm to the following Indian Standards (as amended latest)

CODES	DESCRIPTION
IS: 1554 (Part I)	PVC insulated (heavy duty) electric cables - Part-I for working voltages up to and including 1100 V.
IS: 7098 (Part I)	Cross-linked Polyethylene insulated PVC sheathed cables: Part I for working voltages up to and including 1100kV.
IS: 7098 (Part II)	Cross-linked Polyethylene insulated PVC sheathed cables: Part II for working voltages from 3.3 KV up to and including 66 KV.
IS: 8130	Conductors for insulated electric cables and flexible cords.
IS: 5831	PVC insulation and sheath of electric cables.
IS: 3975	Mild steel wires, strips and tapes for armoring of cables.
IS: 3961 (Part II)	Recommended current ratings for cables: Part II PVC insulated and PVC sheathed heavy duty cables.
IEC: 502	Extruded solid dielectric insulated power cables for rated voltages from 1 KV up to 30 KV.
IS: 10810 (Part 61)	Flame Retardant Test
IS: 10810 (Part 62)	Flame retardant test for bunched cables.
IS: 10418	Drums for electric cables.

8.3 GENERAL CONSTRUCTION OF CABLES

- The cables shall be suitable for laying in trays, trenches, ducts or for underground buried installations with uncontrolled backfill and possibility of flooding by water and chemicals.
- Outer sheath of the cables shall be black in colour and the minimum value of oxygen index shall be 29 at 27 ± 2 degree Celsius. In addition, suitable chemicals shall be added into the PVC compound of the outer sheath to protect the cable against rodent and termite attack.

- c. Sequential marking of the length of the cable in meters shall be provided on the outer sheath at every one meter. The embossing shall be legible and indelible. The size of the cable also shall be indicated on the outer sheath of the cable at regular intervals.
- d. The overall diameter of the cables shall be strictly as per the values declared in the technical information to be furnished along with datasheet subject to a maximum tolerance of $\pm 2\text{mm}$.
- e. PVC / Rubber end caps shall be supplied at his own cost for each drum with a minimum of ten nos. per five hundred meters length. In addition, the ends of the cables shall be properly sealed with these caps to avoid ingress of water during transportation and storage.

8.4 XLPE CABLES

- a. Power cables for 3.3 KV up to and including 66 KV system shall be Aluminium Conductor; XLPE insulated screened, sheathed, armored and overall PVC sheathed XLPE type as detailed below.
- b. Power cables for up to and including 1100 V system shall be Aluminium Conductor, XLPE insulated screened, sheathed, armored and overall PVC sheathed, XLPE type as detailed below. The conductors shall be stranded and compacted circular for all cables.
- c. All cables rated 3.3/6.6kV and above shall be provided with both conductor screening and insulation screening. The conductors shall be provided with non-metallic extruded semi conducting shielding.
- d. The core insulation shall be with cross-linked polyethylene insulating compound applied by extrusion. It shall be free from voids and shall withstand all mechanical and thermal stresses under steady state and transient operating conditions. It shall conform to the properties given in Table-1 of IS: 7098 (part II).
- e. The insulation shielding shall consist of non-metallic extruded semi-conducting compound in combination with a non-magnetic metallic screening of copper.
- f. The conductor screen, XLPE insulation and insulation screen shall all be extruded in one operation by "Triple Extrusion" process to ensure perfect bonding between the layers. The core identification shall be by colored strips or by printed numerals.
- g. The inner sheath shall be applied over the laid-up cores by extrusion and shall conform to the requirements of type ST2 compound of IS: 5831. The extruded inner sheath shall be of uniform thickness.
- h. For multi-core cables, the armoring shall be by galvanized steel strips. If armoring is specified for single core cables in the data sheet, the same shall be with H4 grade hard drawn aluminium round wire of 2.5 mm diameter.
- i. The outer sheath of the cables shall be applied by extrusion over the armoring and shall be of PVC compound conforming to the requirement of type ST2 compound of IS: 5831. The minimum and average thickness of outer sheath for unarmored cables and the thickness of outer sheath shall be as per IS: 7098 - Part 2.
- j. The thickness of the insulation, inner sheath shall be governed by values given in IS: 7098 (Part- 1).

- k. Where specified, 1100 V grade shall also be XLPE insulated and shall meet the requirement specified in IS-7098(Part-1). power cables

8.5 PVC CABLES

- a. All control cables shall be heavy-duty type, 650/1100 V grade with minimum 1.5 sq mm copper conductor, PVC insulated, inner-sheathed, armored and overall PVC sheathed unless specified otherwise.
- b. The core insulation shall be with PVC compound applied over the conductor by extrusion and shall conform to the requirements of type 'A' compound as per IS: 5831. The thickness of insulation and the tolerance on thickness of insulation shall be as per Table 2 of IS: 1554 (Part-1). Control cables having 6 cores and above shall be identified with prominent and indelible English numerals on the outer surface of the insulation. Colour of the numbers shall contrast with colour of insulation with a spacing of maximum 50 mm between two consecutive numbers. Colour coding for cables up to 5 cores shall be as per Indian standard.
- c. The inner sheath shall be applied over the laid-up cores by extrusion and shall be of PVC confirming to the requirements of Type ST-1 PVC compound as per IS: 5831. The minimum thickness of inner sheath shall be as per IS: 1554 (Part-1). Single core cables shall have no inner sheath.
- d. If armoring is specified for multicore cables in the cable schedule, the same shall be by single round galvanized steel wires where the calculated diameter below armoring does not exceed 13 mm and by galvanized steel strips where this dimension is greater than 13 mm. Requirements and methods of tests for armor material and uniformity of galvanization shall be as per IS-3975 and IS-10810 (Part 41). The dimensions of Armor shall be as per method (b) of IS-1554 (Part -1). If armoring is specified for single core cables in the cable schedule, the same shall be with H4 grade hard drawn aluminium round wire of 2.5 mm diameter.
- e. The outer sheath for the cables shall be applied by extrusion and shall be of PVC compound confirming to the requirements of type ST-1 compound as per IS: 5831. The minimum and average thickness of outer sheath for unarmored cables and minimum thickness of outer sheath for armored cables shall be as per IS:1554 (Part-1)
- f. If heat resisting PVC cables are specified in the cable schedule, the following shall be the requirements:
- g. It shall be possible to continuously operate the cable at a maximum conductor temperature of 85°C.

PVC compounds used for heat resistant PVC cables shall be as follows:

Conductor insulation	-	Type C
Inner sheath	-	Type ST 2
Outer sheath	-	Type ST 2

- h. All cable conductors shall be of electrolyte grade high conductivity annealed copper as per IS 191 and shall have a cross-sectional area of not less than:
- i. 10 mm² for cable in between feeder pillar/main lighting distribution board and street lighting

- poles junction boxes.
- j. 2.5 mm² for power circuits such as to supply power to motor windings.
 - k. 2.5 mm² for motor, valve actuator (in case provided) and auxiliary circuits such as for anti-condensation heaters, thermistors, pushbutton stations, etc.
 - l. 1.5 mm² for indoor lighting circuits.
 - m. 1.5 mm² for instrumentation circuits.
 - n. Each neutral conductor shall be of the same cross-sectional area as the associated phase conductors.
 - o. Use of Armored Cables: Cables which are laid external to the electrical panels shall be armored as per IS 3975.
 - p. Use of Unarmored Cables: Unarmored cables shall be used inside each electrical panel for wiring of control circuit.

8.6 CABLE ACCESSORIES

- a. The termination kits for use on the systems shall be suitable for the type of cables offered as per this specification.
- b. The accessories shall be supplied in kit form. Each component of the kit shall carry the manufacturer's mark of origin.
- c. The kit shall include all stress grading, insulating and sealing materials apart from conductor fittings and consumable items. An installation instruction sheet shall also be included in each kit.
- d. The contents of the accessories kit including all consumable shall be suitable for storage without deterioration at a temperature of 50° C with shelf life shall be 5 years.
- e. The terminating kits shall be suitable for termination of the cables to indoor switchgear or to a weatherproof cable box of an outdoor mounted transformer / motor. For outdoor terminations, weather shields / sealing ends and any other accessories required shall also form part of the kit. The termination kits shall be from one of the makes / types mentioned in the approved vendor list.

8.6.1 Installation and Termination of Cables

- a. The contractor shall install, test and commission the cables specified in the specification in accordance with drawings and instructions issued by the Owner or Owner's Representative. Cables shall be laid directly buried in earth, on cable racks, in built up trenches, on cable trays and supports, in conduit and ducts or bare on walls, ceiling etc. as per drawings. contractor's scope of work includes unloading, laying, fixing, jointing, bending and termination of the cables. The Contractor shall also supply the necessary materials and equipment required for jointing and termination of the cables.
- b. All apparatus, connections and cable work shall be designed and arranged to minimize risk of fire and any damage which might be caused in the event of fire. Wherever cables pass through floor or wall openings or other partitions, suitable bushes of an approved type shall

- be supplied and put into position by the Contractor. If required by the Owner or Owner's Representative the Contractor shall seal the cables into the bushes using fire resisting materials to prevent the spreading of fire through each partition.
- c. Inspection on receipt, unloading, storage and handling of cables shall be in accordance with the IS: 1255 and other Indian Standard Codes of Practice.
 - d. Standard cable grips and reels shall be utilized for cable pulling. If unduly difficult pulling occurs, the Contractor shall check the pull required and suspend pulling until further procedure has been approved by the Owner's Representative. The maximum pull tension shall not exceed the recommended value for the cable measured by the tension dynamometer. In general, any lubricant that does not injure the overall covering & does not set up undesirable conditions of electrostatic stress or electrostatic charge may be used to assist in the pulling of insulated cables in conduits and ducts.
 - e. After pulling the cable, the Contractor shall record cable identification with date pulled neatly with waterproof ink in linen tags and shall securely attach such identification tags. Identification tags shall be attached to each end of each cable with non-corrosive wire. The said wire must be non-ferrous material on single conductor power cable. Tags may further be required at intervals on long runs of cables on cable trays and in pull boxes. Cable and joint markers and RCC warning covers shall be provided wherever required.
 - f. Sharp bending and kinking of cables shall be avoided. The bending radii for various types of cables shall not be less than those specified below
 - g. 6.6 KV XLPE multicore: 15 times the overall diameter of the cable armored cables
 - h. 650-1100 V XLPE/PVC insulated: 10 times the overall diameter of the cable
 - i. If shorter radius appears necessary, no bend shall be made until clearance and instructions have been received from the Owner's Representative.
 - j. Power and control cables shall be laid in separate cable racks/trays.
 - k. Where groups of HV, LV and control cables are to be laid along the same route, suitable barriers to segregate them physically shall be employed.
 - l. When power cables are laid in the proximity of communication cables, minimum horizontal and vertical separation between instrumentation and control cables carrying analogue and digital signals shall be separated from LV power cables by at least 300 mm and HV power cables by at least 600 mm. Telecommunication cables shall be segregated from all other cables by at least 600 mm. Power and communication cables shall as far as possible, cross at right angles to each other.
 - m. Where cables cross roads and water, oil, gas pipes, the cables shall be laid in reinforced spun concrete or uPVC conduits. For road crossings the pipe for the cables shall be buried at not less than one meter depth.
 - n. 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. This is then gently filled up to a depth of about 100 mm above the top of uppermost cable to provide bedding for the protective cable covers for LV cables may be of earthenware. The RCC covers shall have one hole at each end, to tie them to each other with GI wires to prevent

displacement. The trench is then 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.

- o. Each cable shall be pulled into the particular conduit and shall be taken from the particular reel designated for the run. All cables shall be neatly trained without interlocking. In hand holes, pull boxes or junction boxes having any dimension over 1000 mm, all conductors shall be cabled and/or racked in an approved manner. Care shall be taken to avoid sharp bending or kinking conductors, damaging insulation or stressing cable beyond manufacturer's recommendations in pulling. Cable shall be protected at all times from mechanical injury and from absorption of moisture at unprotected ends.
- p. In each cable run some extra length shall be kept at a suitable point to enable one or two straight through joints to be made, should the cable develop a fault at a later date.
- q. Cables on cable racks, on cable trays and conduits shall be formed to avoid bearing against edges or trays, racks, conduits or their supports upon entering or leaving trays, racks or conduits. Cables shall be racked or laid directly into cantilevered cable trays where practicable, but in some cases, it may be necessary that cables are pulled or threaded into trays. To facilitate visual tracing, cables in trays shall be laid only in single layers and unnecessary crossing of cables shall be avoided. Cables on trays shall finally be clamped in an approved manner.
- r. Splices shall be made by contractor for each type of wire or cable in accordance with the instructions issued by cable manufacturers and the Owner's Representative. Before splicing insulated cables shall have conductor insulation stepped and bound or penciled for recommended distance back from splices to provide a long leakage path. After splicing, insulation equal to that on the spliced conductors shall be applied at each splice.
- s. At cable terminal points where the conductor and cable insulation will be terminated, terminations shall be made in a neat, workmanlike and approved manner by men specialized in this class of work. Terminations shall be made by the contractor for each type of wire or cable in accordance with instructions issued by cable manufacturer's and the Owner's Representative.
- t. Control cable termination shall be made in accordance with wiring diagrams using colour codes established by the Owner's Representative for the various control circuit, by code marked wiring diagram.
- u. When control cables are to be fanned out and cabled together with cord, the Contractor shall make connections to terminal blocks and test the equipment for proper operation before cables are corded together. If there is any question as to the proper connection, the Contractor shall make a temporary connection with sufficient length of cable so that the cable can be switched to another terminal without splicing. After correct connections are established through operating the equipment, cables shall be cut to their correct lengths, connected to terminals in the specified manner, and corded together.
- v. Cable seals shall be examined to ascertain if they are intact and that cable ends are not

damaged. If the seals are found to be broken the cable ends shall not be jointed until after due examination and testing by the Owner's Representative.

- w. After installation and alignment of motors, the Contractor shall complete the conduit installation, including a section of flexible conduit between motor terminal box and trench/tray. The Contractor shall install and connect the power, control and heater supply cables as per equipment manufacturer's drawings, if any. The Contractor shall be responsible for correct phasing of the motor power connection and shall interchange connections at the motor terminal box, if necessary, after each motor is test run.
- x. Connections to recording instruments, float switches, level electrodes, limit switches, pressure switches, thermocouples, thermostats and other miscellaneous equipment shall be done as per manufacturer's drawings and instructions.
- y. Metal sheath and armor of the cable shall be bonded to the earthing system of the station. The size of conductor for bonding shall be appropriate with the system fault current.
- z. All new cables shall be megger tested before termination. After termination, all L.V. cables shall be megger tested. 1100/650-volt grade cables shall be tested by 1000-volt megger.
- aa. Cable shall be tested in accordance with IS 7098. Contractor shall furnish all testing kit and instrument required for field-testing
- bb. Contractor shall ensure to use calibrated test equipment having valid calibration test certificates from standard laboratories traceable to National Standards.
- cc. Every cable shall be installed in a single length without joints.
- dd. Double compression cable gland shall be used to terminate each end of every armored cable confirming to IS 4218. The cable gland for every cable rated up to 1100 V shall be constructed from brass.
- ee. Every cable shall be identified at each end, in line with the cable schedule.
- ff. Cable laying shall be initiated only after approval of entire cable route.

8.7 CABLE SUPPORT SYSTEMS

8.7.1 Trays for Power Cables

Ladder type cable trays shall be used for power cables & perforated type cable shall be used for control cables. Cable trays shall be as per relevant IS standards. Material of construction shall be of hot dip galvanized steel.

8.7.2 Cables External to Buildings and Structures

- a. Cables external to buildings and structures shall be installed underground through suitable sized uPVC conduits, concrete ducts or shall be directly buried.
- b. Where cables pass below internal or external roads or areas of hard standing, cables shall be laid through concrete ducts. Cable concrete duct systems shall incorporate suitably located draw-pits/inspection chambers/pull boxes whenever there is change in direction of route of the cable. Cables crossing below the walls or structures shall be laid through uPVC conduits.

- c. Minimum 30% space inside uPVC conduits and concrete ducts shall be kept for future expansion. The minimum depth LV cable installation shall be 700 mm.
- d. Cable trays and supports shall be in accordance with IEC 61537.
- e. Cable tray supports shall provide adequate strength with minimum rigid support to the fully laden cable tray along its entire length.
- f. All cable trays inside the control room and out of the trench shall be closed.
- g. A maximum of two layers of cable shall be installed on any tray.
- h. All cable trays shall be supported to prevent sagging.

8.7.3 Metallic Conduit:

All outdoor black stove conduits shall be of rigid galvanized steel, unless otherwise specified. Galvanization process shall go from three stages: Surface Preparation, Galvanizing and Inspection. All metallic conduits shall be as per IS 9537(Part –II)

8.7.4 Non-Metallic Conduit:

- a. All exposed indoor conduits, underground, concealed or concrete embedded conduits shall be uPVC unless otherwise specified on drawing. Conduits in classified areas shall be of uPVC material as per latest Indian Standard.
- b. Conduits shall be round in shape with different mechanical strength as per area requirement i.e., low mechanical strength for indoor conduit installation and high mechanical strength for outdoor and buried application.
- c. Conduit shall be durable and impact resistant as per IS 9537 and IS 14927.
- d. Conduit shall be fire retardant and corrosion resistant as per IS 9537.
- e. Conduit shall have negligible water absorption.

8.7.5 Corrugated Flexible Conduit:

- a. uPVC corrugated flexible conduits shall be manufactured as per IS 9537 ideally suited for electrical wiring and cable protection.
- b. Use liquid tight flexible uPVC conduit for termination at Junction boxes, Local control stations (LCS), termination to motors, field instrumentation and process equipment unless otherwise specified.

8.7.6 Conduit Fittings:

- a. Fittings, as required, for use with conduit specified, with coating and colour same as conduit shall be provided.
- b. All conduit fittings and covers shall be weatherproof and watertight as per Indian standard 3419, unless otherwise noted.

8.7.7 Conduit Fastenings:

- a. Use uPVC straps for uPVC conduits and steel straps for galvanized steel / galvanized iron conduits.
- b. Channel type supports shall be provided for two or more conduits.
- c. All surface installation horizontal runs of conduits should be secured at maximum distance of 0.9 meters and vertical runs of conduits should be secured at maximum distance of 1.2 meters.
- d. Fastening should be properly tightened to restrict thermal movement of conduit.

8.7.8 Expansion Fittings or couplers:

- a. Appropriate water tight expansion sleeves with bonding where conduit crosses a structural expansion joint or to accommodate for thermal movement due to temperature change on surface installations, complete with grounding strap and clamps shall be provided.
- b. Expansion couplers shall be installed with a short side coated with solvent cement and coupler pushed firmly over the conduit down the nib. The slip side coated with silicon grease receives the conduit to a midpoint to the nib. This will then permit for expansion or contraction providing the conduit is free to move in the saddle.

8.7.9 Outlet and Conduit Boxes:

- a. Outlet boxes shall be sized in accordance with IS 3419.
- b. Appropriate Switch boxes shall be provided where wiring devices such as switches, fan regulators etc. are grouped.
- c. Blank cover plates shall be provided for boxes without wiring devices.
- d. Where outlet boxes are used for more than one system appropriate combination of barriers shall be provided.
- e. Outlet boxes made from uPVC or galvanized steel and shall be suitable for mounting/fixing on masonry and/or concrete construction and shall be flush mounted or surface mounted as per site requirement.
- f. All fittings, boxes and covers, in below grade areas, shall be weatherproof conforming to relevant IS unless otherwise noted.
- g. Outlet boxes, conduit boxes and fittings for hazardous locations shall be as per IS 5571.
- h. uPVC and galvanized steel boxes with fittings (bends elbows, tees cross etc.) for surface wiring of switches and receptacles.

8.7.10 Markers:

- a. 300 mm wide polyethylene Cable Marker Tape, Red in colour with the following imprinted continuously over its entire length: "DANGER- "sign of Skull & Bones" BURIED ELECTRIC CABLE BELOW".

- b. The Cable route marker post in circular in shape made up of hot dip galvanized steel of approximate diameter 100 mm and thickness not less than 4 mm. shall be used for cable route indication. The inscription shall indicate the presence of a cable below, the depth and voltage rating.

8.7.11 Sealing Compound:

- a. Conduit fitting shall be installed in the system using solvent cement for restriction of water in it and silicon grease where installation is subject to frequent changes.
- b. PVC solvent cement shall be used as a method of joining uPVC conduit into fitting like couplings, adaptors, bends and boxes, especially formulated for watertight joint.

8.7.12 Packing and marking

- a. Cables shall be dispatched in non-returnable wooden drums of suitable barrel diameter, securely battened, with the take-off end fully protected against mechanical damage. The wood used for the construction of drum shall be properly seasoned, sound and free from defects. Wood preservatives shall be applied to the entire drum. Ferrous parts used shall be treated with a suitable rust preventive finish or coating to avoid rusting during transit or storage.
- b. On the flange of the drum, necessary information such as Project Title, Manufacturer's name, Type, Size, Voltage Grade of cable, length of cable in meters, drum no., cable code, BIS certification mark, gross weight, etc. shall be printed, with also suitable markings showing the direction of rotation of the drum.
- c. Cables shall be supplied in drum lengths as follows: -
 - Medium voltage power cables up to and including 16 sq. mm -1000M.
 - Medium voltage power cables from 16 sq. mm up to and including 300 sq.mm - 500M – 750M
 - Control cables up to and including 27 cores -1000M.
 - HV Cables - 500M
- d. A tolerance of plus or minus 5% shall be permissible for each drum. However, overall tolerance on the total length of each size of cable shall be limited, to $\pm 2\%$. If non-standard drum lengths are specified in the data sheet, the same shall be supplied.
- e. Final confirmations shall be taken from the Owner, regarding the drum lengths for various sizes of cables at the time of order.

8.7.13 Testing and inspection

- a. The cables shall be examined and tested at the manufacturer's works. The Owner representative shall have free access to the manufacturer's works for the purpose of inspecting the process at manufacturer's works in all stages and he will have the power to reject any material, which appears to him to be unsuitable.
- b. After completion of manufacture of cables and prior to dispatch, the cables shall be subjected

to type, routine, acceptance and special tests as detailed below. The Owner reserves the right to witness all tests with sufficient advance notice from the Contractor. The test reports for all cables shall be got approved from the Owner before dispatch of the cables.

- c. All routine tests, acceptance tests, type tests for improved fire performance shall be carried out on cables as listed in IS: 1554 Part-I and IS: 7098 Part I and II.
- d. Following are the special tests to be performed on the cables. Copies of test reports for similar type of cables shall be provided for owner's approval.
 - Flammability Test: The test shall be carried out on finished cable as per IS: 10810 (Parts 61 and 62).
 - Test for rodent and termite repulsion property.

8.8 WIRES & CABLES

8.8.1 General

- a. Installation of wires and cables shall be in accordance with I.S. 732. All wires shall run from box to box without splices. Sharp bends shall be avoided. They shall be pulled in or laid in such a manner that the insulation is not damaged at the time of installation or in service. Care shall be exercised to ensure avoidance of any moisture in terminations. The wire / cable being laid shall be in one length, and straight joints shall be avoided as far as possible.
- b. Insulation shall be removed for making terminations in such a manner that the conductor is not damaged. Conductors shall be clean and free from burrs.
- c. The current carrying ability of the terminations shall be equal to or greater than the wire / cable being terminated, without dependence on the solder. The termination shall be mechanically secure, without dependence on the crimping. Solder and soldering flux, if used, shall be non- corrosive and of a make approved by the cable or wire manufacturer.
- d. Minimum wire size shall be 2.5 sq. mm. copper. Above 10 sq. mm. size, all wires shall be stranded. All wire and cable run under (i) poured concrete or road beds and (ii) passing through walls shall be in (i) RCC pipes and (ii) conduit sleeves respectively.
- e. No wire or cable shall be run through any equipment foundation unless specifically indicated in the drawings, or directed in writing by Owner. Cables shall be kept at least 300 mm away from steam or other hot lines. Where closer than this, Hylem or fibre glass barrier shall be used between pipe and cables. The armoring of all armored cables shall be electrically continuous from Switchgear to equipment and shall be terminated by an appropriate gland fitting and grounded at both ends. Minimum bending radius shall be 12 to 15 times the outside diameter of the cables as recommended by the cable manufacturer.
- f. The colour code of wires shall be same throughout the installations and shall be approved by the Owner. (Where more than one neutral is carried in the same conduit, the neutral conductors shall be identified.)
- g. Where colour coding is not practicable or possible, the above scheme shall be achieved by the use of colour bands provided by the electrical contractor.
- h. No oil, grease or compound other than powdered soap stone shall be used to facilitate the

pulling of wires. Buried cable shall be installed with sufficient slack in the trench along the cable length.

- i. The electrical contractor shall arrange all cables and wires in neat formations along the wall or in suitable cable, including supply and installation of all supporting steel work like angles, channels, etc. and painting of the same.

8.8.2 415/240V System

- a. Wires drawn in conduit will be unarmored. Cables laid in trays or buried in the ground shall be armored.
- b. The number of wires and conduit sizes indicated for the various circuits (control, alarm and signal) were decided for a general scheme of wiring. The actual number of wires installed for each circuit and the required size of conduit shall, however, be as required to accomplish the specified results as required by the manufacturer of the said control equipment.
- c. Wires connected to the same phase and for the required neutral only can be grouped in one conduit, for lighting installation.
- d. No single core wire alone shall run in any conduit unless clearly shown in the drawings.
- e. This part of the specifications covers the responsibility of selecting the proper branch circuit designation in the panel boards and to install the branch circuit wiring in accordance with the phasing sequence as shown on the drawings, so that the loads are balanced across all the phases as closely as possible and to cause minimum unbalance in the panel board neutral wires. If any changes are to be made, approval of the Owner is essential.
- f. No wire shall be pulled until the complete conduit is installed. No splices or joints shall be permitted in either feeders or branches except at the outlet of accessible junction boxes.
- g. Termination of wires and cables at main boards, MCCs, lighting /power panels, fixtures, etc. is to be done preferably with solderless tinned copper terminal lugs duly crimped and using petroleum jelly at all connections. Special permission shall be taken from the Owner for termination with soldering method.

8.8.3 Buried cables

- a. Only armored / cables shall be buried directly in the ground. Trench for H.T. cables shall be 900 mm deep and for L.T. and other lower voltage cables shall be 600 mm deep or as specified in the drawings. Where both H.T. and L.T. cables follow the same route, one trench may be used. In that case, the higher voltage cables shall be installed at 900 mm and then the trench shall be filled to 600 mm with sand and pebbles and the low voltage cables shall be then installed. High voltage cables shall be spaced minimum 75 mm on centers.
- b. When it is necessary to pull the cable into the trench, rollers or a greased wooden trough should be used to reduce friction. A series of sleeves may be necessary to guide the cable around corners. Care should be exercised to avoid contact with sharp stones and other heavy objects in the trench. A two-inch layer of sand or clean earth shall be placed at the bottom of trench to avoid sharp objects coming in contact with the cables.

- c. After the cables are installed, cover the cables with 150 mm of rock-free earth or sand, place a layer of bricks or concrete tiles over that and backfill to grade. Concrete markers shall be placed at each bend and at a approximately 15 meters' intervals along straight runs to show the location of the cables. These markers shall extend above the grade by 25 mm.
- d. Cables shall be laid with slight slack in the trench to allow for the settlement of earth.
- e. After confirming with the Owner, necessary loops shall be made at the locations indicated by him.
- f. Concrete-lined cable trenches for cables inside buildings, if shown on the drawings, shall be provided by others.

9. LIGHTING SYSTEM

9.1 SCOPE

- a. The scope covers supply and installation of LED Light in Indoor & Outdoor lights. The system shall cover all interior and exterior lighting such as area lighting, high bay fittings, Flood Lighting, Transformer yard, Street lighting etc. The constructional features of lighting distribution boards are given in item LT Switch-gear.
- b. Emergency lighting shall be from DC Battery system and shall be provided at important locations. Portable emergency lights shall be provided where DC Battery System is not used.
- c. The type of lighting fixtures and receptacles, illumination level and approximate quantity required shall be generally as per design criteria.

9.2 GENERAL REQUIREMENTS

- a. comprehensive illumination system shall be provided.
- b. It shall be the responsibility of the contractor to work out a detailed layout with detailed requirement of lighting and receptacle system for the whole pumping station, area lighting, MCC building, outdoor switchyard, street light and staff quarters including area lighting as per specification and accordingly procure and install them.
- c. The system shall include, lighting fixtures complete with Lamps and accessories distribution boards, lighting panels, lighting fixtures, junction boxes, receptacles switch boards, lighting pole/masts, conduits, cables and wires, etc.
- d. The system shall cover all interior and exterior lighting such as area lighting, High Bay fitting, Flood Lighting, including Transformer yard etc. The constructional features of lighting distribution boards are given in item LT Switch-gear.
- e. Energy efficient LED lights with aluminium body fitting can be used at suitable locations.
- f. Street Lighting shall be automatically controlled by synchronous timer. Provision to bypass the timer shall be provided in the panel for manual control.
- g. ELCB, MCB to be used for human safety
- h. Light control switches, receptacle units with control switch units, lighting wires, conduits and other similar items necessary to complete lighting system
- i. In all types of cabling, due consideration shall be given to neatness and good appearance
- j. The illumination system shall be designed on the basis of best engineering practice and shall ensure uniform reusable, aesthetically and glare free illumination. The lighting fixtures shall be designed for minimum glare.
- k. The Contractor shall measure the lux levels after installation and be responsible to maintain lux level as per tender requirement. If required additional lighting shall be provided without extra cost

1. The Illumination levels to be adopted for various areas are indicated in Table Below.

ILLUMINATION LEVEL

Pump House, Indoor, outdoor Area	Average Illumination Level in Horizontal plane (in Lux)	Type of fitting
Main Pump house area	200	LED Tube light
Main Pump house area	200	Hi bay LED light
Service Bay	200	LED Tube light
Control Room	300	LED Tube light
Switchgear Room	250	LED Tube light
Cable floors & other areas (each)	100	LED Tube light
W.C; galleries & Staircase	100	LED Down light
Galleries	70	LED Down light
Battery Room	150	LED Tube light
Switch Yard equipment	50	LED Flood light
Switchyard, road light & outside Pump house	30	ED street light

- m. Lighting fixtures rating and quantity shall be provided to achieve above mention lux level in different area.
- n. Lighting design shall be performed using Dia Lux Software with its latest version/ Original Equipment Manufacturer (OEM) validated software.

9.3 LIGHTING LAYOUT

It shall be the responsibility of the contractor to work out a detailed layout for the complete plant in order to provide the levels of illumination as indicated in the design criteria. The type of fixtures to be used in various areas are also indicated in the above-mentioned drawing. The Contractor shall be responsible for measuring the levels of illumination after installation and establish compliance with the specification.

9.4 LIGHTING FIXTURES (LUMINAIRES)

- a. Luminaires shall be designed for continuous trouble-free operation without reduction in lamp life or without deterioration of materials and internal wiring. Outdoor fittings shall be weather- proof and rain-proof type.

- b. The Luminaires shall be designed so as to facilitate easy maintenance, including cleaning, replacement of lamps/starters etc.
- c. Connections between different components shall be made in such a way that they will not work loose by small vibration.
- d. For each type of Luminaires, the Contractor shall furnish the utilization factor tables to indicate the proportion of the light emitted by the bare lamps which falls on the working plane.
- e. All Luminaires shall be supplied complete with lamps suitable for operation on a supply voltage and the variation in supply voltage, frequency and combined voltage and frequency of $\pm 10\%$, $\pm 5\%$ and $\pm 10\%$ respectively.
- f. The Luminaires and accessories shall be designed to have low temperature rise.
- g. The temperature rise above the ambient temperature shall be as indicated in the relevant Standards.
- h. Luminary shall be mounted as far as possible in the luminaries housing only. Outdoor type fixtures shall be provided with outdoor type weather-proof box.
- i. Terminal blocks: Each indoor luminaries shall have a terminal block suitable for loop-in, loop-out and T-off connection by 240 V, 1 core, PVC insulated copper conductor wires up to 4 mm² in size. Outdoor areas the termination at the luminaries shall be suitable for voltage grade of 1100 V, 6 mm² copper conductor, PVC insulated armored cables. Terminals shall be of stud or clamp type. Terminal blocks shall be mounted with minimum two fixing screws.
- j. Mounting facility and conduit knock-outs for the luminaires shall be provided.

1. Earthing

- i. Each luminaire shall be provided with an earthing terminal suitable for connection to the earthing conductor of 12 SWG GI wire.
- ii. Where separate control gear box is provided for housing the accessories the same shall be provided with an earthing terminal suitable for connecting earthing conductor of 12 SWG GI wire.
- iii. All metal or metal enclosed parts of the luminaire shall be bonded and connected to the earthing terminal so as to ensure satisfactory earthing continuity.

2. Painting/Finish

- i. All surfaces of the Luminaire/Control gear box housing accessories shall be thoroughly cleaned and degreased. It shall be free from scale, rust, sharp edges and burrs.
- ii. When enamel finish is specified, it shall have a minimum thickness of 2 mils for outside surface and 1.5 mils for inside surface. The finish shall be non-porous and free from blemishes, blisters and fading.
- iii. The luminaire housing shall be stove-enameled/epoxy stove-enameled- vitreous enameled or anodized as indicated under various types of fittings.
- iv. The surface shall be scratch resistant and shall show no sign of cracking or flaking when bent

through 90 deg. over 1/2" dia. mandrel.

- v. The finish of the luminaire shall be such that no bright spots are produced either by direct light source or by reflection.

9.5 DECORATIVE LUMINAIRES

1. LED SURFACE PANEL LIGHTS

- a. These luminaires shall be generally indoor type shall operate from 90 to 300V AC, be of long life @ above 30000 Hrs., instant start shall house provided with aluminum body housing ceiling mounted complete with all require electrical control accessories mounted on it.
- b. Luminaires shall be suitable for the number of led lamps of specified wattage, direct mounting on ceiling/wall/column pendant mounting or for recess mounting in false ceiling in control rooms and computer rooms.

2. LED TUBE LIGHT LUMINARY

LED Tubes lights shall have more than 25000 working hours, suitable to operate for 90 to 300V, AC Supply, surface mounted, the luminaires shall be provided with PC+ Aluminium body mounting.

3. LED FLOOD LIGHT LUMINARIES

- a. Flood light luminaires shall be of long life, instant start shall house in weather proof construction with robust aluminum housing, wall/ pole recessed/ ceiling fitted, heat resistant, toughened glass cover and necessary neoprene gaskets to prevent ingress of dust.
- b. The housing shall be supported suitably and capable of being swivelled in both horizontal and vertical directions and locked in any desired position.
- c. For focusing purposes, knobs shall be provided along with sector plate indicating the beam angle in degrees more than 110 degree in vertical direction.
- d. The Luminaires shall be suitable for LED lamps, operating from 90 to 300 VAC, Life above 50000 working hours, IC based LED driver, short circuit proof, over voltage & under voltage protected. It shall be mounted in a separate cast aluminum weather proof with preferably IP 65
- e. The luminaire shall be provided with cable gland on the canopy in down ward direction for cable connection.
- f. It shall be possible to replace the lamp from the canopy without opening the front glass.

4. PORTABLE EMERGENCY LIGHT LUMINAIRE

- a. Emergency light of Installed luminaires shall be indoor type for providing emergency light during failure of normal AC supply.
- b. The luminaires shall be with CRCA sheet steel enclosure, complete with metalized mirror reflector, leak proof re-chargeable battery rated for two-hour discharge, battery charger,

charger-on lamp, push button switches, automatic changeover switch/relay, two-meter length cord with plug, mounting pads and other accessories required for satisfactory operation of the luminaries.

- c. The luminaries shall be suitable for connection to 240 V, 50 Hz single phase supply. On failure of normal A.C. supply the luminaries shall pick-up automatically and on restoration of A.C. supply the luminaries shall switch off automatically
- d. The luminaries shall be suitable for LED Lamps

9.6 PANELS/BOARD COMPONENT EQUIPMENT

9.6.1 SWITCHES/MINIATURE CIRCUIT BREAKERS (MCB) & HRC FUSE

- a. Switches/ MCB's shall be conforming to applicable standards.
- b. The switch shall be protected by fuse and the MCB shall be provided with overload/short-circuit protective device.
- c. The minimum breaking capacity of MCBs shall be 6 kA, 415 V A.C.
- d. The connections between switch and fuse shall be insulated and all live connections shall be shrouded. Switch boxes decorative cover shall be 1.6 mm thick and switch box shall be hot dip galvanized MS sheet with 2 mm thick.
- e. HRC cartridge type Fuses of suitable Amperes having rupturing capacity of 50 kA at 415 V shall be provided for light distribution system. Fuses shall be provided with visible indication to show that they have operated. Cartridge fuses shall be mounted in molded plastic carriers. If fuse carriers are not provided, insulated fuse pulling handle shall be provided for each size of fuse for each switchboard.

9.6.2 Indicating Meters And meters

- a. Instruments and meters shall be of the flush mounting type, suitably mounted so as to provide for easy access to CTs and wiring.
- b. Instruments shall be of minimum 96 mm square size, shall have provision for zero adjustment outside the cover and black numerals on white dial.
- c. Ammeter/Voltmeter selector switches having 3 positions and off, with stay-put contacts rated 10A shall be provided when specified.
- d. Fuses shall be provided at the tap-off point from the busbars for the voltmeters.

9.6.3 Instruments Transformers

- a. Current and voltage transformers shall be of the dry type, of metering accuracy class 1.0. Unless otherwise specified, it shall be the responsibility of the Contractor to ensure that the VA burden of the instrument transformer is adequate for the meters connected to it.
- b. Test links shall be provided in both secondary leads of the CTs to easily carry out current and phase angle measurement tests. Facilities shall be provided for short circuiting and grounding the CTs at the terminal blocks.
- c. Voltage transformers shall be provided with suitably rated primary and secondary fuses.

9.6.4 Internal Wiring

- a. Panels/boards shall be supplied completely wired, ready for the external connections at the terminal blocks. Wiring shall be carried out with
- b. Lighting wires shall be 650/1100V grade, PVC insulated, stranded aluminum/copper conductors. Conductors of adequate sizes shall be used to suit the rated circuit current.
- c. Colour of the PVC insulation of wires shall be Red, Yellow, Blue and Black for R, Y, B phases & neutral, respectively and white & grey for DC positive & DC negative circuits, respectively.
- d. Minimum size of wire shall not be less than 1.5 sq. mm for copper and above 6 sq. mm for aluminum. The size of the lighting wires/ cables shall be selected such that the total voltage drop from the LDB to the lighting fixture receptacle does not exceed 3%.
- e. Wiring shall run throughout in separate conduits. Wires of different phases shall run in different conduits.
- f. Wiring for lighting circuits and receptacle circuits shall be carried out in separate conduits and from separate feeders.
- g. Engraved identification ferrules, marked to correspond with the wiring diagram shall be fitted at both ends of each wire.
- h. All wiring shall be terminated on terminal blocks. Terminal blocks shall be one piece molded rated 500 V, of reputed make, preferably stud type for higher current ratings such that wires are connected by cable-lugs and complete with nuts and washers. Terminals shall be adequately rated for the circuit current; the minimum rating shall be 20 A.
- i. Terminals shall be numbered and provided with identification strip for identification of the circuit.
- j. Terminal blocks for C.T. secondary lead wires shall be provided with shorting and disconnecting/earthing facilities.
- k. Lighting panels etc. shall be earthed by two separate and distinct connections with earthing system.
- l. Switch boxes, junction boxes, lighting fixtures, fans, single-phase receptacles etc. Shall be earthed by means of separate earth continuity conductor.
- m. The earth continuity conductor 14 SWG GI wire shall be run along with each conduit run. Cable armors shall be connected to earthing system at both the end.

9.6.5 LABELS & DIAGRAM PLATE

- a. All door mounted equipment as well as equipment mounted inside the switchboard/panels shall be provided with individual labels with equipment designation/rating. Also, the boards/panels shall be provided on the front with a label engraved with the designation of the board/panel.
- b. Labels shall be made of non-rusting metal, 3-ply Limacoid or engraved PVC
- c. Inside the door of the 1 phase ways lighting panels a circuit diagram description shall be fixed for reference and identification.

9.6.6 Light Control Switch

- a. Light control switches of ratings and types, i.e., decorative/industrial shall be supplied as required. The switches shall be suitable for use on 240 V, 1 Ph, 50 Hz supply.
- b. Switches shall be of flush type for mounting behind an insulated plate or incorporated with a switch plate for mounting flush with the surface of wall or switch box/suitable enclosure. The switch box/enclosure shall be recessed into or mounted on a wall as per the requirement of project layouts.
- c. The size of enclosure boxes shall be chosen to accommodate the number of switches to be installed at the particular location. The enclosures shall be 14-gauge sheet steel galvanized. The enclosure box shall be covered with Perspex / insulating cover. An enclosure intended for surface mounting shall not have holes or gaps in its sides other than those expressly provided for cable entry.

9.6.7 RECEPTACLE UNITS

- a. Receptacle units shall consist of socket outlet with associated switch and plug. The socket outlet and switch or MCB shall be flush mounted within galvanized 14-gauge steel enclosure with insulation cover. The box shall be recessed into or mounted on a wall as per requirements of project layouts.
- b. The receptacle units shall be suitable for 240 V, 1 ph. - N, 50 Hz/415 V, 3 Ph - N, 50 Hz supply as required.
- c. Single phase receptacles shall be associated with a switch/MCB of same current rating and the receptacle shall become live only when the associated switch/MCB is in "ON" positions.
- d. Three phase receptacles shall be associated with a TPN switch housed in the same enclosure. The receptacle shall become live only when the associated switch is in "ON" position.
- e. The plugs shall be provided with cord grips to prevent strain and damage to conductors/wires at connection and entry points.

• LIGHTING WIRES

- a. The wires for wiring in lighting system shall be 250/415 V, 1/C, PVC insulated, Unarmored with stranded copper conductors.
- b. The minimum area of conductors shall be 1.5 sq.mm. for light fittings and 5A Receptacles and 2.5 sq.mm for receptacles rated 15 A and above.
- c. The wires shall be coded white for phase/positive of D.C. and black for neutral/negative of D.C.

• CONDUITS

- a. Rigid PVC conduits and their associated fittings as required shall conform to applicable standards. The minimum size of conduit shall be 20 mm for surface installation and 25 mm for concealed installation. They shall be supplied in standard lengths of 5 m.
- b. Supply of conduits shall include all associated fittings like couplers, bends, C Clamp and tees

as required for lighting system installation work. Conduits and fitting shall be cleaned to remove sludge, dirt or trash from the inside, prior to installation.

- c. In no case shall conduits be fastened to other pipes or installed in such a manner as to obstruct the ready removal of pipes for repair or replacement.
- d. All conduit openings shall be capped PVC caps (conduit plugs) during or immediately after installation. Before wires are drawn into conduits, the conduits shall be thoroughly cleaned by use of a swab or blown out with compressed air.
- e. Suitable inspection boxes shall be provided to permit periodical inspection and to facilitate removal of wires when necessary.
- f. Positions of lighting panels, switches, sockets etc. shown in drawings shall be adhered to. If desired by the Owner, the positions of these shall be changed without any extra cost.
- g. The heights for switches and receptacles are as indicated on the respective drawings /standard notes.
- h. All conduit drops from ceiling to the wall must be nearly in the centre of the wall. Conduit drops going out of the wall shall have to be made good by the Contractor at his cost without damaging/ weakening the building structure.

- **JUNCTION BOX**

- a. Junction boxes with terminals shall be supplied for branching and terminating lighting cables when required for outdoor areas, 3 phase receptacles etc. It shall be deep drawn or fabricated type made of 2.0 mm thick CRCA Sheet. The box shall be hot dip galvanized.
- b. The junction boxes shall be dust and vermin proof and shall be fabricated from 14-gauge sheet steel and shall be complete with removable cover plate with gaskets, two earthing terminals each with nut, bolt and washer. Boxes shall be additionally weather proof.
- c. The boxes shall have provision for wall, column, pole or structure mounting and shall be provided with cable/conduit entry knock outs, terminal blocks, HRC fuses as required.
- d. Insulation barriers, galvanized nuts, bolts and washers and provided with identification strips of PVC. The terminals shall be made of copper alloy and shall be of box clamp type.
- e. The boxes shall be painted with one shop coat of red oxide zinc chromate primer followed by a finishing coat of paint.

- **PULL OUT BOXES**

- a. Pull out boxes shall be provided at approximately 4-meter interval in a conduit run. Boxes shall be suitable for mounting on Walls, Columns, Structures, etc. Pull out boxes shall have cover with screw and shall be provided with good quality gasket lining.
- b. Pull out boxes shall be weather proof type suitable for IP: 55 degrees of protection. Pull out box & its cover shall be hot dip galvanized.

- **FAN AND REGULATORS**

- a. Ceiling Fans shall be suitable for operation on 240 V, 50 Hz, AC supply comprising of class

F insulated copper wound single phase motor, 1200mm sweep, aerodynamically designed well balanced MS blades (3 Nos.), down rod, die cast aluminum housing, capacitor, suspension hook, canopies etc. finished in stove enameled white. Power factor of fans shall not be less than 0.9.

9.6.8 Drawings and Data

- a. As art of proposal, the Contractor shall furnish relevant descriptive and illustrative literature on lighting fixtures and accessories dimensioned drawings/data for the respective lighting fixtures with manufacturer's catalogue numbers.
- b. It shall be the responsibility of the Contractor on award of contract to work out a detailed layout for the complete plant in order to provide the levels of installation as indicated under Design Criteria and shall be furnished for the approval of the Owner's representative before commencement of installation.

9.6.9 Lighting Fixture – LED lamp Set

- a. Supplying and erecting LED outdoor as a street light fitting with LEDs with wattage 1 watt and above assembled on single MCPCB, efficiency more than 130 lm/w and corrosion free High pressure die cast aluminium housing with smooth finish powder coated and heat sink extruded aluminium with diffuser and Polycarbonate optics/ lenses with company mark/name engraved or embossed with housing used as a heat sink shall be made of thick sheet steel conforming to IS513/CRCA and high U.V. and corrosion resistance with diffuser 90 to 300 V, power factor more than 0.95 ,THD < 10%,CCT 5000K to 5700 K, uniformity ratio > 0.45 ,Luminaire efficiency > 85 % lumens/watt, LED driver efficiency > 85 %. Each fittings required LM-79 and LM-80 certificate. Index of Protection Level Minimum IP 66. Surge Protection –10KV. (1 No. of Luminaire equivalent to 70W HPSV (3120 Lumens) fitting per street light pole.
- b. The working life of the lamp at junction temperature of 85° C (max) at operating current shall be more than 50,000 working hours of accumulative operation and shall be suitable for continuous operation of 24 hours per day. These features shall be supported with data sheet.
- c. **MARKING:**
The following information shall be distinctly and indelibly marked on the housing: Year of manufacture/ Batch Number/ Serial Number
Name of Manufacturer (Engraving only, stickers not allowed)
Rated watt and voltage & Input frequency

9.6.10 Lighting Poles and Flood Light Pole Mounting

- a. Providing and fixing approved make Swaged steel tubular pole made from CR Sheet steel. The tubular steel poles shall conform to the latest edition of Indian Standard specification IS: 2713 (Part – I, III): 1980 or any other authoritative standards (as amended up-to- date).

- b. Tubular Steel Poles shall be swaged type. Swaged poles shall be made of seamless or welded tubes of suitable lengths swaged and jointed together. No circumferential joints shall be permitted in the individual tube lengths of the poles. If welded tubes are used, they shall have one longitudinal weld seam only and the longitudinal welds shall be staggered at each swaged joint. The pole shall be suitable for wind loadings as per IS 875 part 3 1987.
- c. The length of joints on swaged poles shall be in accordance with clause No. 5.4 of IS: 2713 (Part-I): 1980. Poles shall be well-finished, clean and free from harmful surface defects. Ends of the poles shall be cut square. Poles shall be straight, smooth and cylindrical. The weld joints, if any, shall be of good quality, free from scale, surface defects, cracks, etc.
- d. Number of poles selected for conducting different tests shall be in accordance to clause No. 10.1.1 and No. 10.1.12: of IS: 2713 (Part-I) 1980.
- e. The poles may also be marked with the ISI certification mark if applicable. The poles shall be marked with manufacturer's identification, year of manufacture.
- f. The installation of pole shall be done as per direction of Engineer –In- charge at distance of approx. 25 meters or as per site requirement between two poles. Special care shall be taken while erection of poles so that these are not strained or damaged during erection and are firmly stayed till the foundation are secured, as per instruction of Engineer- in-charge and as per drawing. Foundation of each pole shall be provided as per manufacturer recommendation or as per Engineer in charge.
- g. The alignment of all the poles and the height shall be in one line so that from the distance it looks in one line. The material shall not be dispatched without prior inspection by the inspecting authority appointed by the department Pole drawing from manufacturer must be get approved from concerned department.

Drawings and Data

The following shall be furnished as part of the datasheet.

- i. General arrangement of panels showing plan, elevation and typical section views.
- ii. Technical literature on the equipment offered.

"J" type Foundation Nut-Bolt

Supply and Installation of M 20 x 750 long 'J' type EN 8 grade foundation bolts along with template for the above poles.

Cable Gland

Providing & Fixing of Heavy-Duty ISI Marked Flanged, Double Compression type Brass Cable Gland with rubber ring suitable for required XLPE Insulated Alu. Armored cable completes with outgoing tails, insulating taps etc. - (2 Nos. Glands Per Syntax Box on St. Light Pole.

Lugs

Providing & Fixing of Solder less Crimping Type Aluminium Lugs (4 Nos. per termination)

conforming to IS suitable for required XLPE Insulated Aluminium Armored cable tail complete erected with insulating materials for each termination. - (2 Nos. Termination Per St. Light Pole).

12mm Thick Backlite Sheet

Supplying and erecting bakelite sheet 12mm thick on existing angle iron frame or in the pole suitable size complete with bakelite connector strip with stud type terminals suitable for cable with, single pole 6 A to 32 A, MCB with mounting clamp with nuts, bolts & washers suitable for erection on pole with cable clamps & earth bolt. - (1 No. Per St. Light Pole)

Single Arm bracket

Provide & Installation of Single Arm Bracket consisting of Light Class M. S. pipe of suitable outside dia. Complete with require size pole top having sufficient fasteners for fixing the brackets and having suitable rise as per site condition as directed and spread of 2 m with suitable welded stiffener reducer and lock nut complete painted with one coat of PU base primer and two coats of PU paint suitable for side entry fitting brackets, as per site condition and as per drawing / directed by Engineer In-charge. - (1 No. Per St. Light Pole) The bracket shall be hot dip galvanized as per IS 2629/IS 2633/IS 4759 standards with minimum coating thickness of 85 micron.

DWC Pipe

Providing & laying of approved make Doubled Walled Corrugated Pipes (DWC) of polyethylene (conforming to IS 14930 - II) with necessary connecting accessories like coupler, Tee, L - Bow, etc. of same material at required depth (90 cm) including excavation for laying of cable below ground/ road surface for enclosing cable and back filling the same to make ground as per original & as per instruction of Engineer In-charge - for Street light Cable.

10. EARTHING SYSTEM

10.1 SCOPE

- a. The scope includes collection of data, design of the system as per relevant National/International Standards preparation of layout drawing supply of earthing conductors, earth electrode, earthing strips installation and approval to the satisfaction of electrical inspector under this tender specification.
- b. Earthing system shall be provided to ensure equipment safety, personnel safety and facilitate designed operation of protective switching during earth fault conditions in the associated system.

10.2 GENERAL

- a. All metal vessels, process pipe lines, tanks, buildings and other metal structures that may receive lightning stroke or develop a static charge shall be earthed, as per details on applicable drawings.
- b. All equipment to be earthed shall be cleaned down to bare metal before attaching the ground wire.
- c. Neutral conductor shall not be used for equipment earthing.
- d. All earthing connections shall be carried out in an approved manner and with specified materials. Typical methods of earthing as per standard drawings will be adopted for the earthing, as indicated in the applicable drawings.
- e. The entire plant shall be earthed by a series of ground loops. The loops will be effectively earthed by means of earthed electrodes.
- f. All earth connections shall be applied bitumen compound if welded with the system earthing grid / equipment. However, welding should be avoided as far as possible.
- g. Sizes of the earth wires shall be as shown in the applicable standard drawings.
- h. Copper strip if used shall be tinned at the joints.
- i. Armoring of cables shall be earthed at both ends through suitable cable glands.
- j. Earthing wires and cables shall be terminated on the earth bus with solderless cable sockets with silicon bronze / G.I. bolts.
- k. Each earthing wire shall be in one length from the equipment to the earth bus.
- l. Pipe electrodes in earth pit as per standard drawing shall be provided unless otherwise indicated in the relevant drawings. The earthing electrode and pits shall be in accordance with IS: 3043.
- m. The earth pit centre shall be at a minimum of 2 meters distance from the nearest building. Distance of not less than 3 meters shall be maintained between centers of two earth pits.
- n. The neutrals of transformers shall be connected to separate earth electrodes through NGR.
- o. Specialized Earthing shall be provided to the sensitive equipment by means of dedicated Cu.

earthing pits, Cu. earthing conductor and Cu. earth bus bar mounted on the insulators.

10.3 240 V EQUIPMENT

- a. All 240 V equipment shall be earthed with minimum one number of 12 SWG cu. wire unless stated otherwise on the relevant drawing.
- b. For lighting circuits in conduits, one number 12 SWG. copper wire shall run inside the conduit for earthing.
- c. fluorescent fixtures and all other fixtures provided with earthing terminals shall be earthed by 12 SWG copper wire.
- d. Switch and single-phase lighting receptacle housings shall be earthed with 12 SWG copper wire. The earthing wire shall be connected to the earthing screw on the switch or receptacles by a solder less cable socket duly crimped.
- e. All street lighting poles shall be earthed as indicated in the drawings

10.4 415 V EQUIPMENT

- a. All 415 V equipment shall be earthed by 2 independent paths to earth through earth wires. The earthing conductors shall be of the sizes as specified on the drawings and be of G.I., aluminium or bare copper where buried. Outside the building, a minimum of 300 mm of cover shall be provided.
- b. All motor frames, hoist rails, pipe racks, etc. shall be effectively earthed, as shown on the applicable drawing.
- c. Earth strip extending above the floor shall be protected from mechanical injury by running it through GI pipe sleeve to at least 300 mm height.
- d. The entire conduit system, supports, cabinets, transformers, motor control centers and equipment shall be effectively earthed as shown on the drawings and in accordance with the latest Indian Codes.
- e. All three phase receptacles shall be earthed with 8 SWG G.I. wire or as specified in the drawing.

10.5 EARTH ELECTRODE SYSTEM

- a. Earthing pit shall comprise of G.I. earthing plate or G.I. earthing rod. The plate/rod shall penetrate a minimum of three meter below ground level as per IS 3043. Where multiple rods are used, distance between them shall not be less than as specified in IS 3043.
- b. Marker posts and plates shall be provided to mark the route of buried electrodes. The markers shall be similar to those provided for cable routes.

10.6 EARTHING OF POWER OR MOTOR CONTROL CENTRE, DISTRIBUTION BOARDS

- a. Each switchgear, control panel and distribution boards shall be provided with an earth busbar running along its entire length. The earth busbar shall be located at the bottom of the Switchgear, Control Panel and Distribution Board.
- b. The sizes of conductors for earthing various equipment shall be referred in technical datasheets.
- c. Lightning protection shall be provided for the equipment, structures and buildings as per relevant IS standards. An independent earthing network shall be provided for lightning protection and this shall be bonded at least at two points with the main earthing network below ground. Lightning down conductor shall be brought to earth electrode in shortest straight path as feasible to minimize surge impedance
- d. The main earthing network shall be used for earthing of equipment to protect against static electricity.
- e. All medium and high voltage equipment (above 240V) shall be earthed by two separate and distinct connections with earth.
- f. Plant instrument system clean earthing, UPS system clean/safety earth, etc shall be separate from the electrical earthing system.
- g. All paint, scale and enamel shall be removed from the contact surface before the earthing connections are made.
- h. All earthing connections for equipment earthing shall be preferably from the earth plate mounted above ground wherever provided.
- i. Equipment foundation bolts shall not be used for earthing connection.
- j. Earth connections shall be made through compression type cable lugs/by welded lugs.
- k. All hardware used for earthing installation shall be hot dip galvanized or zinc passivated.
- l. Spring washers shall be used for all earthing connections and all connections adequately locked against loosening.
- m. Lighting fixtures and receptacles shall be earthed through the extra core provided in the lighting circuit/cable for this purpose.

11. SAFETY EQUIPMENTS

11.1 REQUIREMENTS AND MISCELLANEOUS ITEMS:

Following safety procedure and practice should be provided by Contractor in switchgear room/ sub- station as per latest edition of I.S. 5216.

- a. 1000 mm wide, 12 mm thick, class-B antiskid insulating rubber mat as per IS 15652/ IEC 61111 and of reputed make to be spread in front of the 11kV, 415V switch gear panels, HV panels & power DBs, DCDB etc.
- b. 1000 mm wide, 03 mm thick, class-A antiskid insulating rubber mat as per IS 15652/ IEC 61111 and of reputed make to be spread in front of the 1.1kV, 415V panels & as per site requirement etc.
- c. First aid box with all the standard contents.
- d. First aid chart made of cloth for electrical shock treatment printed in English, Hindi and Gujarati duly framed with front glasses.
- e. Charts/ drawings duly framed with front glass.
- f. HV and LV power supply single line diagrams in adequate sizes approved by Purchaser/ Purchaser's representative & in line with the local electrical inspector.
- g. Routine maintenance schedule for High Voltage Switchgear, Distribution Transformers, Low voltage Switchgears, APFC panels, Fire Alarm System, UPS system etc.
- h. Provision of portable type Class A, B, C, and D type fire extinguishers and fire bucket at various locations in line with the statutory requirements.
- i. Pair of rubber hand gloves suitable for working on 11 KV / 22 KV power supply.

11.2 FIRE SAFETY:

- a. The requirement of hand appliance in switchgear room, electrical equipment room shall be provided as per Clause 4.0 of Fire Protection Manual by Regional Tariff Committee, 10th edition 1988.
- b. Water Sealing & Fire Barriers at appropriate locations as specified in this specifications & good engineering practices.

11.3 DEGREE OF PROTECTION:

- a. The enclosures of the control cabinets, junction boxes and Marshalling boxes, panels etc. to be installed shall provide minimum degree of protection as detailed here under
 - i. Installed outdoor – IP 55
 - ii. Installed indoor – IP 54
- b. The degree of protection shall be in accordance with IS 13947 (Part I)/ IEC 947 (Part I)/ IS 2063/ IEC 529

11.4 ELECTRICAL EQUIPMENT FOR HAZARDOUS AREAS:

The electrical equipment for hazardous areas shall be selected as per IS 5572. Following factors shall be considered for proper selection of electrical equipment for use in Hazardous Area.

- a. Area Classification (Zone)
- b. Gas Classification (Group) – The characteristics of the gas or vapour involved in relation to the ignition or energy and safe gap data
- c. Temperature Classification- The ignition temperature of the gas or vapour involved or lowest value of the ignition temperature, if more than one combustible material is present.
- d. Environmental conditions – In which apparatus is to be installed. The selected electrical apparatus shall be adequately protected against corrosive and solvent agencies water ingress, thermal and mechanical stresses as determined by the environmental condition.

12. INSTALLATION, TESTING & COMMISSIONING - ELECTRICAL & INSTRUMENTATION EQUIPMENT

12.1 GENERAL:

- a. In accordance with the specific installation instructions, as shown in Contractor's drawings or as directed by the Engineer in Charge the Contractor shall unload, erect, install, wire, test and place into commercial use of all electrical & instrumentation equipment included in the contract. Equipment shall be installed in a neat manner so that it is level, plumb, and properly aligned and oriented.
- b. The Contractor shall furnish all supervision, labour, tools, equipment, rigging materials and incidental materials such as bolts, wedges, anchors, concrete inserts etc. required to completely install, test and adjust the equipment.
- c. Drawings, instructions and recommendations shall be correctly followed in handling, settling, testing and commissioning of all equipment and care shall be exercised in handling to avoid distortion to stationary structures, the marring of finish, or damaging of delicate instruments or other electrical parts.
- d. The Contractor shall erect and commission the equipment as per the instructions of the Purchaser/ Engineer in Charge and shall extend all co-operations to him.
- e. In case of any doubt/ misunderstanding as to correct interpretation of drawings or instructions, necessary clarification shall be obtained from the Engineer's Representative. The Contractor shall be held responsible for any damage to the equipment consequent to not following instructions correctly.
- f. The Contractor shall move all equipment into the respective buildings through regular doors or floor openings provided specifically for the equipment. The Contractor shall make his own arrangement for lifting of equipment.
- g. Where assemblies are supplied in more than one section, the Contractor shall make all necessary mechanical and electrical connections between sections including the connections between bus bars/ wires. The Contractor shall also carry out the adjustments/ alignments necessary for proper operation of the circuit breakers. All insulators and bushings shall be protected against damage during installation. Insulators or bushings chipped, cracked or damaged due to negligence or carelessness shall be replaced by the Contractor at his own expenses.
- h. The Contractor shall take utmost care in handling instruments, relays and other delicate mechanisms. Wherever the instruments or relays are supplied separately, they shall be mounted only after the associated control panels have been erected and aligned. The blocking material/ mechanism employed for the safe transit of the instruments and relays shall be removed after ensuring that the panels have been completely installed and no further movement of the same would be necessary. Any damage to relays and instruments shall be immediately reported to the Engineer In charge.
- i. Equipment furnished with finished coats of paint shall be touched up by the Contractor if the surface is spoiled or marred while handling.

- j. Foundation work and grouting of fixing bolts or channels for all transformers, switchgear, motors, and control panels shall be carried out by the Contractor.

12.2 POWER/ DISTRIBUTION TRANSFORMERS:

Inspection, storage, installation, testing and commissioning of transformers shall be in accordance with the latest Indian Standards Code of Practice IS: 10028. All commissioning tests as applicable, vide Appendix B of IS: 10028 (Part II) shall be carried out. Fire Wall of 4 Hr. fire rating shall be provided between two transformers.

12.3 HV/ LV SWITCHGEAR CONTROL PANELS:

- a. Switchgear control panels shall be installed in accordance with the latest Indian Standard Code of Practice 10118. The switchgear panels shall be installed on finished surface or concrete or steel sills. The Contractor shall be required to install and align any channel sills which form part of the foundations. Tape or compound shall be applied where called for. The base of outdoor type units shall be sealed in an approved manner to prevent ingress of moisture.
- b. Following minimum clearances shall be observed while finalizing the HV/ LV panel layouts-
 - i. Minimum clearance of 1.0 meter shall be maintained from the rear of the panel to the nearest wall /structure.
 - ii. Minimum clearance of 2.0 meter between panels facing opposite to each other.
 - iii. Side clearance for LV panels shall be either $\leq 200\text{mm}$ or $\geq 800\text{ mm}$.
 - iv. For HV metal enclosed, indoor panels, Minimum 1 meter clearance from all sides & 1.5 meter in the front.
- c. Emergency Exit doors shall be provided for electrical room, complying with the requirements of NBC 2005 latest edition.
- d. After installation of all power and control wiring, the Contractor shall perform operating tests on all switchgear and panels to verify the proper operation of switchgear/ panels and the correctness of the interconnections between various items of equipment. This shall be done by applying normal a-c or d-c voltage to the circuits and operating the equipment. Megger tests for insulation, polarity checks on the instrument transformers, operation tests on equipment, and installation tests shall be carried out by the Contractor who shall also make all necessary arrangements for proper functioning of the equipment.

12.4 EARTHING AND LIGHTNING PROTECTION SYSTEM:

- a. The Contractor shall install copper/ steel conductors, braids, etc., required for the system and individual equipment earthing. All work such as cutting, bending, supporting, painting/ coating, drilling, brazing/ soldering/ welding, clamping, bolting and connecting onto structures, equipment frames, terminals, rails or other devices shall be in the Contractor's

scope of work. All incidental hardware and consumables such as fixing cleats/clamps, anchor fasteners, lugs, bolts, nuts, washers, bituminous compound, welding rods, anti-corrosive paint as required for the complete work shall be deemed to be included by the Contractor as part of the installation work.

- b. The quantities, sizes, material of earthing conductors and electrodes to be installed as per requirement. Routes of the conductors and locations of electrodes shall be shown in the earthing layout drawings, which are to be prepared by Contractor & approved by Purchaser's representative.
- c. The work of embedment of earthing conductor in RCC floors/ walls along with provision of earth plate inserts/ pads/ earth risers shall be done by the Contractor when the floors are cast or during construction of walls. Contractor's scope of installation shall also include, laying the conductors in position with 60 mm concrete cover, making welded connections to inserts/pads/risers above the floor near the equipment. The embedded conductors shall be connected to reinforcing rods wherever necessary.
- d. If the tap connections (earthing leads) from the floor embedded main earthing grid to the equipment are more than 500 mm long then the same shall be embedded in floor by the Contractor where required, together with associated civil work such as excavation/chasing, concreting and surfacing. The concrete cover over the conductor shall not be less than 60 mm.
- e. Installation of earth conductors in outdoor areas, buried in ground, shall include excavation of earth up to 600 mm deep 450 mm wide, laying of conductors at 600 mm depth, brazing/ welding as required, of main grid conductor joints as well as risers of length 500 mm above ground at required locations and then backfilling material to be placed over buried conductor shall be free from stones and other harmful mixtures. Backfill shall be placed in layers of 150 mm, uniformly spread along the ditch, and tampered utilizing pneumatic tampers or other approved means. If the excavated soil is found unsuitable for backfilling, the Contractor shall arrange for suitable material from outside.
- f. Installation of earth connection leads to equipment and risers on steel structures/ walls shall include laying the conductors, welding/ cleating at specified intervals, welding/ brazing to the main earth grids risers, bolting at equipment terminals and coating welded/ brazed joints by bituminous paint. Galvanized conductors shall be touched up with zinc rich paint where holes are drilled at site for bolting to equipment/ structure.
- g. Electrodes shall be installed in constructed earth pits, and connected to main buried earth grid, The scope of work shall include excavation, construction of the earth pits including all materials required for construction of earth pits, placing the rod and fixing test links on those pipe/ rod/ plate electrodes in test pits and connecting to main earth conductors.
- h. Installation of lightning conductors on the roofs of buildings shall include laying, anchoring, fastening and cleating of horizontal conductors, grouting of vertical rods wherever necessary, laying fastening/ cleating/ welding of the down comers on the walls/ columns of the building and connection to the test links to be provided above ground level.
- i. Installation of the test links shall include mounting of the same at specified height on wall/column by suitable brackets and connections of the test link to the earth electrode.

- j. Whenever main earthing conductor crosses cable trenches, they shall be buried below the trench floor.
- k. Suitable earth risers shall be provided above finished floor/ ground level. If the equipment is not available at time of laying of the main earth conductors, the minimum length of such riser inside the building shall be 200 mm and outdoors shall be 500 mm above ground level. The risers to be provided shall be marked in project drawings.
- l. Earth leads and risers between equipment earthing terminals and the earthing grid shall follow as direct and short a path as possible.
- m. An earthing mat shall be provided under each operating handle of the isolator and operating mechanism of HV breakers. Operating handle of the isolator and supporting structure shall be bonded together by a flexible connection and connected to the earthing grid.
- n. A separate earth electrode bed shall be provided adjacent to structure supporting lightning arrestors. Each connection shall be as short and as straight as practicable. For arrestors mounted near transformers, earth conductors shall be located clear off the tank and coolers.
- o. Wherever earthing conductors passes through walls, galvanized iron/PVC sleeves shall be provided for the passage of earthing conductor. The pipe ends shall be sealed by the Contractor by suitable water proof compound.
- p. Earthing Connections:
 - i. All connections in the main earth conductors buried in earth/ concrete and connection between main earthing conductor and earth leads shall be of welded type.
 - ii. Connection between earth leads and earthing terminal provided on the equipment shall be bolted type.
 - iii. All bimetallic connections shall be treated with suitable compound to prevent moisture ingress.
 - iv. Metallic conduits and pipes shall be connected to the earthing system.
 - v. Lightning protection system down conductors shall not be connected to other earthing conductors above ground level. Also, no intermediate earthing connection shall be made to lightning arrester and transformer earthing leads which shall be directly connected to pipe electrode.
- q. Earth Electrodes:
 - i. Electrodes shall as far as practicable, be embedded below permanent moisture level.
 - ii. Test pits with concrete covers shall be provided for periodic testing of earth resistance. Installation of pipe electrodes in test pits shall be suitable for watering. The necessary materials required for installation of test pits shall be supplied and installed by Contractor. The installation work shall also include civil work such as excavation and connection to main earth grid.
 - iii. Earth pits shall be treated with salt and charcoal. In case found necessary, then with the approval of Purchaser's representative, Back fill compound of suitable composition may be used. Back fill material shall not be water soluble & shall retain moisture & enhance conduction around electrode. Back fill compound shall be low resistance & non corrosive earth enhancement compound which shall provide safe discharge path to

fault current & lightening current.

- iv. Ohmic value shall be within safe limits & it shall be stable & not fluctuating.
- v. Soil, salt and charcoal placed around the electrode shall be finely graded, free from stones and other harmful mixtures. Backfill shall be placed in layers of 250 mm thick uniformly spread and compacted. If excavated soil is found unsuitable for backfilling, the Contractor shall arrange for a suitable soil from outside.

12.5 INSTALLATION OF CABLE RACKS AND CABLE TRAYS:

12.5.1 General

- a. Lines and grade for trays may be measured from building steel and finished floor elevations. Change in line or grade, or the addition of offsets by means of cutting standard tray sections and inserting additional tray fittings to match with the existing arrangement shall be considered as a normal part of the work.
- b. Where embedded steel inserts in concrete floors/ walls for welding the supports for cable racks/ trays are not available, Contractor shall provide suitable anchor fasteners at no extra cost.
- c. Cable shall be clamped to the cable trays at every 750 mm distance.
- d. Flexible metallic conduits shall be used for termination of connection to equipment such as motors, limit switches and other apparatus.

12.5.2 Cable Trays:

- a. All the cable tray shall be hot dipped galvanized with minimum galvanization thickness as per mentioned in these specifications.
- b. Cable tray shall be of perforated sheet steel with formed flanges and of minimum thickness not less than 1.25 mm for trays up to 100 mm width, not less than 1.5 mm for trays from 100 mm to 150 mm width and not less than 2.0 mm for trays from 150 mm to 300 mm width.
- c. All the cable trays above 300 mm width shall be of ladder type with minimum thickness of 2.5 mm.
- d. Cable tray for use in areas where chlorine gas may be present shall be constructed from U-PVC or GRP. Cable tray supports shall be of a compatible finish with the associated cable tray.
- e. All cable trays tees, intersection units, bends, turns and sets shall be prefabricated (made by the manufacturer) and shall be of a matching design to the main section of cable tray.
- f. Tray shall only be joined by couplers supplied by the manufacturers. The joint shall be secured in accordance with the manufacturer's instructions.
- g. Cable tray supports supplied by a manufacturer or made up on Site shall have adequate strength to maintain rigid support to the fully laden cable tray along its entire length and shall ensure that the deflection of any one section does not exceed 15 mm at mid span.
- h. Wherever possible, cable trays shall be installed in full lengths without cutting. Should it be

necessary to cut or drill a length of tray, the bared ends or damaged section of the tray shall immediately be given a coat of zinc rich cold galvanized paint. All site manufactured accessories, supports and metal fittings required to ensure correct installation of the cable trays shall be similarly treated.

- i. All cables shall be firmly secured to the tray using purpose made saddles, as approved by the Purchaser's Representative, together with proprietary nylon fasteners and/or cable cleats. Following installation of cables, the tray shall remain rigidly supported and the deflection of any section shall not exceed 15 mm at mid span. All brackets and tray work shall be suitable for withstanding a temporary weight of 125 kgs.
- j. Cable trays shall not be cut to allow the passage of cables through the surfaces of the tray
- k. The sizing of the cable tray shall provide a minimum of 20% spare capacity.
- l. The tray shall be run at least 300 mm clear of plumbing and mechanical services.
- m. Bends in the installation shall take account of the minimum bending radii of cables to be installed.
- n. All the cable trays shall be supplied with cable tray supports (of adequate size) at no more than 1.2-meter interval.
- o. other cable tray details & cabling system shall be as per typical drawings attached with the specifications.

12.5.3 Cable Trunking – Metal:

- a. Cable trunking shall be manufactured from mild steel of not less than 1.25 mm and shall be hot dipped galvanized. The Contractor shall ensure that the size of the trunking is adequate for the number of cables to be installed together with 50% spare capacity and shall in any case be 50 mm x 50 mm minimum size.
- b. Segregation of cables shall be carried out if required using continuous sheet steel barriers with the bottom edge welded to the trunking.
- c. The trunking shall have two return flanges for rigidity. Where necessary, additional strengthening straps shall be fitted internally. The cover shall overlap the trunking and be made of the same gauge. Fixing screws for covers shall be recessed and be of the self-retaining 'quick fix' type. All bends, tees and intersections shall be of the gusset type and shall, wherever possible, be purpose made by the manufacturer and of a matching design to the main trunking.
- d. Cables shall be retained in the trunking when the cover is removed by means of straps. Internal connecting sleeves shall be fitted across joints in the trunking and earth continuity ensured by bonding each section of trunking to a continuous earth wire.
- e. Non-flammable fire barriers shall be inserted where the trunking passes through walls or floors. Conduit connections to trunking shall be made by flanged couplings and male bushes.
- f. Trunking shall be supported at intervals not greater than 2 meters horizontally or 2.5 meter vertically.
- g. Crossings over expansion joints shall be made in flexible conduit.

- h. Should it be necessary to cut or drill a section of trunking or a trunking fitting the bared ends shall immediately be given a coat of zinc rich cold galvanizing paint.
- i. Cable and conduit/ trunking runs shall be determined by the Contractor and agreed by the Purchaser's Representative before any work is started. The run shall be at least 300 mm clear of plumbing and mechanical services.
- j. Conduit/ trunking systems erected outside a building shall be weatherproof.

12.6 CABLE INSTALLATION:

12.6.1 General:

- a. Cable installation shall be in accordance with IS 1255: 2001 - latest edition.
- b. Cables shall be installed in such a way that the minimum bending radii are not reduced when installed or during installation. Cables shall not be installed in ambient temperatures below that recommended by the cable manufacturer.
- c. Cables grouped together shall have insulation capable of withstanding the highest voltage present in the group.
- d. Cables of different categories shall be installed so as to maintain satisfactory clearances for safety and in order to reduce the possibility of electrical interference. The following Table details the distances in mm that shall be maintained between the different categories of cable.

Table of Separation Distances in mm between different Categories of Cable

Cable Category	HV Power	LV Power	C&I/ Protection	Tele- communication
HV Power	N/A	300	600	600
LV Power	300	N/A	300	300
C&I/ Protection	600	300	N/A	200
Tele- communication	600	300	200	N/A

- e. These separations are minimum and special circumstances such as the presence of high current flows, or harmonic content may necessitate larger separation distances.
- f. A distance of minimum 300mm shall be maintained between the cables to be laid on trays/ conduits carrying low voltage AC and DC signals and a distance of minimum 600 mm shall be maintained between cables carrying HV and LT signals.
- g. In order to make economic use of the cable support system, cables shall be arranged in groups of 50 mm maximum overall diameter. These groups shall be securely tied to the cable support system at intervals not exceeding 900 mm for horizontal runs and 300 mm intervals on vertical runs.
- h. In order to make the most economic use of cable tray and duct capacity, multicore cabling shall be utilized in order to connect instrumentation groups by using suitably located sub-distribution junction boxes. The junction boxes shall be suitable for the area in which they are to be installed and for the type of circuit. They shall be readily accessible for maintenance

and clearly labeled junction boxes shall be constructed of die cast Aluminium and provide degree of protection IP 65.

- i. Instrumentation cables shall be continuous without any joints. Separate cables shall be used for digital and analogue signals at all times. Digital and analogue signals shall be segregated within junction boxes.
- j. Cables shall be laid in a manner such that any electrical interference between cables shall not have a detrimental effect on the life and operation of Plant.
- k. Where practical a separate cable support system shall be provided for power and non-power cables. Where this is not practical a separation as per indicated in above table shall be maintained between power and non-power cables when run on the same support system.
- l. Heavy duty galvanized iron cable tray and ladder racking shall be used for cable support systems. FRP/ GRP cable support systems shall be used in areas used for the storage and handling of chlorine. These systems shall be used to route cables around walls and within cable trenches. Cables shall be securely fixed to the support systems. Bundling of cables shall be permitted where allowance for this practice has been made in sizing the cables.

12.6.2 Laying of Cables:

- a. Each instrumentation and power supply cable shall be terminated to individual panel/ terminal box.
- b. Identification of each cable shall be by proper ferrules at each junction as per cable schedule to be prepared by Contractor.
- c. Cables shall be laid in accordance with layout drawings and cable schedule which shall be prepared by Contractor and submitted for approval.
- d. All cable routes shall be carefully measured and cables cut to the required lengths, leaving sufficient amount for the final connection of the cable to the terminals on either end.
- e. Various cable lengths cut from the cable reels shall be carefully selected to prevent undue wastage of cables.
- f. A loop of 1.0 meter shall be left near each field instrument before terminating the cable.
- g. Cables shall be complete uncut lengths from one termination to the other.
- h. Separate cables shall be used for digital and analog signals.
- i. All cables shall be identified close to their termination point by cable numbers as per cable interconnection schedules.
- j. Identification tags shall be securely fastened to the cables at both the ends.
- k. Cable shall be rigidly supported on structural steel and masonry, using individually cast or malleable iron galvanized clips, multiple cable supports or cable trays.
- l. The Contractor shall take the actual measurement of the cables and the associated accessories such as cable trays, conduits etc. required at site, prior to the placement of order on the cables.

12.6.3 Cables Laid Direct in Ground:

- a. Buried cable up to 1.1 kV shall have a laid at a minimum depth of 750 mm measured from FGL to the top of the highest cable. On crossing roadways, the cable shall be run through a PVC-U duct of minimum diameter 100 mm with a minimum of 1000 mm cover and encased on all sides by 150 mm of concrete.
- b. Cables of greater than 1.1kV shall be buried at a minimum depth of 1 meter.
- c. The bottom of the cable trench shall be freed of sharp stones and such like and 75 mm of sieved sand laid below the cable. After cable laying 75 mm of sieved sand shall be laid above the cable. For HV cables sand bedding shall be of 150 mm & cables shall be covered with half round Hume pipes of twice the diameter of cable.
- d. Interlocking cable protective covers, minimum 1 m long x 300 mm wide, marked 'Danger-Electric Cable' in English and the vernacular shall be laid on top of the sieved sand. Covers shall extend the whole length of the cable trench and shall overlap cables by a minimum of 50 mm.
- e. Warning tape shall be laid a minimum of 200 mm above the protective covers.
- f. Cables are to be installed without tees or through joints unless otherwise approved by the Purchaser's Representative. Single core cables shall be run in trefoil formation.

12.6.4 Cables Laid in Underground Ducts:

- a. Underground ducts shall be constructed of impact resistant PVC-U and laid at a minimum depth of 750 mm, ducts shall be surrounded by at least 75 mm of sieved sand except at road crossings where it shall be 1.0 meter deep and encased on all sides by 150 mm of concrete.
- b. The Contractor shall ensure that sufficient draw-in points have been provided and that adequate room has been allowed for installation of cables. Drawstrings shall be provided in all ducts to enable additional cables to be installed when required.
- c. Where cables pass in or out of any duct entries into or within buildings such entries, together with any spare ducts shall be sealed against the ingress of moisture by means of duct stoppers and bituminous compounds or by any other method approved by the Purchaser's Representative. The stopper shall have a fire resistance of at least 30 minutes. Single core cables in trefoil formation shall pass through the same duct and shall not be separated. However, for two different trefoil formations, they shall be laid in separate ducts.

12.6.5 Cables installed in Conduit:

- a. Conduits shall be galvanized heavy gauge solid drawn or welded screwed steel type and be in accordance with IS 9537, Part 2 or BS 4568. Accessories shall either be malleable cast iron screwed type or pressed steel and galvanized.
- b. A space factor of 40% shall not be exceeded, but in any case, conduit of less than 20 mm diameter shall not be permitted. The tubing shall be perfectly smooth inside and out and free from flaws and imperfections of any kind. Both ends of every length of tubing shall be properly reamed with all sharp edges removed before erection.

- c. Where a number of conduits converge, malleable cast iron or heavy gauge sheet steel adaptable boxes shall be employed in order to avoid crossings. Conduits shall be connected by means of male brass bushes and couplings.
- d. Where conduits are greater than 25 mm, straight through joint boxes shall be of the trough type. Where conduit and/ or fittings are attached to equipment casings, the material or case of the casing shall be tapped for a depth of not less than 10 mm or male bushes and flanged couplings shall be used.
- e. Heavy hexagonal lock nuts shall be used at all positions where running joints are required and care shall be taken to ensure that they seat firmly and evenly on to the mating faces of coupling or other adjacent accessories. All junction boxes, draw-in boxes, and inspection fittings, shall be so placed that the cables can be inspected and, if necessary, withdrawn and re-wired throughout the life of the installation.
- f. Generally, not more than two bends or offsets or one coupling will be permitted without a suitable inspection accessory. Fish wires shall not be left in conduits after erection. The whole of the installation shall be arranged for a loop-in type of system with joints being carried out at switches, isolators, etc. Intermediate joints in the cable will only be allowed by arrangement with the Purchaser/ Purchaser's Representative.
- g. Ends of conduits which are liable to be left open for any length of time during building operations shall be plugged to prevent the ingress of dirt, cement, etc. and covers, either temporary or permanent, shall be fitted on all boxes.
- h. Generally, conduits shall not cross expansion joints of buildings, but where they cannot be installed in any other manner then a flexible conduit shall be used across the expansion joint. A total 150 mm movement shall be allowed.

12.6.6 Surface Installation:

- a. Surface conduits shall be secured and fixed by means of distance spacing saddles or approved purpose made clips at every 500mm, which allow the conduits to be taken directly into accessories without sets or bends. Conduits shall be run in a square and symmetrical manner. An efficient means shall be adopted to provide for the drainage of condensation and the runs shall be properly ventilated. All surface conduit runs shall be marked out for approval by the Purchaser's Representative before the installation is carried out. Where large multiple parallel conduit runs would occur, use may be made of galvanized cable trunking. Conduits installed on structural steelwork shall be secured at spacing not exceeding those for surface conduit by girder clips, otherwise fixing shall be as for surface conduits on walls, drilled and tapped to the metalwork. Power driven fixings shall only be used with the express permission of the Purchaser's Representative. Any drilling or access which is required through any structural member of the building shall be agreed with the Purchaser/ Engineer in Charge before carrying out the work.
- b. Exposed threads and places where galvanizing has been damaged shall be cleaned and then painted with two coats of an approved metallic zinc-based paint. This treatment shall be applied as the work proceeds.

12.6.7 Concealed Installation:

- a. Concealed conduits shall be securely fixed to prevent movement before laying of screeds, floating of plaster, casting of columns or other building operations necessary after the conduit installation. Crumpets or similar fixings shall be used for attaching the conduit to blockwork, etc. Building nails will not be accepted.
- b. At least 15 mm cover shall be allowed for finishes over the conduit. Where this cover cannot be maintained then expanded metal shall be fitted with the conduit. Conduit cast into reinforced concrete floors shall be fixed to the steel reinforcing with binding wire and the conduit boxes filled with expanded polystyrene or enclosed in a plastic bag to prevent the ingress of concrete when poured. Where possible, the conduit boxes shall be fixed to shuttering to give a flush finish.
- c. Conduit installed in voids, false ceilings, and other concealed routes shall be installed as specified for the surface conduits. Wiring shall be carried out after the false ceiling or permanent ducts have been completed. Conduit installed in floors shall be sealed against ingress of moisture.
- d. The conduit installation shall be inspected by the Purchaser's Representative before the building operation conceals the work.

12.6.8 Cable Installed in Flexible Conduit:

- a. Flexible conduit shall be of the waterproof galvanized type or PVC wire-wound type with cadmium plated mild steel couplings. Lengths of flexible conduits shall be sufficient to permit withdrawal, adjustment or movement of the equipment to which it is attached and shall have a minimum length of 300 mm. Flexible conduit shall not be used as a means of providing earth continuity. A single earth conductor of adequate size shall be installed external to the conduit complete with earth terminations.
- b. Where conversion from rigid conduit to flexible metallic conduit is to be made, the rigid conduit shall terminate in a through type box and the flexible conduit shall extend from this box to the equipment, the earth continuity cable shall be secured to the box and to the piece of equipment by properly designed earthing screws. The use of lid facing screws, etc., will not be permitted. Adapters shall incorporate a grub screw or a gland to prevent the flexible conduit becoming loose.

12.6.9 Cable Clipped Direct:

- a. All cable hangers, clips, cleats and saddles shall be of an approved type and appropriate to the type and size of cable installed. Their spacing shall be such as to ensure a neat appearance and prevent sagging of the cables at all times during their installed life.

12.6.10 Cable Installed in Internal Floor Trench:

- a. In shallow trenches (maximum depth 500 mm)
- b. In shallow trenches used for electrical services only, cables may be laid in a neat and orderly manner on the floor of the trench. One layer only shall be allowed. Additional cables shall

be installed on the walls of the trench in an acceptable manner & such a way that, in no case the distance between two different types of cable shall not be less than the separation distance tabulated above.

- c. Where the trench is shared by other services, cables shall be installed on the walls of the trench in an acceptable manner & such a way that, minimum separation distance of 300mm shall be maintained.
- d. All other trenches including walk through service ducts
- e. Cable trenches & cable installation shall be in accordance with the attached typical cabling system drawings.
- f. Where other services are present the cables shall be segregated from them by separation distances as mentioned above and wherever possible kept above 'cold' wet services. Cables should not be run, if at all possible, above or in close proximity to 'hot' services.
- g. The cabling shall be installed in such a manner as to allow access to the other services for normal maintenance without disturbance of the electrical installation

12.6.11 Cable Terminations and Joints:

a. Power Cable Terminations

- i. Power cables shall be terminated in suitable boxes arranged for bolting to switchgear, motor starters and motors.
- ii. Cores shall have either crimped lugs or sleeves to match either post terminals or bolted clamp terminals.
- iii. Each cable entry into a terminating box shall be made through a suitable gland, which shall have provision for securing the armor where applicable. Where single core glands are required, these shall be of the non-magnetic type and the associated box bottom plate, where the core passes through, shall not have a continuous magnetic path.
- iv. Adequate provision shall be made to bond the cable armoring to the box and/or switchgear casing of a suitable size to withstand the prospective short circuit fault current of the system, glands shall be fitted with earth bonding tags where intimate screwed contact between gland and cable box is not possible.
- v. Where cable glands are exposed to the weather these shall be protected by heat shrink plastic sleeve or purpose molded sleeves covering the gland continuously from overall sheath to the gland neck.
- vi. Where terminations of multicore type have to be made on to items of Plant which have to be dismantled for maintenance, these shall be made off through glands into an adaptable box containing terminals and flexible single cores taken into the equipment via flexible waterproof plastic covered conduit, and a separate earth core linking the box to the equipment.
- vii. Where single core cables are glanded to or pass-through cabling plates the gland plate or cabling plate shall be constructed of non-magnetic material.

b. Power Cable Joints:

- i. Through joints shall only be allowed with the approval of the Purchaser's Representative. Where such joints are necessary in thermoplastic and elastomeric cables, the cables shall be jointed with epoxy or acrylic resin cold setting compound, which has been premeasured and pre-packed ready for use. The boxes shall preferably be of split, molded plastic type with filling vents for compound. Bonding straps shall be fitted with armor clamps across the joint and inspected by the Purchaser/ Purchaser's Representative prior to filling the box with compound. Wrapped pressure type joints will not be accepted.

c. Multi-core or Control Cable Terminations:

- i. A sufficient number of terminals shall be provided to terminate all cable cores. For control and auxiliary wiring an additional 20% of this number shall be provided as spares.
- ii. Not more than one core of internal or external wiring shall be connected on any one terminal. Where duplication of terminal blocks is necessary, purpose-made solid links shall be incorporated in the design of the terminal blocks.
- iii. Terminals which remain energized when the main equipment is isolated shall be suitably screened and labeled.
- iv. Terminal blocks for different voltages or circuit type shall be segregated into groups and distinctively labeled.

12.6.12 Cable Fixings:

- a. Ties and strapping shall be suitable for securing cable and cable groups to cable tray or ladder. They shall be resistant to chemical and marine corrosion. Plastic coated metal ties used in order to obtain corrosion resistance shall not be acceptable. Nylon ties shall be resistant to the effects of ultra-violet light and shall be self-extinguishing.
- b. Large single cables shall be secured with cable clamps or cable cleats.

12.6.13 Cable Identification:

At each end of each cable, in a uniform and visible position a label shall be fixed on the cable in accordance with the cable schedule. Labels shall be made of PVC and shall be indelibly marked to the approval of the Purchaser's Representative. The label shall be retained using proprietary nylon strips passing through two fixing holes at either end of the label. If the cable gland is not normally visible, then the label shall be fixed inside the panel by means of screws.

12.6.14 Marking Locations of Underground Cables:

- a. The location of all underground cables shall be engraved on brass or other non-corrodible plates to be fixed to the exterior surface of all walls of buildings 300 mm above ground level

and directly above the point where cables pass through the wall.

- b. Cable route markers as per the attached drawing shall be installed at an interval not more than 30 meter & at bending/ road crossings the interval shall be at every 10 meters.
- c. The minimum depth for laying of underground cable route markers shall be as per indicated in the typical drawings attached with this tender.

12.6.15 Additional Requirements for Cable Installations:

- a. The Contractor shall install, test and commission the cables specified in the specification. Cables shall be laid directly buried in earth, on cable racks, in built up trenches, on cable trays and supports, in conduits and ducts or bare on walls, ceiling etc. as per drawings, which are to be prepared by Contractor & approved by Purchaser's representative. Contractor's scope of work includes unloading, laying, fixing, jointing, bending, and termination of the cables & all related accessories. The Contractor shall also supply the necessary materials and equipment required for jointing and termination of the cables.
- b. All apparatus, connections and cable work shall be designed and arranged to minimize risk of fire and any damage which might be caused in the event of fire. Wherever cables pass through floor or wall openings or other partitions, suitable bushes of an approved type shall be supplied and put into position by the Contractor.
- c. Standard cable grips and reels shall be utilized for cable pulling. If unduly difficult pulling occurs, the Contractor shall check the pull required and suspend pulling until further procedure has been approved by the Engineer's Representative. The maximum pull tension shall not exceed the recommended value for the cable measured by the tension dynamometer. In general, any lubricant that does not injure the overall covering and does not set up undesirable conditions of electrostatic stress or electrostatic charge may be used to assist in the pulling of insulated cables in conduits and ducts.
- d. After pulling the cable, the Contractor shall record cable identification with date pulled neatly with waterproof ink in linen tags. Identification tags shall be attached securely to each end of each cable with non-corrosive wire. The said wire must be non-ferrous material on single conductor power cable. Tags shall further be attached at 10-meter intervals on long runs of cables on cable trays and in pull boxes. Cable and joint markers and RCC warning covers shall be provided wherever required.
- e. Sharp bending and kinking of cables shall be avoided. The bending radius for various types of cables shall not be less than those specified below:
 - i. 11 kV, XLPE insulated, multicore : 15 times the overall dia of the cable armored cables
 - ii. 1.1 kV, XLPE insulated, multicore : 12 times the overall dia of the cable armored cables
 - iii. (If shorter radius appears necessary, no bend shall be made until clearance and instructions have been received from the Purchaser/ Engineer in charge)
- f. Power, control and instrumentation cables shall be laid in separate cable racks/ trays.
- g. Where groups of HV, LV and control cables are to be laid along the same route, suitable

barriers to segregate them physically shall be provided.

- h. Where cables cross roads and water, oil, gas or sewage pipes, the cables shall be laid in reinforced spun concrete or steel pipes. For road crossings the pipe for the cables shall be buried at no less than one meter depth.
- i. 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. This is then gently filled up to a depth of about 100 mm above the top of uppermost cable to provide bedding for the protective cable covers which are placed centrally over the cables. The protective cable covers for LV cables may be of earthenware and for HV cables of reinforced concrete. The RCC covers shall have one hole at each end, to tie them to each other with GI wires to prevent displacement. The trench is then 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 75 mm in the centre and tapering towards the sides of the trench.
- j. In each cable run some extra length shall be kept at a suitable point to enable one or two straight through joints to be made, should the cable develop a fault at a later date.
- k. Cables on cable racks, on cable trays and conduits shall be formed to avoid bearing against edges of trays, racks, conduits or their supports upon entering or leaving trays, racks or conduits. Cables shall be racked or laid directory into cantilevered cable trays where practicable, but in some cases, it may be necessary that cables are pulled or threaded into trays. To facilitate visual tracing, cables in trays shall be laid only in single layers and unnecessary crossing of cables shall be avoided. Cables on trays shall finally be clamped in an approved manner.
- l. Cable splices will not be permitted except were permitted by the Purchaser/ Purchaser's Representative. Splices shall be made by Contractor for each type of wire or cable in accordance with the instructions issued by cable manufacturers and the Engineer's Representative. Before splicing, insulated cables shall have conductor insulation stepped and bound or penciled for recommended distance back from splices to provide a long leakage path. After splicing, insulation equal to that on the spliced conductors shall be applied at each splice.
- m. Jointing of cables shall be in accordance with relevant Indian Standards Codes of Practice. Materials and tools required for cable jointing work, including cold setting bituminous compound shall be supplied by the Contractor. Cables shall be firmly clamped on either side of a straight through joint at a distance of not more than 300 mm away from the joints. Identification tags shall be provided at each joint at all cable terminations.
- n. At cable terminal points where the conductor and cable insulation will be terminated, terminations shall be made in a neat, workmanlike and approved manner by men specialized in this class of work.
- o. Control cable termination shall be made in accordance with wiring diagrams, using colour codes established by the Purchaser's Representative for the various control circuit, by code marked wiring diagram.

- p. When control cables are to be fanned out and cabled together with cord, the Contractor shall make connections to terminal blocks, and test the equipment for proper operation before cables are corded together. If there is any question as to the proper connection, the Contractor shall make a temporary connection with sufficient length of cable so that the cable can be switched to another terminal without splicing. After correct connections are established through operating the equipment, cables shall be cut to their correct lengths, connected to terminals in the specified manner, and corded together where necessary to hold them in place in a workmanlike manner.
- q. Cable seals shall be examined to ascertain if they are intact and that cable ends are not damaged. If the seals are found to be broken the cable ends shall not be jointed until after due examination and testing by the Purchaser/ Purchaser's Representative. Before joining is commenced, insulation resistance of both sections of cables to be jointed shall be checked by megger.
- r. After installation and alignment of motors, the Contractor shall complete the conduit installation, including a section of flexible conduit between motor terminal box and trench/ tray. The Contractor shall install and connect the power, control and heater supply cables as per equipment manufacturer's drawings.
- s. Metal sheath and armor of the cable shall be bonded to the earthing system of the station. The size of conductor for bonding shall be appropriate with the system fault current.

12.7 LIGHTING SYSTEM INSTALLATION:

12.7.1 Requirements

This covers the requirements of installation of the following:

- a. Lighting fixtures complete with lamps and accessories
- b. Main Lighting distribution board
- c. Lighting panels
- d. Receptacles and lighting control switches
- e. Point wiring
- f. Street lighting poles and flood light towers
- g. Multi core cables for street and boundary lighting
- h. Maintaining equipment/ materials during storage and being responsible for the equipment/ material until they are handed over to Purchaser.
- i. Installation, testing and commissioning shall be carried out in accordance with the drawings and as stipulated in this specification.

12.7.2 Standards

Applicable Standards for lighting system installation

Electrical wiring installations : IS: 732

(System voltage exceeding 650 V)

Code for practice for interior illumination (Part-1)	:	IS: 3646/ BS: 8206
Code of practice for street lighting installation	:	IS: 1944
Code of practice for industrial lighting	:	IS: 6666
Code of practice for fire safety of building	:	IS: 1646
Boxes for enclosure of electrical accessories	:	IS: 5133(Part-1)
Guide for safety procedures and practices in electrical works	:	IS: 5216
Ceiling roses	:	IS: 371

12.7.3 Lighting Fixtures:

- a. The installation of lighting fixtures shall be based on the mounting arrangement shown in the drawings. The rates quoted for installation shall include all materials required to mount the fixtures. Hooks in RC slabs for suspension of high bay fixtures shall be provided wherever not already provided. Cost of supply and installation of such hooks shall be included in the cost of installation of lighting fixtures. Rate for installation of lighting fixtures shall include cost of installation of control gear box wherever applicable.
- b. Installation of receptacles and switches shall be carried out suitably. Switch shall be mounted in flush with the front cover plate. Cost of supply and installation of necessary hardware shall be included in the lump sum rates quoted for installation of receptacles/ switches.
- c. Lighting distribution boards shall be installed at the suitable location. Installation shall include supply and installation of base channels, foundation bolts, etc.
- d. Outdoor lighting distribution boards shall be installed on a concrete plinth. The top of plinth shall be 1000 mm (min.) above the grade level. Cost of construction of concrete plinth shall be included in Contractor's scope. No cement and steel will be supplied by Purchaser. Installation cost of lighting distribution board shall include cost of installation of earthing conductor from LDB to the nearest earthing grid.

12.7.4 Point Wiring:

- a. Contractor has to prepare the detailed conduit layout drawing showing primary & secondary point wiring points. Point wiring also covers the wiring of the associated control switches of lighting fixtures/control switches of receptacle units.

i. Primary Point Wiring:

Primary point wiring covers the wiring between a circuit of the lighting panel to the junction box of the first lighting fixture/receptacle unit and between junction boxes of the subsequent lighting fixture connected to that circuit of the lighting panel. In some cases where there are junction boxes, the primary point covers the wiring between junction box and the first lighting fixture/receptacle unit in that circuit.

ii. Secondary Point Wiring:

Secondary point wiring covers the wiring of the remaining lighting fixtures/receptacle unit other than that covered under primary point of that circuit in the lighting panel. Secondary point wiring also covers the wiring of the associated control switches of lighting fixtures/control switches and control switches of receptacle units.

b. Supply and Installation of Conduit Point Wiring:

- i. The point wiring shall include supply of necessary materials for the conduit wiring such as galvanized rigid steel conduit, galvanized M.S. fixing saddles with spacer plates, nylon/fiber fixing plugs, galvanized M.S. fixing screws, 12 SWG galvanized steel earthing wire, FRLS PVC insulated Copper conductor wires, control switches and pulling, termination of the earthing/ FRLS PVC insulated wires as required, installation of control switches, drilling holes in brick walls/ RCC roof slabs for taking the wiring conduits and refinishing and any other works/material necessary for making point wiring complete in all respects.
- ii. Wires used for conduit point wiring of lighting fixtures/ceiling fans, 5A receptacles and receptacles above 15A shall be 1.1 kV grade, FRLS PVC insulated, single core, multistranded Copper conductor wires of sizes not less than 1.5 sq. mm and 2.5 sq. mm respectively. Wires shall conform to IS: 694 and shall bear the ISI mark.
- iii. Contractor shall take into consideration necessary galvanized MS fixing clamps when the wiring conduits are to be supported from steel roof truss/structural members.

c. Supply & Installation of cabling for Street and Flood Lighting

- i. Work includes supply and installation of cables required between LDB and junction box mounted on street lighting pole/flood lighting tower and also between junction box mounted on flood light tower to metal enclosed control gear box located near flood light fixture, supply and installation of all the termination accessories such as crimping type cable lugs and double compression cable glands at each junction box and fixture, termination, testing and commissioning of cables. Contractor's scope of work also includes excavation, preparation of riddled soil bedding, supply and installation of protective covers over the cable, backfilling, ramming, supply and installation of route markers, supply and installation of HDPE / Hume pipes for road crossing, etc., supply and installation of necessary cleating arrangement for cabling on flood light tower, supply of labour, supervision, welding equipment, all tools and tackles and testing equipment as required.
- ii. Contractor shall plan and cut the cables in such a way that there is no wastage and no cable jointing is required in any run. However, should any joint become necessary the same shall be provided by the Contractor and a joint marker shall also be provided at no extra cost. Earthing of street light pole/flood light tower, lighting fixtures, etc. are included under Contractor scope.

d. Point wiring shall also include/ hold good for the following:

- i. Supply and installation of lighting control switches and switchboxes complete with fixing accessories.
- ii. Drilling holes in brick/ RCC wall and roof for taking cable or conduit, sealing and refinishing with cement plaster.
- iii. Testing, commissioning and handing over the lighting system in commercial working condition.
- iv. Marginal shifting of any fixture/accessory from the location indicated in the lighting layout drawings.

12.7.5 Outdoor Lighting (Street and Flood Lighting):

The following shall be deemed to be included as part of the installation work for outdoor lighting point wiring.

- a. Installation of multicore/ single core cables between LDB and junction box mounted on street light pole/flood lighting tower, from junction box to metal enclosed control gear box.
- b. Supply and installation of crimping type cable lugs, double compression type cable glands at each junction box and fixture, termination, testing and commissioning of cables.
- c. Contractor's scope shall also include excavation and preparation for buried cables. Supply and installation of route markers, supply and installation of HDPE/ Hume pipes for road crossing shall also be included in the scope of installation of point wiring.
- d. Supply and installation of necessary cleating arrangement for cabling on flood light poles.
- e. Contractor shall provide necessary foundation for erecting street light pole/ flood light tower and install the same. Contractor shall prepare foundation drawings with necessary details & Purchaser Representative's approval shall be obtained.
- f. Contractor shall plan and cut the cables in such a way that there is no wastage and no cable jointing is required in any run. However, should any joint become necessary, the same shall be provided by the Contractor and joint marker shall also be provided at no extra cost.
- g. Earthing of street light pole/flood light tower, lighting fixtures, control gear boxes, junction boxes, etc. are also included in the scope of installation of point wiring. Contractor shall earth street light pole/flood light poles and junction box with 25x3 mm G.S. flat tap off from the 25x3 mm M.S. flat earthing grid along the street lighting included in scope. The Contractor shall interconnect earthing grid to plant main earthing grid at first and last pole of each feeder circuit and at one intermediate pole.
- h. Installation of lighting Poles and Towers for Outdoor Lighting (Street and Flood Lighting)-
 - i. Work includes supply and installation of street light poles and flood light towers including associated junction boxes with fuses, links and terminals for junction boxes and junction boxes near each flood light fixtures.
 - ii. All street light poles and towers shall be painted with one shop coat of red oxide oil primer followed by two coats of aluminium alkyd paint.

12.7.6 LDB & LIGHTING PANELS

Installation of Lighting Distribution Board, Lighting Panels (AC & DC), 230 V, AC 1- Ph Distribution Boards.

Installation of above items shall include necessary foundation channels, bolts/ nuts, etc. for grouting lighting distribution boards, iron brackets/ grouting brackets, bolts/nuts for wall/ column mounted panels and associated civil works.

12.7.7 REQUIREMENTS

Details of work requirements are covered in lighting installation notes and details and typical drawings which form the part of specification. Any changes, if necessary due to site conditions/requirements shall be carried out after obtaining approval of Purchaser/ Purchaser's Representative. The changes carried out shall be marked clearly in the layout drawings by Contractor and 'AS BUILT DRAWING' shall be prepared by the 'Contractor' and this shall be forwarded to Purchaser's site / design office.

a. Wiring

- i. Wiring shall be carried out strictly as per project drawings and technical specification. All exposed conduit wiring shall have provision for easy inspection. Where cable wiring is specified, cable shall be cleated on to the wall as close to the ceiling as possible. In all types of wiring due consideration shall be given for neatness and appearance.
- ii. Wherever DC emergency lighting is provided, emergency lighting wires shall run in a separate conduit. Colour of the wires used shall be as follows; white for positive, black for negative.
- iii. Wherever lighting system has three phase distribution, separate conduits shall be used for different phases. For easy identification of phases and neutral wires the following colour wires shall be used.

R - Phase - Red

Y - Phase - Yellow

B - Phase - Blue

N – Neutral - Black

- b. There shall be a circuit breaker on each live conductor of supply mains at the point of entry.
- c. Conductors not arranged for connection to the same system or supply different phases of the same supply, shall be kept apart throughout their entire run.
- d. Receptacles and lighting fittings in general shall be fed from different Circuits. Five amps receptacles for toilet or small rooms can be fed from the lighting circuit with proper isolating arrangement.
- e. Each final sub-circuit from a lighting panel shall be controlled by a single pole switch connected to the live conductor.
- f. For long conduit wiring runs, inspection/ pull boxes shall be provided at intervals not exceeding 10 meters. Such facilities shall also be provided at conduit bends.

12.7.8 General Practices for lighting:

- a. All receptacles and switches to be installed in offices and control rooms shall be flush mounted within the wall and those in other areas shall be wall or column mounted.
- b. Ceiling roses shall not embody fuse terminals as an integral part. For voltages exceeding 250 volts, a ceiling rose or any similar attachment shall not be used.
- c. All exposed metal parts of the plug, when the plug is in complete engagement with the socket outlet, shall be in effective electrical connection with the earthing pin.

12.7.9 Earthing for lighting:

- a. Conduits and fittings shall be earthed by 12 SWG GI wires run along the length of the conduit and secured by means of suitable clamps efficiently fastened to conduit tip. To achieve perfect electrical continuity, the conduits shall be bonded effectively on either end of a coupling and other joints.
- b. Conduits shall be earthed at the ends adjacent to switch boards at which they originate or otherwise at the earth clip, clamp or gland, in effective electrical contact with the conduit.
- c. For outdoor lighting poles & mast 8 SWG GI earth wire shall be run buried in ground at a depth of 600 mm along-with lighting cables and shall be terminated up to the junction box on the pole and 12 SWG wire shall be taken up to the pole fitting. In case of lighting poles where the main earth grid is far away from the pole, local pits shall be provided for pole earthing.

13. INSPECTION & FIELD TEST OF ELECTRICAL EQUIPMENT'S

13.1 Scope

The work to be performed under these guidelines cover the quality assurance plan for the inspection and testing of electrical installations at site.

13.2 General requirements

- a. The contractor shall furnish necessary meters, instruments, temporary wiring and labour to perform all required tests, adjustments and wiring of all equipment installed and/ or connected under the contract including electrical equipment supplied by others, if any, to determine proper polarity, phasing, freedom from grounds and shorts and the proper operation of the equipment, meters, relays, etc. All testing instruments shall be calibrated and certified for accuracy by competent authority.
- b. Inspection and testing shall be carried out to ensure that all equipment and materials have been installed as required and as per the relevant International Standard Specifications and Codes, Local Rules and Regulations, requirements of Fire Insurance, Chief Electrical Inspector and any other authorities having jurisdiction. The installation must pass all inspection and will be subject to the approval of the Owner and the concerned local authorities.
- c. Before the electrical facilities are placed in operation, the Contractor shall make suitable tests to establish to the satisfaction of the Owner that all equipment, devices and wiring have been correctly installed, are in satisfactory condition and will operate as intended.
- d. All tests shall be performed by or under the direct supervision of men qualified for carrying out inspection and testing.
- e. Owner reserves the right to witness all tests, and he shall be informed in this regard two weeks before the tests are to take place. Owner reserves the right to approve the test results before circuits or equipment will be energized for the first time.
- f. If motors record low insulation resistance, then they must be dried to obtain the required insulation resistance values. Approval of the drying methods shall be obtained from Owner before applying heat.
- g. All results of the tests shall be recorded on prescribed test data sheets. All tests described herein shall be recorded on forms provided or agreed upon by Owner. Test reports shall include, for each test, the date of performance and name of the person in charge of the test.
- h. Before starting the tests, a visual inspection of the material / equipment is to be made to determine that all components are installed as per drawings and in a neat and workman-like manner and that, in general, the equipment is ready for testing.
- i. In case of fault, the Contractor shall isolate the fault and shall take necessary steps to eliminate the fault to the satisfaction of Owner. All defects through faulty workmanship of contractor or of equipment and material supplied by him shall be corrected or replaced at his own expense.
- j. Before commencement of any test, all equipment shall be thoroughly cleaned by blower and

checked for proper and rigid connection of termination, fixing of foundation bolts, etc.

- k. Contractor shall submit all formats for tests to be conducted on each equipment/system in accordance with these specifications for approval to the Owner before entering the test readings.

13.3 Site Acceptance Test (SAT)

Check all units for proper rating and size. Inspect earth connections, terminations on EHV, HV & LV sides. Checks for oil leaks at all fittings and connections. Check for thermometer, breather and other safety devices. Check oil level and colour of silica gel.

13.3.1 EHV equipment

Lightning Arrester, CTs, VTs, isolators, circuit breakers, insulators

1. Insulation resistance test with 5KV/1KV megger as applicable for each equipment and for system.
2. Physical checking of equipment - visual examination.
3. Operational tests for Circuit breakers, isolators and associated relays, motors.
4. Ratio tests, polarity tests, secondary injection, primary injection tests for CTs/VTs.
5. Interlocks checking / testing.
6. Earth continuity test.
7. Phasing checks on system energization.
8. All other tests as per equipment supplier's recommendations.

13.3.2 Power transformer

A. Tests

1. Winding insulation resistance shall be measured from primary and secondary windings to earth and from primary to secondary winding. The winding, which is not under test, shall be earthed during the test.
2. The insulation resistance should be measured by at least 1000 Volts megger. Every time the voltage should be applied for 1 minute. While taking the insulation resistance measurements, the value of insulation resistance shall not be less than 400 Mega ohms at 30 Degree Celsius and 200 Mega ohms at 40 Degree Celsius for HV winding and 50 Mega ohms at 30 Degree C and 25 Mega ohms at 40 Degree Celsius for LV winding. If the values obtained are less than the above figures, drying out process shall be necessary.
3. Measure the dielectric strength of transformer oil in accordance with IS: 335. The oil should withstand at least 40KV for 1 minute when tested.
4. Test operation of Buchholz relay in accordance with Manufacturer's instructions

B. On-load tap changer (OLTC)

1. General

Check for oil leakage, at all fittings and connections. Check for selector switch, tap changing contacts, motor and manual driving mechanism and all indicating and control instruments.

2. Tests

- i. Test the automatic operation of the on-load tap changer connected to the transformer. Measure the primary and secondary voltage with tap changer in each position and verify that the voltage ratios are in accordance with the specified data on the nameplate.
- ii. Test the gear for correct operation of tap position indicator, step-correcting switches, limit switch, over travel torque limiter, counter, sequence switches and similar devices.
- iii. Dielectric strength of oil shall be in accordance with Indian Standard 335. Minimum acceptable value shall be 40 KV for 1 minute.
- iv. Prior to placing the transformer with OLTC in regular service, tap changer shall be set to provide rated secondary voltage at no load for the value of primary voltage expected at start-up, and OLTC will be set for automatic operation.
- v. Before energizing the OLTC, the insulation resistance of electrical control circuits shall be measured from phase to earth. Minimum acceptable value will be 1 Mega ohm.

C. Off-circuit tap changer (OCTC)

- i. Check for oil leakage, at all fittings and connections. Check for tap changing contacts, manual driving mechanism and all indicating instruments.
- ii. Tests
 - (1) Test the operation of the off-load tap changer connected to the transformer. Measure the primary and secondary voltage with tap changer in each position and verify that the voltage ratios are in accordance with the specified data on the nameplate.
 - (2) Test the gear for correct operation of tap position indicator.
 - (3) Prior to placing the transformer with off-circuit tap changer in regular service, tap changer shall be set to provide rated secondary voltage at no load for the value of primary voltage expected at start-up.

13.3.3 High voltage switchgear

- a. Before switchgear is energized, the insulation resistance of each bus shall be measured from phase to phase and from phase to earth. Measurements shall be repeated with circuit breakers in operating position and contacts open. Each test shall be held until constant reading is obtained. Minimum time shall be ten seconds. Minimum megger reading shall be 10 Mega ohms.
- b. Before switchgear is energized, the insulation resistance of all D.C. control circuits shall be measured from phase to earth. Minimum acceptable value shall be 1 Mega ohm.
- c. Each adjustable protective relay shall be set, calibrated and tested by using a cycle counter, load box, ammeter, and voltmeter as required or by using a suitable relay test set having good wave form. Settings, calibration points, and test points shall be in accordance with values given by the approved relay settings for the job.
- d. Test all current transformer secondary circuits by applying current (thro secondary injection test) to transformer secondary windings and verifying that relay(s) and/or meter(s) operate properly.

- e. Test all potential transformer secondary circuits by applying voltage to potential transformer secondary winding and verifying that relay(s) and/or meter(s) operate properly.
- f. Test all the circuit breakers for proper interlocking operation. The sequence of interlocking shall be as indicated on single line diagram.
- g. Test the operation of tie breakers / bus couplers.
- h. The following tests shall be performed on all circuit breakers before they are operated: -
 - 1. Contact alignment shall be checked and adjusted where necessary in accordance with manufacturer's instructions.
 - 2. Each circuit breaker shall be drawn out of its cubicle and shall be closed manually, and then its insulation resistance shall be measured from phase to phase and from phase to earth.
 - 3. All adjustable direct acting trip devices shall be set using values given in the approved relay settings for the job.
- i. Before switchgear is energized, the following tests shall be performed on each circuit breaker in its 'test' position: -
 - 1. Close and trip circuit breaker from its control switch, push button, or operating handle.
 - 2. Test operation of circuit breaker latch and check switch, where provided.
 - 3. Test proper operation of lockout device in the closing circuit, where provided, by simulating conditions, which would cause a lockout to occur.
 - 4. Trip breaker by manual operation or by applying current or voltage to each of its associated protective relays.
 - 5. All automatic control operations and interlocks shall be tested for correct operation.
- j. After completion of tests, all test results shall be recorded in standard format approved by Owner, witnessing site Owner and contractor's representative.
- k. All test reports shall indicate the details of the instruments used for test with date and time of test.
- l. After commissioning of the equipment, all measuring and indicating instruments to be checked properly for operation. Any improper operation of these indicating lamps / instruments shall be corrected by checking fuse / connections, polarity, etc. If still these are found to be not in working condition, the supplier should report the same to the Owner for suitable action for replacement.

13.3.4 Medium voltage switchgear

- a. Main LT switchboard
 - 1. Before switchgear is energized, the insulation resistance of each bus shall be measured from phase to phase and from phase to earth. Measurements shall be repeated with circuit breakers in operating position and contacts open. Each test shall be held until constant reading is obtained. Minimum time shall be ten seconds. Minimum megger reading shall be 10 Mega ohms.
 - 2. Before switchgear is energized, the insulation resistance of all D.C. control circuits shall be measured from phase to earth. Minimum acceptable value shall be 1 Mega ohm.
 - 3. Each adjustable protective relay shall be set, calibrated and tested by using a cycle counter,

load box, ammeter and voltmeter as required or by using a suitable relay test set having good wave form. Settings, calibration points and test points shall be in accordance with values given for the approved relay settings for the job.

4. Test all current transformer secondary circuit by applying current (thro secondary injection test) to transformer secondary windings and verifying that relay(s) and/or meter(s) operate properly.
 5. Test all the relevant circuit breakers for proper interlocking operation. The sequence of interlocking is as indicated on single line diagram.
 6. Test the operation of tie breakers / bus couplers.
 7. The following tests shall be performed on all circuit breakers before they are operated: -
 - i. Contact alignment shall be checked and adjusted where necessary in accordance with manufacturer's instructions.
 - ii. Each circuit breaker shall be drawn out of its cubicle and shall be closed manually, and then its insulation resistance shall be measured from phase to phase and from phase to earth.
 - iii. All adjustable direct acting trip devices shall be set using values given in the approved relay settings for the job.
 8. Before switchgear is energized, the following tests shall be performed on each circuit breaker in its 'test' position: -
 - i. Close and trip circuit breaker from its control switch, push button or operating handle.
 - ii. Test operation of circuit breaker latch and check switch, where provided.
 - iii. Test proper operation of lockout device in the closing circuit, where provided, by simulating conditions, which would cause a lockout to occur.
 - iv. Trip breaker by manual operation or by applying current or voltage to each of its associated protective relays.
 9. All automatic control operations and interlocks shall be tested for correct operation.
 10. After completion of tests, all test results shall be recorded in standard format approved by Owner, witnessing site Owner and contractor's representative.
 11. All test reports shall indicate the details of the instruments used for test with date and time of test.
 12. After commissioning of the equipment, all measuring and indicating instruments to be checked properly for operation. Any improper operation of these indicating lamps / instruments shall be corrected by checking fuse / connections, polarity, etc. If still these are found to be not in working condition, the supplier should report the same to the Owner for suitable action for replacement.
- b. RTCC, motor control centre (MCC), DCDB, APFC Panels
1. Before energizing, the insulation resistance of each bus shall be measured from phase to phase and from phase to earth with disconnecting devices. Repeat measurements with devices closed but with contactors open. Minimum acceptable value shall be 10 Mega ohms.

2. Contact alignment of each contactor shall be checked and adjusted where necessary in accordance with manufacturer's instructions.
3. Before energizing, the insulation resistance on both the "line side" and "load side" of each contactor shall be measured separately from phase to phase and from phase to earth. Minimum acceptable value shall be 10 Mega ohms.
4. Set each adjustable relay and direct acting trip device in accordance with values given in the approved relay setting record.
5. Each contactor shall be closed and tripped from its control switch and/or push-button station to test proper operation.

c. other distribution boards

1. Before energizing, the insulation resistance of each bus shall be measured from phase to phase and from phase to earth with circuit breakers/isolating switch open. Measurements shall be repeated with circuit breakers/isolating switch closed.
2. The distribution boards shall be checked for rigid mounting, earthing connections, proper rating and size of components, interlocking and overload settings.

13.3.5 H.V. cable

- a. A D.C. high voltage test shall be made, after installation, on HV XLPE cables.
- b. Test data shall be noted for record purposes. Measure values of leakage current versus time.
- c. The D.C. high voltage tests shall be performed in accordance with following: -
 1. Cables shall be installed in final position, with all through splices complete. Terminations shall be kept unfinished so that motors, switchgear, transformers, etc. are not subjected to the test voltage. However, insulation shall be penciled and otherwise prepared for completion of the termination of the cable, including making up & grounding of stress cone for shielded cable.
 2. Where potheads are employed, all internal work in making up the pothead shall be completed including filling. Pothead insulators shall be clean and dry.
- d. The test voltage, duration of test, and test procedure shall be in accordance with IS: 1255.

13.3.6 L.V cable

- a. A megger test shall be made for continuity and proper end-to-end connection and correct termination after installation, on all feeder cables including motor feeder cables.
- b. Record test data between phase to phase and phase to earth.
- c. The test voltage, duration of test and test procedure shall be in accordance with IS: 4288.

13.3.7 Wiring

- a. Before energizing, the insulation resistance of every circuit shall be measured from phase to phase, from phase to neutral and phase to earth.

- b. The insulation resistance of the circuits noted below shall be measured as follows: -
 - 1. Motor feeders: with motors disconnected, measure insulation resistance from load side of circuit breakers or contactors.
 - 2. Motor control circuits: With push buttons and over current devices connected, measure insulation resistance from phase to earth.
 - 3. Lighting feeders: Measure insulation resistance with circuit breakers or switch-fuse units on panel boards connected but with lighting branch circuit breakers or switches open.
 - 4. Lighting branch circuits: Measure insulation resistance after all lamp holders, receptacles, fixtures, etc. are connected but before fixing of lamps.
- c. Where splices or terminations are required in circuits rated above 600 Volts, measure insulation resistance of each length of cable before splicing and/or terminating. Repeat measurements, after splices and/or terminations are complete.
- d. Measure the insulation resistance of buried cable circuits before cable trenches are backfilled. Repeat measurements after backfilling.
- e. Test light intensity of each room by light intensity meter at working height and record the same.
- f. All receptacles shall be tested for correct phase sequence and by test lamp for operation of switch and continuity of earthing.

13.3.8 Alarms

All electrical alarms shall be tested for proper operation by causing alarm to sound under simulated abnormal conditions.

13.3.9 Earthing

a. Specifications

Earthing shall be carried out as per IS Code of Practice: 3043 and as shown in the relevant drawings.

b. General inspection

Check that earthing system is installed as per drawings.

Check that all connections are tight and connections are protected from mechanical injury.

c. Testing

The resistance to ground shall be measured at the following locations:

- i. The resistance of the system/neutral earthing should be maintained preferably at less than 1 Ohm.
 - ii. At each earthing point provided for lightning protection, the earth resistance shall preferably not exceed 1 Ohm.
 - iii. At any one point of each system used to provide earthing to electrical equipment enclosures, resistance shall not preferably exceed 1 Ohm.
- d. Measurements shall be done before connection is made between the earth and the object to be earthed.

13.3.10 Insulating liquid dielectric test

For test of the dielectric strength of insulating liquid or oil in transformer or reactor, test sample of liquid shall be drawn from equipment after filling. In some cases, a test also shall be made with samples drawn from the liquid container before the equipment is filled. Tests shall be carried as per IS: 335.

14. MODE OF MEASUREMENT & PAYMENT

All measurements must confirm to relevant IS (Indian Standards) or IEC standards (if applicable). Measurements should include Supply, Installation, Testing and commissioning. If not, these must be measured as separate line items. The Payment shall be made as per tender conditions given in price bid document and after supply, installation, testing and commissioning of all required item.

Mode of measurement & payment should be given as per below table.

Sr. No.	Item	Mode of measurement & payment
1	Switch Fuse Unit	Per number basis
2	LV panel (ATS starter)	Per number basis of complete assembly
3	Light distribution board	Per number basis
4	Medium voltage cables	Per running meter basis
5	Cable gland	Per number basis
6	Cable lugs	Per number basis
7	Copper earth plate	Per number basis
8	Earth pit	Per number basis
9	GI strip	Per weight basis
10	Wire of given size (main wiring)	Per running meter basis
11	Point wiring	Per number basis
12	LED tube light	Per number basis
13	LED street light with all required accessories i.e., pole, pole box, bracket, GI mounting pipe etc.	Per number basis
14	Copper strip & plate	Per weight basis
15	GI strip wire	Per weight basis
16	Celling fan	Per number basis
17	Exhaust fan	Per number basis
18	Fire extinguisher	Per number basis
19	First aid box	Per square meter basis
20	Instruction chart	Per number basis
21	Fire bucket	Per number basis
22	Rubber matting	Per square meter basis
23	Hand gloves	Per number basis