

ELECTRICAL WORKS SPECIFICATION

DOC. NO.	OAB REDEVELOPMENT, NLSIU, BENGALURU	PROJECT NO.
ELE / 001	MATERIAL SPECIFICATION - ELECTRICAL SYSTEM	AD/0123

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MEDIUM VOLTAGE (MV) CABLES

This specification covers design, manufacture, testing, packing and delivery of 1100 Volts grade, Aluminum/ Copper conductor, XLPE insulated multi core power cables by road/rail to the site.

The cable shall conform in all respects to high standards of engineering, design and workmanship and shall be capable of performing in continuous commercial operation, in a manner acceptable to purchaser. The offered material shall be complete with all components necessary for their effective and trouble-free operation. Such components shall be deemed to be within the scope of Bidder's supply irrespective of whether those are specifically brought out in these specifications and / or the commercial order or not.

STANDARDS

Unless otherwise specified elsewhere in this specification, the rating as well as performance and testing of the LT XLPE power cables shall conform to the latest revisions available at the time of placement of order of all the relevant standards as listed in, but not limited to standards as below.

- IS: 7098 (Part 1) / 1988 (amended up to date) suitable for working voltages up to and including 1100 Volts.
- IS: 5831 / 1984 modified up to date in all respects with regard to PVC insulation and sheath of electric cables
- IS: 8130 / 1984 - PVC insulated for conductors for insulated electric cables and flexible cords.
- IS: 3975 / 1988 for Mild Steel wires, formed wires and tapes for armouring of cables
- IS: 10462 (Part I) / 1983 - Fictitious calculation method for determination of dimensions of protective covering of cables.

In case of imported item, the standards of the country of origin shall be applicable if these standards are equivalent or more stringent than the applicable Indian standards.

The cables shall also conform to the provisions of Indian Electricity Rules and other statutory regulations currently in force in the country. In case Indian standards are not available for any item, standards issued by IEC/IEEE or equivalent agency shall be applicable.

The MV cables shall be cross linked polyethylene (XLPE) insulated PVC inner sheathed and FRLS PVC outer sheath of 1100 volts grade as asked for in the schedule of quantities. Cables up to 16 sq.mm shall be with copper conductor and 25 sq.mm and above 25 sq.mm shall be with aluminium conductor.

The following code is used throughout the specification and drawings.

- a) PVC ----- polyvinyl chloride insulated
- b) PVC/PVC ----- Polyvinyl chloride insulated and sheathed
- c) PVC/DSTA/PVC ----- Polyvinyl chloride insulated, double steel tape armored and polyvinyl chloride over sheath.
- d) PVC/SWA/PVC ----- Polyvinyl chloride insulated, steel tape armoured and polyvinyl chloride over sheath.
- e) XLPE/PVC ----- Cross-linked polyethylene insulated, polyvinyl chloride over sheath.

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- f) FRLS ----- Fire resistant layer with polyethylene insulated fire retardant low-smoke

Cables shall be delivered to site in the manufacturer's standard packing with seals and labels intact, except that cables larger than 4 mm² may be delivered in required lengths. Colour code shall be according to IS 732. When necessary, cable ends shall be temporary sealed and tested before connection.

All cable ducts and pipes shall be sealed by the Contractor. No joint will be allowed without the consent of the Engineer in-charge. Wooden cable drums shall be treated by wood preservative and insecticide.

Specifications of PVC insulated copper cable shall be as follows:

a. Conductor

The conductors shall be solid for conductor of nominal area of up to 10 mm² for Aluminium, and the conductor shall be solid or stranded for nominal area of 1.5 mm² to 6 mm² for Copper. The conductor from 10 mm² and above for Copper and from 16 mm² and above for Aluminium shall be stranded as per IS 8130. Cables with reduced neutral conductor shall have sizes as per Table 1 of IS 1554.

b. Insulation

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. Control cables having 6 cores and above shall be identified with prominent and indelible Arabic numerals on the outer surface of the insulation. Colour of the numbers shall contrast with the 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. Laying-up

Insulated conductors of multi core cables shall be with thermoplastic fillers in the interstices. The phase identification of cores shall be by coloured strips.

d. Inner Sheath

Cores shall be surrounded either by a wrapped or an extruded PVC sheath. The inner sheath shall be applied over the laid-up cores by extrusion and shall be of PVC conforming 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. Single core cables shall have no inner sheath.

e. Armouring

The armouring shall be provided over the inner sheath. Single core cable shall have dia -magnetic armouring. If armouring is specified for multi core cables in the data sheet, the same shall be by single round galvanized steel wires where the calculated diameter below armouring does not exceed 13 mm and by galvanized steel strips where this dimension is greater than 13 mm. Requirement and methods of tests for armour material and uniformity of galvanization shall be as per IS: 3975 and IS: 10810. The dimensions of Armour shall be as per method (b) of IS: 1554. If armouring 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.

f. Outer Sheath

Single and multi-core cables are provided with an extruded FRLS grade PVC outer-sheath. The thickness of the sheath shall be as per IS: 1554-1988. The PVC compound for the outer-sheath shall confirm to Type ST1 of IS 5831. The colour of the outer sheath shall be black with marking at every meter.

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Suitable additives are added to prevent attack by rodents and termites. All serving must be given anti-termite treatment.

Specifications for XLPE aluminium / copper cable shall be as follows:

a. Conductor

Stranded compacted circular conductor shall be of electrical grade high conductivity aluminium per IS 8130/84

b. Insulation

The insulation shall be of natural unfilled chemically cross linked polyethylene conforming to IS 7098. The thickness of insulation shall be as per the relevant codes. It shall be free from voids and shall withstand all mechanical and thermal stresses under steady state and transient operating conditions. The insulation screen shall consist of non-metallic extruded semi-conducting compound in combination with a non-magnetic metallic copper/Aluminium screen. Unless specified otherwise, the copper/Aluminium screen for all the three cores together shall be capable of carrying the single line to ground fault current value and the duration specified in the data sheet.

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 coloured strips or by printed numerals

c. Laying-up

Insulated conductors of multi core cables shall be with plastic fiber in the interstices. The phase identification of cores shall be by coloured strips.

d. Inner Sheath

The cores shall be surrounded by either a wrapped or by an extruded PVC sheath. The thickness of the inner sheath shall be as indicated in the relevant codes.

The inner sheath shall be applied over the laid up cores by extrusion and shall conform to the requirements of type ST 2 compound of IS: 5831. The extruded inner sheath shall be of uniform thickness. In case of single core cables, there shall be extruded inner sheath between insulation metallic screen and armouring.

e. Armouring

The armouring shall be provided over the inner sheath. Single core cable shall have non-magnetic armouring. Multi core cables shall have either galvanized round steel wires or flat steel strip. Steel wires and strips for armouring confirm to IS: 3975. The direction of lay of armouring shall be opposite to that of cores.

f. Outer Sheath

Single and multi-core cables are provided with an extruded FRLS grade PVC outer-sheath. The thickness of the sheath shall be as per IS: 1554-1988. The PVC compound for the outer-sheath shall confirm to Type ST2 of IS 5831. The colour of the outer sheath shall be black with marking at every meter.

Current ratings of the cables shall be as per IS: 3961. The Conductor shall be stranded Aluminum/Copper circular/ sector shaped and compacted. In multi core cables the core shall be identified by red, yellow, blue and black coloring of insulation. Repaired cables shall not be used. The cables shall be suitable for laying in racks, ducts, trenches, conduits and underground buried installation with uncontrolled back fill and chances of flooding by water. Progressive automatic in line sequential marking of the length of cables in meters at every one meter shall be provided on the outer sheath of all cables. Cables shall be supplied in non-returnable wooden drums as per IS: 10418. Both ends of the cables shall be properly sealed with PVC/Rubber caps so as to eliminate ingress of water during transportation, storage and erection.

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The product should be coded as per IS: - 7098 Part-I as follows:-

Aluminium Conductor	A	
XLPE Insulation	2X	
Steel round wire armour		W
Steel strip armour	F	
Steel Double round wire armour	WW	
Steel Double strip armour	FF	
Non-magnetic (Al.) round wire armour		Wa
Non-magnetic (Al.) strip armour	Fa	
PVC outer sheath	Y	

Control cables and indicating panel cables shall be multi core PVC insulated copper conductor and armoured cables.

Inspection

All cables shall be inspected by the contractor upon receipt at site and checked for any damage during transit.

Fire Resistant (FRLS) Cables

Cable shall be manufactured in accordance with relevant IS code. Cable shall be tested in accordance to Category C, W & Z of SS299 Part 1 for fire resistant, water and mechanical shock respectively. All fire resistant cable shall be Halogen free and conform to IEC 754 Part 1. Armoured FRLS cables shall be tested in accordance to BS6724.

The fire resistant cable shall be of 660/1000 volts grade, suitable for surface wiring and wiring in conduit or duct. The cable shall be both fire resistant and flame retardant to IEC 331 and IEC 332 respectively. It shall be approved by the local authority for use as fire resistant cables in emergency circuit's applications. Test Certificate to substantiate the compliance to IEC standards shall be submitted.

The conductor shall be made of stranded, soft anneal copper wires. The outer jacket shall be made of fire retardant low chlorine PVC. Core identification of the cable shall be by colour of the insulation according to IS 732. The maximum resistance of the conductors at 20 deg C shall not exceed.

The cable and accessories shall be designed for operation up to a conductor temperature of 105 deg C. The cable shall be suitable for installation by conventional methods without requiring expensive special tools, seals or terminations. They shall be non-hygroscopic, maintenance free and insensitive to vibrations.

Cables shall be strapped or tied to the cable support system using stainless steel cable ties or strappings. The stainless steel cable ties and strap shall be tested and approved for used in fire resistant wiring systems with minimum grade of 304.

The spacing of the straps/ties shall conform to the manufacturer recommendation but shall in all cases not exceed 1 meter interval.

As far as possible, joints shall be avoided. Where this is not possible due to extra-long run, prior written approval shall be obtained from the S.O. This shall include the joint method and material use which shall not undermine the fire, mechanical and electrical integrity of the cable under all circumstances.

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RATING

The cables shall be rated for a voltage of 660/ 1100 volts.

CORE IDENTIFICATION

Cores shall be provided with the following colour scheme of PVC insulation:

- a. 1 core Red / Black / Yellow / Blue
- b. 2 core Red and Black
- c. 3 core Red, Yellow & Blue
- d. 3.5 / 4 core Red, Yellow, and Blue & Black

CABLE PROCUREMENT, RECEIPT AND STORAGE

The contractor shall inspect and mark the route /route length along which he proposes to lay the cables and obtain the approval of the clients. Cables shall then be ordered. All the cables shall be supplied on drums.

Upon receipt at site, all cables shall be inspected and checked for any damage during transit. Megger and core continuity tests shall be carried out and recorded.

The contractor shall take care to see that all the cables received at site are apportioned to various locations as approved earlier. Cables shall be stored in drums with flanges of the cable drum in vertical position.

LAYING OF CABLES

Cables shall be laid as per the specifications given below. Cables shall be laid by experienced workman using rollers. The cable drums shall be placed on jacks before unwinding the cable. Care shall be taken while laying cables to avoid formation of kinks.

Tags shall be provided at both ends and all change in directions, both sides of the wall and floor crossing. Cables crossing through walls and floor shall be through pipe and shall be sealed with fire retardant sealant and shall be painted with fire retardant paint up to 1 Mr. on all joints, terminations and both sides of crossing.

A. OUTDOOR

Cables shall be laid in outdoor trenches wherever called for. The depth and width of the trench shall as per the drawing. However, where more than one cable is laid an axial distance of highest cable size diameter shall be allowed between the cables. The trenches shall be cut square with vertical side walls and with uniform depth. Suitable shoring and propping may be done to avoid caving in of trench walls during the cable laying.

The cable drums shall be unrolled in the direction of the arrow for unrolling. The cable shall be tested for continuity and insulation resistance. Wherever cables are bent, the minimum bending radius shall not be less than 12 times the diameter of the cable. Cables shall be laid in RCC Hume pipes at all road crossings and in GI pipe at the wall entries. Cable route markers to be provided as per standards.

Proper care to be taken to ensure that the trench is properly protected on both ends to prevent any human being to fall into it. Danger signages and reflectors to be installed at strategic locations to warn people. Route markers shall be provided along straight lines of cables at an interval not exceeding 20 Mtrs. also, for change in the direction.

B. INDOOR

MV cables laid indoor, above false ceiling wherever specified shall be laid on slotted angle steel cable trays/ supported on MS angle supports, on walls, on columns/beams as required. Suitable clamping with straps and

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saddles shall be used for keeping the cable in position. Spacing between the cables shall not be less than the overall diameter of the cable.

Cables run on wall surface, up to 600mm above FFL, shall be protected by GI pipe of adequate size. Cables run inside concrete trenches shall be supported on cable trays/ on MS angle supports and shall be neatly arranged and clamped.

Cable entry from outdoors to indoors shall be via GI/ Stoneware/ RCC pipes and shall be sealed water tight with approved type of sealant to avoid water entering the building. Cable tags shall be affixed to all cables.

CABLE JOINTING

Joints in cables shall NOT be allowed as a rule. Where joints are unavoidable, the location of such joints shall be got approved.

Cable joint box / kit shall be of appropriate size, suitable for PVC insulated, armoured MV cables of particular voltage grade.

All cable joints shall be made in suitable, approved cable joint box / kit. Jointing of cables in the joint boxes and filling in of compound shall be done in accordance with manufacturer's instructions and in an approved manner.

Joints that are directly buried such as Straight-through and T-joints shall be done in epoxy mound boxes with epoxy resin. End terminations shall be done using brass cable gland and heat-shrinkable cable jointing kits.

All cables shall be jointed colour to colour and tested for continuity and insulation resistance both BEFORE and AFTER jointing. The seals of cables must not be removed until preparations for jointing are completed. Joints shall be finished on the same day as commenced and sufficient protection from the weather shall be arranged. Joints shall be made by means of proper size crimping type copper lugs for conductors. The conductors shall be firmly pushed into / butted into the lug/ferrule and crimped using correct crimping die / tool and anti-corrosive paste. The conductors /lugs shall then be efficiently insulated with insulating tape and by using spreaders of approved size and pattern. The joints shall be completely topped up with epoxy compound/ covered with stress relieving heat-shrink sleeve.

BONDING OF CABLES

Where a cable enters any piece of apparatus, it shall be connected to the casing by means of an approved type of copper clamp for the gland. The clamp must grip the armouring firmly to the gland or casing, so that no undue stress is passed on to the cable conductors due to vibrations. The gland shall be fixed to the lead sheath by means of either a plumbing joint or a cone of approved material, capable of being compressed onto the armouring. The gland or cone shall be capable of effecting a good electrical bond between both the armouring of the cable and the casing.

TESTING OF CABLES

Tests shall be conducted for insulation between phases and between phase and earth for each length of cable on receipt, before and after jointing and on completion of cable laying work. The following tests shall be conducted in the presence of the Owner /Consultant:

- Insulation Resistance Test (sectional and overall)
- Continuity Resistance Test.
- Armour Continuity Test.
- Sheathing Continuity Test.
- Hi-pot Test.

All tests shall be carried out in accordance with the relevant standard code of practice and Electricity Rules. The contractor shall provide necessary instruments, equipment, and labor for conducting the above tests and shall

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bear all expenses in connection with such tests. All test equipment used for the tests shall bear a calibration seal not more than six months old. All tests shall be carried out in the presence of the Owner / Consultant.

Soil Conditions:

The knowledge of the soil and environmental conditions helps in selecting the type of finish of protective covering of the cable and the route of lying. The knowledge of the type of micro biological organizations and termites existing in the soil where the cables are to be stored or installed may also be useful.

Chemical Action:

The soil may contain such chemicals which are detrimental to the life of the cable. It is, therefore, advisable that the pH value and the chemical composition of the soil to be determined.

Electrolytic corrosion:

Where the possibility electrolytic corrosion exists for example, adjacent to DC traction system the potential gradient along the pipeline and the cable sheath should be specified.

Minimum permissible Bending radius:

The cable should not be bent to a sharp radius minimum recommended bending radii are given below:

Single core	Multi core	Voltage in kV
15 D	12 D	up to 1.1
15 D	15 D	above 1.1 to 11
20 D	1 D	above 11

* D is outer radius of the cables

Markers and warning plates

Approved GI Cable markers shall be provided along the route of the cable at every 30 M distance and at both ends at road crossings, indicating "HV/MV/LV Cables". Special GI cable markers shall be provided at all buried cable joints indicating "Electrical Cable Joint".

Applicable Standards

IS 1255 : Cable laying

Cable nomenclature:

- ❖ A - Aluminium Conductor. When type designation does not begin with A the cable has copper conductor.
- ❖ Y - When at first or second place in type designation, it stands for PVC
- ❖ W - Round steel wire armouring
- ❖ F - Flat steel strip armouring

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- ❖ WW - Steel Double round wire armouring
- ❖ FF - Steel flat double strip armouring

Packing & Dispatch

Cables shall be drummed in maximum continuous lengths. Returnable steel drums for all H.V. cables and L.V. cables of large cross sectional areas or long drum lengths.

Non-returnable wooden drums where the manufacturer can guarantee that such drums are of sufficient strength to protect cable during shipping, handling and outdoor storage for three year period.

Cable ends shall be sealed and fixed to the drum so that both ends are accessible. To protect the cable during shipment, battens shall be fitted around the entire periphery of the drum. Drums shall be suitable for long term outdoor storage at site.

All cable drums shall have the Purchase Order Number, Purchase Order Item Number, Drum Number and Stock Code Number clearly stenciled on the outside of both flanges.

Drum identification labels shall be of non-corrosive, non-hygroscopic material and attached to the outside and inside of the drum flanges. Labels shall be protected by transparent plastic envelopes and give the following information:

- a) Drum identification number and its direction of rotation for cable removal.
- b) Cable voltage grade
- c) Cable construction (e.g. PVC SWA PVC or AIFY)
- d) Number of cores and cross sectional area
- e) Cable quantity (Metres)
- f) Purchase order number and item number
- g) Total weight of cable and drum (kg)
- h) Manufacturer's name
- i) Year of manufacture
- j) Stock code number

The following minimum information shall be furnished.

- a) Standard and maximum drum lengths for all the types of cable offered and the proposed drum lengths for all items.
- b) Inspection test plan.
- c) Cable dimensions (together with tolerances) :
 - i. Diameter of (individual in case of multi stranded) conductor wire
 - ii. Percentage of compaction as per data sheet.
 - iii. Diameter under conductor screen (where applicable)
 - iv. Diameter over conductor screen (where applicable)
 - v. Diameter over individual core insulators
 - vi. Lay of cable in case of multi-core cable
 - vii. Diameter over inner sheath (mm)
 - viii. Diameter over centre sheath (mm)
 - ix. Diameter over lead sheath (mm) (where applicable)
 - x. Diameter under armour (mm)
 - xi. Diameter over armour (mm)
 - xii. Diameter of armour wires (mm)
 - xiii. Overall diameter (mm)

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- d) Cable Physical Properties:
 - i. The filler materials to be used.
 - ii. Cable weight in kg/km
 - iii. Minimum bending radius (x OD)
 - iv. Maximum conductor continuous operating temperature (°C)
 - v. Suitability of outer sheath to resist attack from chemicals.
- e) Cable electrical data :
 - i. Conductor dc resistance per km at 20°C
 - ii. Conductor ac resistance per km at operating temperature and system frequency
 - iii. Conductor inductive reactance per km at system frequency
 - iv. Conductor impedance per km at operating temperature and system frequency
 - v. Conductor capacitance per km
 - vi. Cable armour resistance per km
- f) The current carrying capacity of single and multi-core cables when installed in defined conditions in air, in ducts and direct buried in the soil, together with rating factors for varying ambient temperatures, grouping and installation conditions and methods.
- g) Cable short circuits withstand capacity presented in graphical form or by formulae.
- h) Descriptive literature (catalogues etc.).
- i) Cross sectional view of the physical make up of each cable.
- j) Recommended temperatures below which installation of cable should not be carried out.
- k) Minimum ambient temperature at which cables can be used.
- l) Maximum pulling force for each cable and any special pulling instructions.
- m) Maximum unsupported run of cable both horizontally and vertically.

Test / Inspection

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. Consultant's / Owner reserve the right to witness all tests with sufficient advance notice from seller. The test reports for all cables shall be approved from the Engineer before dispatch of the cables.

All routine tests, acceptance tests, type tests and additional type tests for improved fire performance shall be carried out as listed in IS: 1554 and IS: 7098 on PVC and XLPE insulated cables respectively.

The test requirements for PVC insulation and sheath of cables, shall be as per latest revision of IS: 5831.

Test for Resistance to Ultra Violet Radiation: This test shall be carried out as per ASTM G-53 on outer sheath. Test certificates with respect to this test (not older than one year) from recognised testing laboratory to be furnished for review by Consultant's before dispatch clearance of cables. In case test certificates are not available, test is to be conducted by seller at his own cost in any recognised test laboratory or in house testing laboratory, before dispatch clearance of cables. Sampling for this test is to be done randomly once for each order, provided outer sheath remains same.

Acceptance tests as per IS-1554, IS-7098 and the following special tests to be performed on the cables as per sampling plan.

Accelerated water absorption test for insulation as per IS 10810. Test certificates with respect to the test (not older than one year) from recognised testing laboratory to be furnished for review by Consultant's before dispatch clearance

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of cables. In case test certificates are not available, test is to be conducted by seller at his own cost in any recognized test laboratory or in house testing laboratory, before despatch clearance of cables. Sampling for this test is to be done randomly once for each order, provided type of insulation remains same.

Dielectric Retention Test: The dielectric strength of the cable insulation tested in accordance with NEMA WC - 5 at 75 \pm 1° C shall not be less than 50 % of the original dielectric strength. (For PVC insulated cables). Test certificates with respect to this test (not older than one year) from recognised testing laboratory to be furnished for review by Consultant's before despatch clearance of cables. In case test certificates are not available, test is to be conducted by seller at his own cost in any recognized test laboratory or in house testing laboratory, before despatch clearance of cables. Sampling for this test is to be done randomly and once for each order.

Oxygen Index Test: The test shall be carried out as per IS 10810 or applicable Indian Standard specifications. Sampling to be done for every offered lot/size as per sampling plan.

Flammability Test: The test shall be carried out on finished cable as per IS - 10810. Sampling for these tests is to be done randomly once for each order, provided outer sheath remains same. The acceptance criteria for tests conducted shall be as under:

The cable meets the requirement if there is no visible damage on the test specimen within 300 mm from its upper end.

The maximum extent of the charred portion measured on the test sample should not have reached a height exceeding 2.5 m above the bottom edge of the burner at the front of the ladder.

Test for rodent and termite repulsion property: The sellers shall furnish the test details to analyse the property by chemical method. Sampling to be done for every offered lot / size as per sampling plan.

Fire retardant Cable Paint & Fire Barrier

The fire retardant paint / barrier shall be listed by independent test agencies such as UL, FM or OPL and be tested to, and pass the criteria of ASTM E 814 (UL1479) standard test method for fire test through- penetration fire stops and ASTM E 1996 (UL 2079) standard test method for fire resistive joint system.

Fire retardant cable Paint

The Fire resistant cable coating / painting shall be intumescent / ablative, water based compound and the coating shall expand up to 10 times, supplied in a manufacturer seal container indicating manufacturing and expiry dates. The coating material shall be non-toxic, asbestos free, & halogen free and shall have good mechanical strength. The colour of paint shall be white and density of coating shall be 1.3kg/ltr, coating shall have a snap time of 30 minutes, the expansion shall begin at 230 deg.C and it shall have an oxygen index of 41%.

Coating shall be applied by ordinary paint brush after cleaning the cables of dust and oil deposition. A minimum textured finish of 3 mm wet film thickness shall be achieved by applying the material in 2-3 layers leaving intervals of 2 to 8 hours depending upon the moisture and thickness, moisture and temperature hours between each coat.

Fire Barrier sheet for floor and wall sealing

The framing & fixing part of fire barrier sheet shall be very simple & directly fixed around walls & floors by help of anchored bolts & washer. For 2 hour fire rating the fire barrier sheet shall be minimum 7.62 mm thick and shall be cut as per the profile of penetration and opening. The small gap left around the penetration shall be closed with fire rated soft & moldable putty. Fire barrier must be design on the intumescent technology to seal larger penetration through the fire rated walls & floors. Fire barrier must be a composite construction with the quality incorporated with organic/ inorganic fire resistive elastomeric sheet with specific gravity of 1.6 gm/ cubic centimeter.

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CABLE TRAY SPECIFICATION

Scope:

This specification covers the design, material, construction features, manufacture, inspection and testing at the manufacture works and delivery to site of Cable Trays, Raceway, Marshalling boxes.

The cable trays / ladders shall be fabricated according to the design specified by IEC 61537 and should be tested for Safe Working Load (SWL). The relevant details of SWL and the load chart with respect to SWL, supporting distance and the deflection should be according to the following chart.

Safe Working Load (SWL) with a span length up to 3 meters						
Description	Side Height (in mm)	Width (in mm)	Span length (in meters)			
			1.5m	2m	2.5m	3m
			Permitted Load (in kg/meter)			
Perforated Cable Tray	40	50 – 300	125	90	50	-
	60	50 – 600	150	100	50	-
	85	100 – 600	175	110	50	-
	100	100 – 550	185	130	75	60
Cable Ladder	40	200 – 600	180	140	100	55
	60	200 – 600	-	225	150	100
	100	200 – 600	-	310	200	140

Safe Working Load (SWL) with a span length up to 10 meters									
Description	Side Height (in mm)	Width (in mm)	Span length (in meters)						
			4m	5m	6m	7m	8m	9m	10m
			Permitted Load (in kg/meter)						
Perforated Cable Tray for long span distance	100	200 - 300	160	110	75	-	20	-	-
		400 - 600	200	150	100	-	40	-	-
	160	200 - 300	230	180	140	100	70	-	-
		400 - 600	250	200	160	130	100	-	-
Cable Ladder for long span distance	100	200 - 300	160	110	80	40	-	-	-
		400 - 600	210	150	100	70	-	-	-
	160	200 - 300	230	180	140	100	70	-	-
		400 - 600	250	200	160	130	100	-	-
	200	200 - 600	-	-	300	250	200	140	100

General

a) Cable trays shall be of approved perforated type and constructed of minimum 1.50 mm thickness up to 300mm wide good quality galvanized mild steel and Polyester powder coated. Both inside and out of cable tray shall be

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protected by two coatings of approved corrosion-resistant material (e.g., zinc, cadmium, or enamel). Enamel shall not be used outdoors or in wet locations. For outdoors or wet locations, approved material and coating shall be used.

b) Cable ladders shall be of approved heavy duty type and constructed of minimum 2.5 mm thickness good quality galvanized mild steel and polyester powder coated. Cable ladder shall be protected by two coatings of approved corrosion-resistant material (e.g., zinc, cadmium, or enamel). Enamel shall not be used outdoors or in wet locations. For outdoors or wet locations, approved material and coating shall be used.

c) Cable ladders shall be of approved heavy duty type and constructed of minimum 2.5 mm thickness good quality hot dip galvanized mild steel and polyester powder coated. Cable ladder shall be protected by two coatings of approved corrosion-resistant material (e.g., zinc, cadmium, or enamel). Enamel shall not be used outdoors or in wet locations. For outdoors or wet locations, approved material and coating shall be used.

Cable tray width and Thickness:

1. 100 to 450mm wide = 1.5/1.6mm thickness
2. 600 to 750mm wide = 2.0 thickness
3. 1000 to 1500mm wide = 2.5 mm thickness

d) Contractor shall select the trays according to the following requirements:-

- i. All cables in one layer.
- ii. Allow spacing between supports and cable ties/clips (filling coefficient: 1.4 for power cables; 1.2 for cable size less 50 mm²).
- iii. 20% spare for future usage.
- iv. Deflection of not more than 1/100th of the span at temperature +40 deg C to +50 deg C when full weight (including future 20% capacity) applied to the trays.

e) Cable trays shall be approved for the purpose and shall comply with the following:

- i. Shall have suitable strength and rigidity to provide adequate support for all contained wiring.
- ii. Shall not present sharp edges, burrs or projections injurious to the insulation or jackets of the wiring.
- iii. Shall be adequately protected against corrosion.
- iv. Shall include fittings or other suitable means of changes in direction and elevation of runs.
- v. Shall have side edges of minimum 15 mm for the width of 100 mm and below; and minimum 50 mm for the width of 150 and above.
- vi. Shall be able to withstand the total load (including weight of cables, cable accessories, associated equipment, cable tray, and additional 20% future load) applied to the cable tray with a deflection of not more than 1/100th of the span at temperature +40 deg C to +50 deg C.

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- f) If the conditions are not able to achieve, cable ladder shall be used.
- g) Colors of cable tray for different services shall be selected by the Superintending Officer. In addition permanent labels shall be provided on the bottle of trays at 1200 mm interval or at the location when the trays change direction/penetrate wall and floor.
- h) Trays for extra low voltage cable shall be zintec coated with approved permanent label "TELEPHONE", "COMPUTER", "SECURITY" etc.. Onto the trays to indicate the different services. Permanent label "ELECT" shall be used for electrical services. Colors of cable tray for different services shall be "ORANGE" for electrical, "WHITE" for computer, MATV and "GREEN" for telephone system. Separate tray system shall be installed for the normal and emergency supply cables/circuits.

CODES AND STANDARDS:

- a) The design, construction, manufacture and performance of the equipment/components shall conform to latest applicable standards as on date of submission of the bid and comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment/components will be installed. Nothing in this specification shall be construed to relieve the contractor of this responsibility.
- b) Where no standards are available the supply items shall be backed by test results, shall be of good quality and workmanship and any supply items which are bought out by the contractor shall be procured from approved manufacturers acceptable to the ENGINEER INCHARGE.
- c) In case of conflict between the standards and this specification, this specification shall govern.
- d) Galvanized steel or MS with Aluminium Alkyd Paint or epoxy paint or Aluminium cable trays (ladder and perforated types), cable tray covers and vertical raceway covers.

CABLE TRAYS AND ACCESSORIES:

- a) Cable trays shall be of Mild Steel with Aluminium Alkyd/Epoxy paint or of Galvanized Steel/Aluminium and of ladder/perforated type, complete with all necessary coupler plates, elbows, tees, bends, reducers, stiffeners and other accessories and hardware as detailed in the relevant drawings. All hardware (i.e. bolts, nuts, screws, washers, etc.) shall be galvanized.
- b) Each 2.5 meter section of all types of cable trays and all elbows, tees, crosses, etc. shall be provided with two side coupler plates and associated bolts, nuts and washers.

MOTOR TERMINAL ADAPTOR BOXES:

- a) The CONTRACTOR shall supply motor terminal adaptor box, wherever required suitable for the number and size of the power cable(s) proposed. The adaptor box will have to be mounted separately on the pedestal. When mounted on the motor, the box shall be adequately sized with necessary lead extension needed to properly terminate the cable(s) considering the obstruction of foundation, etc. When mounted separately, the box shall be provided with suitably sized bus bars and supports to receive the required number/size of cables.
- b) The box shall be dust and vermin-proof, (IP-55) made of 2.5 mm thick sheet steel, complete with cable glands, cable lugs and fixing hardware. Necessary clearances shall be maintained between live parts and earth. The colour of the paint shall have the same colour shade as the motor.

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c) The CONTRACTOR shall furnish unit rates for supply of these boxes based on the weight of the finished adaptor box in kgs including painting.

TERMINAL BLOCKS:

a) The CONTRACTOR shall supply terminal blocks wherever required by the PURCHASER, at the unit rates quoted by him. Terminal blocks shall be complete with all accessories like mounting channels and plates, marking rags and clamps, protective covers, etc.

b) The terminal blocks shall be of ELMEX or equivalent make. All the terminal blocks shall be rated for 650V, 15A and shall be with disconnecting/shorting link.

JUNCTION BOXES WITH TERMINALS (JB):

a) Junction Boxes shall be galvanized, of outdoor/weather-proof construction (IP-55) and provided with gasketed front door hinged at one end and fixed with captive screws at the other end. The terminals shall be suitable for terminating 2 nos. 2.5 mm² stranded copper conductors on each side. At least two terminals in each box shall be suitable for terminating 4 mm² conductors.

b) All terminals blocks shall be rated for 1100V and 15A, unless otherwise specified in project drawings. These shall be of clip on type. All the terminals shall be complete with insulated barriers, terminal studs, washers, nuts, locknuts, identification strips, etc.

c) The terminal blocks shall be of ELMEX.

d) Minimum size (H x W x D) and number of 15 amps terminals and details of knockouts for cable/conduit entry for each junction box shall be as described in Schedule of Prices Section F.

Cable Ladder

The cable Ladder and all accessories shall be fabricated from sheet steel and has to be hot dip galvanized against corrosion confirming to ISO 1461-1999 for installations in both indoor and outdoor applications & should have a Free Base Area classification Y according to IEC61537

a) Cable ladder shall comply with the following :

- i. Shall include fittings or other suitable means of change in direction and elevation of runs.
- ii. Shall be protected against corrosion.
- iii. Shall withstand the total load (including weight of cables, cable accessories, associated equipment, ladder and additional 20% future load) applied to the cable ladder.
- iv. The height of the cable ladder shall be minimum 100 mm.

b) The cable ladder channels shall be strengthened by reinforcing inserts to increase the torsional rigidity.

c) The cable ladder shall be completed with rung slots of 50 mm width and of minimum thickness of 2 mm spaced at maximum 300 mm at the straight runs.

d) Protective enclosure shall be provided for the cable ladder when the ladder has been used for H.V. cable installation except in the H.V. cable chamber. The protective enclosure shall have permanent label "H.V." for identification.

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Tray/ladder Installation

- a) Cables tray/ladder shall be installed as a complete system with all necessary long radius bends, coupling accessories, elbows, tees, crosses, branch and reducer sections, cable dropout accessories, and fixing brackets fabricated from galvanized mild steel flat. Field bends of modifications shall be so made that the electrical continuity of the cable tray system and support for the cables shall be maintained.
- b) Mild steel hangers fixed to wall or structural slab (with metal threaded studs) complete with washer, two locknuts using cartridge hammer in an approved manner shall be provided not more than 1200 mm intervals to prevent stress on cables. Additional supports shall be provided at junctions of cable tray/cable tray system or cable tray/steel cable trunking system. The hangers shall be painted with a primer and two coats of semi-glossy grey or other-approved colour.
- c) Cable tray/ladder shall be permitted to extend transversely through partitions and wall or vertically through floors.
- d) Each run of cable tray shall be completed before the installation of cables.
- e) Where tee, cross and reducer are required, factory fabricated tee, cross and reducer section of cable tray/ladder shall be used.
- f) Cables shall be fastened securely to transverse members of the cable tray/ladder. Where single conductor cables comprising each phase of neutral of a.c., circuit are installed, the conductors consisting of phase neutral and earth of the same circuit shall be installed in group. Single conductors shall be securely bound in circuit group to prevent excessive movement due to fault current magnetic force.
- g) An appropriate size of copper links, brass bolts and nuts shall be installed at each joint trunking to provide earth continuity.
- h) The end of the cable tray/ladder shall be connected to the earth bar of the associated distribution board by 70 mm² PVC (GREEN/YELLOW) cable.
- i) Sufficient space shall be provided and maintained above cable tray/ladder to permit adequate access for installing and maintaining the cables.
- j) Whenever the steel cable tray/ladder passing through a full height fire wall or floor approved fire stop putty and approved equal material shall be used to seal the cavity of the cables and the air-gaps between wall or floor and steel cable tray.
- k) Where the cable tray is suspended, the installation shall not be subject to any vertical and horizontal distortion. Suspension parts are to be purpose made of suitable length when facilities incorporated for allowing adjustments to be made to the height of the suspended tray. The design of the suspension system shall be such that there is no distortion to the cable tray after all the services are lay on it. This cost for these works shall be deemed to include in the Contract. Any distortion found on site shall be replaced at the Sub-Contractor's expense.
- l) Fixings for the cable tray shall be disposed at regular intervals not exceeding 1200 mm and at 50 mm from bends and intersections. Fixings shall be fabricated from mild steel flat bar complying with BS 4360 and shall be painted with two coats of primer and two coats of semi-glossy grey.
- m) All cable trays shall be mechanically and electrically continuous throughout.

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n) Cable trays shall only cut along a line of plain metal not through the perforations. All edges of galvanized cable tray shall be painted with two layer of primer and two coats of approved zinc rich paint. Any scratched or exposed parts of cable trays shall be painted with the zinc rich paint.

o) When welding had been employed in the fabrication of the tray and/or accessories the area around the joint shall be mechanically prepared and thereafter treated with zinc chromate primer or zinc rich paint according to the original finish of the metal.

p) Holes cut in the cable tray for the passage of cable shall be provided with grommets complying with BS 1767. Alternatively they shall be bushed or lined.

q) The cable ladder shall be supported not more than 2000 mm interval by approved hangers or brackets.

r) All couplers, bends, riser, interconnection clamps and supporters and other fittings shall be of manufacturer's standard products and shall be supported such that it will carry the designated load.

s) Load test for the cable ladder shall be carried out on the complete system in accordance to the manufacturer's recommendation.

Mounting Accessories (Supports and Brackets):

The mounting accessories shall be fabricated from steel and has to be hot dip galvanized against corrosion confirming to ISO 1461-1999 for installations in both indoor and outdoor applications and should be of completely modular type.

All supports and Brackets should be factory made, hot dip galvanized after completing welding, cutting, drilling, other machining operations and tested according to IEC 61537 according to the arrangements in the enclosed drawing.

The system shall be designed such that it allows easy assembly at site by using Bolts and Nuts. The main support and brackets shall be fixed at site using necessary brackets, clamps, fittings, bolts, nuts and other hard ware etc to form various arrangements required to support the cable trays. Welding of the components at the site shall not be allowed.

JOINTS

Joints shall be smooth and without projections or rough edges that may damage the cables. The Contractor will be required to cover joints with rubber cement or other non-hardening rubberized or plastic compounds if in the opinion of the joints may damage cables.

Joints shall as far as possible be arranged to fall on supports. The two cable tray ends shall butt tightly at the centre of the splice and the splice shall be bolted to each cable tray by means of at least 8 round head bolts, nuts and washers. Splices shall have the same finish as the rest of the tray.

Fixing To Supports

Trays shall be bolted to supports by at least two round head bolts per support. Bolts shall be securely tightened against the tray surface to avoid projections which might damage cables during installation.

Fixing to the Structure

Where installed on concrete or brick, the supports for cable trays and ladders shall be securely fixed by means of at least 2 heavy duty, expansion type anchor bolts. Cantilevered trays shall be supported by a minimum of two expansion bolts per support.

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It is the responsibility of the Contractor to ensure that adequate fixing is provided since cable trays and ladders that work loose shall be rectified at his expense. The fixing shall take in to account site conditions that prevail during installation.

Horizontal trays and ladders shall in general be installed below slabs, ceilings, etc. to facilitate access during installation of cables.

Multiple runs shall be spaced at least 300 mm apart unless a different spacing is specified.

Corrosion Protection:

The cable tray / ladder/accessories shall be of HOT DIP Galvanized (ISO 1461-1999) for installations in corrosive atmospheres both indoor and outdoor application. Sample tray / ladder / accessories / mounting accessories and supports should be salt spray tested according to ISO 9227 for > 500 hours. (*550 hours according to class 6 for Hot dip Galvanized surface as per ISO)

MEDIUM VOLTAGE MOULDED CASE CIRCUIT BREAKERS (MCCB) FOR MAIN SWITCH BOARDS, SUB SWITCH BOARDS AND MAIN DISTRIBUTION BOARDS

GENERAL

Moulded case circuit breakers shall conform to the latest IEC 60947-2. All moulded case circuit breakers shall have minimum rated service breaking capacity ($I_{cs} = I_{cu}$) at 415 Volts A.C. as the associated switchboard or as stated on the drawing.

The circuit breaker unit shall have a fire retardant, Insulating molded case. MCCB shall not have any line-load connection restrictions & shall be suitable for isolation as per IEC. It should be with Class II front facia. Release shall have thermal memory and EMC.

MCCB shall be calibrated at ambient temperature of 50°C and carried its rated current continuously when operated in free air at this temperature. All MCCB in switchboard or distribution board(s) shall be of the same manufacturer. Extended rotary lever handles shall be provided for all MCCB in the switchboards.

All MCCB feeding to feeder or plug in bus ways shall be current limiting type unless otherwise stated. Nonmetallic, non-flammable insulating barriers shall be fitted between adjacent terminals of the incoming and outgoing sides of the MCCB. Adjustable ampere trip settings type of MCCB is used, the ampere trip **must** be calibrated and set in the factory and the adjustable trip unit **must** be permanently sealed by approved methods.

MCCB Ratings up to 160A shall be Thermal-Magnetic type with adjustable Thermal, Adjustable Magnetic settings ($I_r = 0.7$ to $1 \times I_n$, $I_i = 5$ to $10 \times I_n$). It shall be possible to ensure neutral protection with tripping threshold shall be equal to that of the phases or to a reduced value (half of that of the phases). MCCBs with should have provision for separate Short Circuit Signal facility through a short-circuit trip signaling switch.

MCCB Ratings 200A and above shall be with Electronic trip units with LIG: ($I_r = 0.4$ to $1 \times I_n$, $I_i = 1.5$ to $12 \times I_n$, $I_g = 0.2$ to $1 \times I_n$). All the release settings should have settings in absolute values. Neutral Protection should be possible in 3 pole as well as 4 pole MCCB execution. The Neutral Pole should be 100% protected neutral. (Neutral Protection – 50%, 100%, Off)

MCCB Trip units shall comply with Electromagnetic Compatibility as per the following standards: CISPR 11, Class A & B; IEC / EN 60947-1, Appendix S; IEC / EN 60947-2, Appendix B, F, J & N. Positive position indication for the moulded case circuit breakers (MCCB) to determine the status of the breaker to be provided.

Discrimination / selectivity to be ensured. Manufacturer to give combination up to 50kA (or calculated fault level). Time

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based discrimination will be preferred. No load line Bias in MCCB. A selectivity / discrimination study based on actual load current shall be provided for the complete LV distribution system from the incoming protective device to the final circuit protective device. The study shall be provided in paper and electronic format for approval. All switchgear shall be sourced from the same manufacture (i.e. ACBs/MCCBs/MCBs etc.). Mixing of switchgear manufacturer is not permitted. To allow grading of the switchgear, the selected manufacturer shall have own software for grading and network analysis.

Operation

Moulded case circuit breakers shall be operated by a toggle-type handle and shall have a quick-make over-centre switching mechanism that is mechanically trip free from the handle so that the contacts cannot be held close against short circuits and abnormal currents tripping due to overload or short circuit and they shall be clearly indicated by the handle automatically assuming a position midway between the manual "ON" and "OFF" position. All latch surfaces shall be so constructed that they open, close and trip simultaneously.

MCCB shall be trip free and capable of manual operation in addition to other normal means, such as electrical or pneumatic operation.

Construction

Each pole of these breakers shall provide inverse time delay and instantaneous circuit protection by means of thermal magnetic elements. Ambient compensation shall be accomplished by a secondary bi-metal that will allow the breaker to carry rated current at $40^{\circ}\text{C} \pm 2^{\circ}\text{C}$ with tripping characteristics that are the same throughout this temperature range.

Breakers shall be completely enclosed in a moulded case. Non-interchangeable trip breakers (below 150 amp. frame) shall have their cover sealed; whereas interchangeable trip breakers (150 amp. frame and above) shall have the trip unit sealed to prevent tampering. Contacts of circuit breaker shall be of non-welding silver alloy.

Manual trip button and front-adjusting magnetic trip device shall be incorporated in the moulded case circuit breaker. Trip indication shall be by means of the handle position being midway between 'ON' and 'OFF'. To reset the trip mechanism, the handle shall be moved to extreme 'OFF' and 'ON' position.

For current limiting (CL) moulded case circuit breakers, the current limiting breakers shall be fuse less type for 400A and below and shall have the same operation as Clause (2) and same construction as Clause (3). They shall meet the IEC requirements. All three phases shall be opened simultaneously under fault conditions. The contact opening and arc extinguishing shall be less than 1/4 cycle to reduce and limit peak let-through current and let-through energy.

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MEDIUM VOLTAGE MINIATURE CIRCUIT BREAKERS (MCB) FOR DISTRIBUTION BOARDS

GENERAL

Miniature circuit breakers shall comply with the IEC 60898 and PUB requirement with latest amendments test duty sequence 240V for single pole and 240/415V for multi-poles. Unless otherwise stated, miniature circuit breakers and distribution boards shall have minimum short-circuit capacities of R.M.S. symmetrical amperes of **10 kA** for lighting & power circuit distribution boards at 240 or 240/415 Volt A.C.

All miniature circuit breakers (MCB) shall be calibrated at ambient temperature of 40° C and carried their rated current continuously when operated in free air at this temperature. All miniature circuit breakers (MCB) shall have tripping characteristic type **"C"** curve before kWh meters and tripping characteristic. All miniature circuit breakers provided shall have tripping characteristic type **"C"** curve unless otherwise stated.

For the UPS distribution miniature circuit breakers (MCB) of tripping characteristic type **"D"** curves should be used. Miniature circuit breakers and the distribution board enclosure shall be from the same manufacturer. Irrespective to the mounting positions, the miniature circuit breakers shall be operated according to the factory calibrated characteristic. All miniature circuit breakers shall be of positive plug-on or bolted-on, no error connection type. Miniature circuit breaker **must have positive contact position.**

OPERATION

Miniature circuit breakers shall be operated by a toggle-type handle and shall have a quick-made, positive quick-break over centre switching mechanism that is mechanically trip free from the handle so that the contacts cannot be held close against short circuits and over current conditions. When the circuit breaks and over current conditions. When the circuit breakers automatically trip, the operating handle shall be assured a position between "ON" and "OFF" positions. The contacts shall also be of positive quick-make and quick-break on manual and automatic operation.

Contact position indicator (colored) linking physically to the contacts for the positive indication of isolation must be provided. Two and three pole circuit breakers shall be commonly tripped with individual spring pressure on each contact. The magnetic operation (Instantaneous Trip) of these MCB shall be tripped between **3 to 5 millisecond**.

CONSTRUCTION

Each pole of the circuit breakers shall have a factory calibrated thermal bi-metal over current element with inverse time delay characteristic and a factory calibrated instantaneous magnetic tripping device for short circuit condition. Ambient temperature compensation shall be accomplished by a secondary bi-metal that shall allow the circuit breaker to carry rated current between 25oC to 40oC with tripping characteristics that are the same throughout this temperature range, and that shall not cause nuisance tripping.

Circuit breakers shall be completely enclosed in a high dielectric strength casing. The properties of the dielectric strength casing shall not deteriorate with time. Contacts of circuit breaker shall be silver-tungsten or silver-graphite for ensuring a reliable contact of low resistance and highly resistant to welding.

The high pressure plug-on busbar connector shall assure solid positive contacts without screw to tighten and no chance of error. Load terminals shall be constructed to assure electrical efficiency and reliability, with minimized possibility of localized heating, and straight in wiring.

Arcing shall be extinguished rapidly and effectively by arc chute barrier, in normal switching as well as protective tripping, to minimize deterioration of contacts and adjacent insulating materials. Trip indication shall be by means of the handle position lying between "ON" and "OFF". To reset the trip mechanism, the handle shall be moved to extreme "OFF" position.

All MCBs shall be ISI marked as per BIS guidelines. The manufacturer (through the bidder) has to submit the valid BIS license certificate at the time of offer submission.

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RESIDUAL CURRENT CIRCUIT BREAKERS (RCCB) FOR DISTRIBUTION BOARDS

GENERAL

RCCB shall be current operated independent of the line voltage; current sensitivity shall be of 30 mA at 240/415 volts. Residual current protective devices shall trip for both sinusoidal AC residual currents and pulsating DC residual currents. Type A RCCB shall be provided.

Residual current circuit breaker (RCCB) and method of installation shall comply with latest IS 12640 including the amendments. All residual current circuit breakers (RCCB) shall bear **with local authority approved marking**.

For single phase supply, the residual current circuit breaker (RCCB) shall be rated 240 Volt 50 Hz A.C. 2 poles. For three phase supply, the residual current circuit breaker (RCCB) shall be rated 415 Volt 50 Hz A.C. 4 poles. All RCCB shall be surge proof design to prevent nuisance tripping due to transient over-voltage. A local trip indication in the form of window on the front face of the RCCB shall be provided to differentiate between OFF and TRIPPED position. A test button shall be incorporated to enable periodic check on the tripping mechanism of the RCCB.

All incoming and outgoing cables, and copper links connected to residual current circuit breakers (RCCB) shall be insulated. The Contractor shall test all the residual current circuit breakers (RCCB) installations by an approved residual current circuit breaker (RCCB) tester. Testing shall be carried out in the presence of the Engineer in-charge/ consultant/PMC or his/her representative. The actual value and one step below the actual tripping current shall be tested. The terminals of the RCCB shall be able to seal to prevent tampering. Four (4) sets of test results endorsed shall be submitted to the Engineer in-charge/ consultant/PMC.

All RCCBs shall be ISI marked as per BIS guidelines. The manufacturer (through the bidder) has to submit the valid BIS license certificate at the time of offer submission.

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MEDIUM VOLTAGE ISOLATORS

GENERAL

Isolator shall of non-automatic moulded case circuit breaker (MCCB without trip unit) type housed in an approved metal housing. All isolators shall comply with latest IEC60947 Part 3 and mounted at 1350 mm above finished floor level unless otherwise stated or directed by Engineer in-charge/ consultant / PMC.

Isolators shall be heavy-duty pattern non-automatic MCCB in an approved galvanized metal cabinet pretreated with Chromate Primer and two coats of grey paint. Front access doors shall be fitted with dust-excluding gaskets. Isolators shall be 500 V rating and shall be clearly marked with their current rating.

Non-Auto moulded case circuit breakers shall conform to the latest international Standard IEC 60898. Isolator shall of on load switching type. The metal housing shall make have not less than 14 SWG (2 mm) IS 1137 thick steel sheet.

Extended rotary lever handle shall be interlocked with the housing door so that they cannot be opened when the non-automatic MCCB is at the 'ON' position. This operating handles shall be lockable in the "OFF" positions and shall have visible on-off indication.

Nonmetallic, non-flammable insulating barriers shall be fitted between adjacent terminals of the incoming and outgoing sides of the MCCB, if the terminals of non-auto MCCB are busbar type the rating shall be permanently shown on the MCCB as well as on the housing. All steel doors shall be earthed to the enclosures. Isolators shall be approved by Engineer in-charge/ consultant /PMC.

Operation

Non-auto moulded case circuit breakers shall be operated by a toggle-type handle and shall have a quick-make over-centre switching mechanism. All latch surfaces shall be so constructed that they open and close simultaneously.

Construction

Breakers shall be completely enclosed in a moulded case. Contacts of circuit breaker shall be of non-welding silver alloy. The contacts shall be maintained minimum 5 mm apart when it is at OFF position.

Arcing shall be extinguished rapidly and effectively by Arc-extinguishing device, in normal switching to minimize deterioration of contacts and adjacent insulating materials.

Terminals shall be constructed to assure electrical efficiency and reliability, with minimized possibility of localized heating.

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MEDIUM VOLTAGE & LOW VOLTAGE MAIN AND SUB-MAIN SWITCHBOARD

General Requirements

The switch board shall be metal clad, totally enclosed, rigid, compartmentalized design, floor/wall mounting, air insulated, extensible cubicle type for use on medium voltage power, 500V 3 phase 4 wire 50Hz AC system. The switchboard shall be of the self-contained, total insulated, floor mounting, extensible modular construction, metal clad, flush-fronted, front and rear access cubicle type, built up from completely enclosed units housing all the circuit breakers, meters, selector switches, indicating lamps and protection relays etc. all as indicated in the drawings and Specifications.

The Tenderer shall state the rating and size of all necessary equipment having due regards to the arrangement and loading of his particular equipment and his contract price shall be deemed to include the cost for suitably rated equipment, and for the completion of the switchboards in every respect ready for continuous operations whether such requirement are directly mentioned in the specification or not. No extra cost will be considered for additional equipment necessary to complete the switchboards.

The whole switchboard shall be designed in accordance with IEC60898 design panels and suitable for 500 volt, 3-phase 4 wire, 50 Hz indoor service in an ambient temperature of up to 40 deg C with 100% R.H. at maximum continuous rating without exceeding the maximum temperature permitted by relevant Indian Standards. It shall withstand without damage, stresses under short circuit condition up to the minimum interrupting capacity Icu (kA) at 415 volts 50 Hz A.C. as stated on the drawings for 1 second.

The manufacturer shall guarantee all L.V. switchboards are constructed in accordance with the requirements of IEC60898 panels. All air circuit breakers, MCCB and equipment shall be housed in a separated, totally insulated module.

Drawings

The Contractor shall submit detailed construction drawings of all switchboards for the approval of the Engineer in-charge/ Consultants before fabrication and installation. Such drawings shall show constructional details and shall incorporate a full list of proposed materials, equipment, meters and accessories to be used, and the method of supporting equipment and bus bars.

On completion of the installation, the Contractor shall provide and mount on frames single line diagrams for every switch room and load centre showing full details of connected circuits, current transformers rating, bus-bar, size, time setting or protective devices, sizes and types of cable installed etc. suitably framed in glass panels. The minimum size of the diagrams shall be approximately 1000 mm x 750 mm for L.V. switch room.

The equipment shall be designed for operation high ambient temperature and high humidity tropical atmosphere conditions. Means shall be provided to facilitate inspection, cleaning and repairs, when in service where continuity of operation is of prime importance.

STANDARDS

LV switchgear / control gear shall be as per IEC60947. Switchboard assemblies shall conform to the requirements of IS 8623-1993.

The equipment and materials used and the method of construction as applicable shall conform to the following Indian Standard (IS) or International Electro technical Commission (IEC). These standards shall be the minimum requirement of the equipment.

- a) Switchboard - IEC60898 OEM panels.
- b) Busbar connections, arrangements and markings, and grade of copper - IS 375

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- c) Air circuit breakers for A.C. system up to 1000 V - IEC60947
- d) Moulded case circuit breakers - IEC60947
- e) Indicating instruments - BS 89 1st. grade -IS 1248
- f) Integrating meters - BS 37 parts 1 and 2 -IS 722
- g) Protection relay - BS 142 IS 3231
- h) Cartridge fuses for voltage up to 1000 V.A.C. - BS 88 IS 13703
- i) Contactors - BS 775 or IEC 158 ,IEC-60947-4.
- j) Indicator lights - BS 4099 IS 13947
- k) Air-break switches, air-break fuse switches and air-breakers switch-fuse IEC60947
- l) Control Switches - IEC60947
- m) Terminal marking for switchgear and control gear -BS5581 , -IS11353/IS 5578
- n) Contactor relays - BS 5583 IS 10705

CONSTRUCTION

The construction should take care of following points:

- A. Safety
- B. Reliability
- C. Maintainability

The switchboard shall be of bolted construction (No welded construction). The module layout (of feeders) to be standardized for ease of interchangeability & modularity.

The panel shall be metal enclosed, indoor / outdoor, floor / wall mounted free standing cubicle type, as specified in three distinct zones namely

- D. Busbar zone
- E. Functional units zone
- F. Cabling zone
- G. Control zone

The requisite vertical sections when coupled together shall form continuous dead front/rear access switchboards, as required

- i. With dust, vermin and damp protection.
- ii. Readily extendable as required by the addition of vertical sections after removal of the end covers.
- iii. With access to the feeders, bus bars, cable terminations, cable alley etc., as required.

Each vertical section shall comprise:

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A front framed structure of rolled/ folded CRCA sheet / MS angle section of minimum of 3mm thick rigidly welded / bolted together. This structure shall house the components contributing to the major weight of the equipment such as circuit breaker cassettes, fuse switch units, main horizontal bus bars, vertical risers, and other front mounted accessories.

The structure shall be mounted on a rigid base frame of ISMC / folded CRCA sheet steel of minimum 6mm thickness and 75mm height. The design shall ensure that the weight of the components is adequately supported without deformation or loss of alignment during transit or during operation.

A cable chamber housing the cable end connections and power/control cable termination. The design shall ensure generous availability of space for ease of installation and maintenance of cabling and adequate safety for working in one vertical/ horizontal section without coming into accidental contract with live parts of the adjacent section. A cover plate at the top of the vertical section, provided with a ventilating hood where necessary. Any aperture for ventilation shall cover with perforated sheet having less than 1mm dia. Perforation to prevent entry of vermin.

Front and rear doors fitted with dust excluding neoprene gaskets with fasteners designed to ensure proper compression of the gaskets. When covers are provided in place of doors generous overlap shall ensured between sheet steel surfaces with closely spaced fasteners to preclude the entry of dust.

The height of the panel shall not more than 2300mm unless otherwise specified. However operating height of switch / Breaker should not exceed 1800mm from the floor level. Total depth of the panel shall be adequate to cater for proper cable termination and spacing.

Front doors shall be of minimum of 14G / 2mm sheet steel and other doors / partitions shall be of 16G / 1.6mm sheet steel. All sheet steel work forming the exterior of switchboards shall be smoothly finished, leveled and free from flaws. The corners should be rounded.

The apparatus in the switch boards shall be so arranged as to facilitate ease of operation and maintenance and at the same time to ensure the necessary degree of safety.

Apparatus forming part of the switch boards shall have the following minimum clearances: Vendors to share the calculation details for the compartment sizing with proper ventilation.

- i. Between phases - As per standard
- ii. Between phases & neutral - As per standard
- iii. Between phases & earth - As per standard
- iv. Between neutral & earth- As per standard

When, for any reason, the clearance is not available, suitable insulation barrier shall be provided. Clearances shall be maintained during normal service conditions. Creep age distances shall comply with those specified in relevant standards.

All insulating material used in the construction of the equipment shall be non-hygroscopic material treated to withstand the effects of high humidity, high temperature and tropical ambient service conditions.

Functional units such as circuit breakers, fuse switches, MCCBs, etc., shall not be arranged in multi-tier formation except that ACB feeders shall be mounted in single tier and all ACBs shall be mounted & accessible at same height. Note: Two tier executions are not allowed.

Metallic / insulated barriers shall be provided within vertical sections and between adjacent sections to reduce damage due to arcing fault and prevention of accidental contact with:

- i. Main bus-bars and vertical risers during operation, inspection or maintenance of functional units and front mounted accessories.

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- ii. Cable termination of one functional unit, when working on those of adjacent unit/ units.

All covers providing access to live power equipment / circuit shall be provided with tool operated fasteners to prevent unauthorized access. One such tool shall be supplied along with each panel.

Provision shall be made for permanently earthing the frames and other metal parts of the switchgear by independent connection. All the doors shall be provided with braided flexible copper earth connection. Doors with cutouts for instruments / relays shall be provided with stiffeners to avoid buckling Only CRCA steel sheet shall be used for fabricating the cubicle. Thickness tolerance for sheets shall be as applicable in the relevant IS

METAL TREATMENT AND FINISH

Generally the treatment and finish of the metal surface shall be as per detailed specifications enumerated below.

- i. Cold phosphating using eight tank process
- ii. Degreasing with alkaline solution followed by cold water rinsing
- iii. Derusting to remove rust scales followed by cold water rinsing
- iv. Phosphating followed by cold water rinsing
- v. Passivation in de-oxalite solution
- vi. Drying in dust free conditions
- vii. Two coats of corrosion resistant stoving primer with oven drying
- viii. Electro – static powder coating of approved color

BUS BAR ZONE

The zone comprised of horizontal bus bar, vertical bus bars, heat shrunk PVC sleeves, SMC Insulated supporting system.

The bus bars chambers shall be suitable for 415V, 3phase 4 wires, 50Hz, the short circuit level as specified in BOQ.

- i. Rated current, voltage and frequency
- ii. Withstand capability during short circuit condition
- iii. Protection against vermin, falling tools, hardware which tend to bridge and initiate arcing faults.
- iv. Protection against and conducting deposits which accelerates tracking on supporting surface and consequently cause failure of the supporting system.
- v. Proper ventilation for heat dissipation.
- vi. The orientation and spacing between the bus bars to withstand short circuit.
- vii. Temperature rise and de-rating factor.
- viii. Arcing faults.
- ix. Insulation levels.
- x. Proximity effects.

The bus bar shall be either tinned copper or aluminum as specified in the BOQ.

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The conductivity of aluminum or copper bus bars should be high and electrolytic grade copper of 99.9% IACS and Aluminium of 55% IACS (International annealed copper standard) conforming to IS 5082 – 1981 , Aluminium grade 63401 – WP.

The bus bar shall be provided with black color heat shrunk PVC sleeves along the entire length, but the joints shall be shrouded. When bus bar / links are connected in parallel some gap should be maintained between the buses of same potential to improve heat dissipation. The gap should be equal to the thickness of the bus of 10mm whichever is higher.

Stiffeners shall be provided between bus of same potential to avoid bending stress on conductors and number of such stiffeners shall depend on the partial force. The total stress under short circuit condition should not exceed 0.1% proof stress of the bus bar material.

The insulation material used for the supports should have following desirable properties.

- High mechanical strength.
- High Di-electric strength
- High temperature withstands.
- Non flammable properties.
- Non hygroscopic properties.
- High comparative tracking index.

When marking bus bar joints the safe minimum bending radius shall be T for copper bus bars and 2T for Aluminium bus bars where the T is the thickness of the bus bars. The bus bar section shall be joint either by the overlapping or by providing fish plates and bolt or clamping the sections together. Bolting and clamping methods should provide joints that have satisfactory service life.

The main requirement for any bus bar joints is that electrical efficiency should remain stable under all conditions of service. To achieve this, the following factors to be taken in to account when the joint is made. They are,

- i. Proper contact pressure must be applied and maintained.
- ii. The surface of the Aluminium must be cleaned before bolting up.
- iii. Air and moisture must be excluded from the joints.
- iv. The overlap should be at least equal to the width of the bus bars.

The bus bars shall be suitably supported with DMC / SMC supports designed to provide a fault withstand capacity as specified. High tensile bolts and spring washers shall be provided at all bus bar joints.

An earth bus of size shall be suitable as per the tested design and shall run throughout the length of the switch board at top or bottom as required.

MOULDED CASE CIRCUIT BREAKER (MCCB)

The MCCB shall be 3 P / 4P AC and shall conform in all respect to IEC60947 – PART 1 & PART 2. They shall incorporate quick make, quick break, and independent manual type with trip free feature. The handle position shall give positive indication whether the breaker is in ON, OFF or TRIP condition.

The short circuit and the current rating of MCCB shall be as described under Annexure / BOQ.

MCCB shall be provided with AC shunt trip / UV release as specified in the BOQ. MCCB shall be of category A with a rated service breaking capacity (Ics) equal to the ultimate breaking capacity (Icu) on all the ratings @ 415VAC i.e. Ics = 100% Icu. MCCB should be fully rated up to 50 deg C. The Microprocessor Release MCCBs should be equipped with non saturable type Rogoswki CTs for reliable & accurate protection.

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MCCBs shall be provided with rotary handle operating mechanism with door interlock & door interlock shall be defeatable when required.

- i. All MCCB feeding to feeder or plug in bus ways shall be current limiting type unless otherwise stated or directed by the Engineer in-charge.
- ii. Nonmetallic, non-flammable insulating barriers shall be fitted between adjacent terminals of the incoming and outgoing sides of the MCCB.
- iii. All moulded case circuit breakers (MCCB) shall have tripping characteristic type "3" curve.
- iv. MCCB shall refer to the relevant sections of the specification.
- v. MCCB Ratings up to 160A shall be Thermal-Magnetic type with adjustable Thermal, Adjustable Magnetic settings ($I_r = 0.7$ to $1xI_n$, $I_i = 5$ to $10xI_n$). It shall be possible to ensure neutral protection with tripping threshold shall be equal to that of the phases or to a reduced value (half of that of the phases). MCCBs with should have provision for separate Short Circuit Signal facility through a short-circuit trip signaling switch.
- vi. MCCB Ratings 200A and above shall be with Electronic trip units with LIG: ($I_r = 0.4$ to $1xI_n$, $I_i = 1.5$ to $12xI_n$, $I_g = 0.2$ to $1xI_n$). All the release settings should have settings in absolute values. Neutral Protection should be possible in 3 pole as well as 4 pole MCCB execution. The Neutral Pole should be 100% protected neutral. (Neutral Protection – 50%, 100%, Off)
- vii. - The MCCB Trip units shall comply with Electromagnetic Compatibility as per the following standards: CISPR 11, Class A & B; IEC / EN 60947-1, Appendix S; IEC / EN 60947-2, Appendix B, F, J & N

SWITCH - DISCONNECTOR -FUSE UNIT

The SDF units shall be of the load break heavy duty , independent manual operating cubicle type conforming to the requirement of IEC60947 part 3 (AC 23 amperes duty). The SDF units shall be double break and shall have quick make and quick break mechanism designed to ensure positive operation.

The unit shall be provided with the front operating handle. The ON and OFF positions of the switch handle shall be clearly and indelibly marked. Interlock shall be provided so as to prevent opening of the unit door when the SDF is in the ON position and also to prevent closing of the switch with the door not properly secured. It should, however, be possible for a competent examiner to operate the switch with door open by releasing interlock. The interior arrangement of the switch unit shall be such that live parts are shrouded.

Frame Construction

The sections and subsections of the switchboard cubicle shall be modular in design in accordance to BS 5486 IS 2675 / IS 13032 and shall stand rigidly on top of the floor opening. The cubicle shall be installed on a framework of channel steel 50mm x 50mm x 2.5mm with flushed cover and panels made of 2mm thick mild steel plate flanged for added strength and shall be constructed without any sag, deformation or warping and be able to withstand the load likely to be experienced during normal operation, maintenance or under a fault condition of not less than the specified kA for 1 second. All steel sheets and channel shall preferably be zinc alloy coated.

Structural members and bracing where necessary shall be welded or bolted to the frame. Each cubicle shall be standard size, uniform in height, width and depth. Each module of section and subsection of the switchboard cubicle shall be type tested to withstand a fault level of specified kA for 1 second. The cubicle shall have rear panels.

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Full access shall be provided to the control equipment inside the cubicles by means of suitable door, secured in closed position by means of recessed key operated catches, which shall be mechanically interlocked with the controlling switch, to prevent the door from being opened with the switch in the 'ON' position. The doors shall be fitted with strengthening strips to give the necessary rigidity. Rear panel door for every module shall be full height, hinged and fitted with recessed key operated catches.

The cubicles shall be constructed with degree of protection IP 4x and shall also meet the special requirement for use in tropical climates. All switchboards shall be dust and vermin proof construction. The degree of protection shall be IP54 (For outdoor application) for switchboard ratings up to 1600A & IP42 (For Indoor Application) for switchboard ratings 2000A & above. (Louvers/ ventilation box shall be adequately sized taking account the ambient & temperature rise as specified).

All the doors shall be fitted with neoprene gasket cemented to the frame. All edges for the openings at the front panel shall be fitted with gasket. The interior of each cubicle shall be dust, insect and vermin proof and wire nets shall be permanently welded to the panels.

Base Plate and Insulating Panels

The switchboard shall be of the front and rear access type. All equipment shall be mounted on rigid base plates made of not less than 14 S.G. (2 mm thick) steel sheet with folded edges and welded stiffeners wherever necessary. Whenever insulating panels are required to mount special equipment they shall be of high quality rigid, non-hygroscopic fiberboard. All edges must be cut straight and squared and shall be chamfered on the front edge with 3.2 mm chamfer. Any defective or damaged panel shall be rejected and the Contractor shall replace it at his own expense.

Lighting Contactor Cubicles

In the case of lighting contactor cubicles electrically/mechanically interlocks shall be provided with the circuit breakers to prevent door being opened with the circuit breakers in the 'ON' position.

Finishing and Metal Work

All painted parts of the steel work are to be phosphate and finished with rust proof stove-dried polyester or epoxy-resin electro statically power coating. Non painted steel parts are to be electrostatic ally zinc alloy coated.

All metal parts exposed by cutting and any part of the painted surfaces that has been scratched or marked shall be prepared and finished to match the original paint finish. Colour of the switchboard shall be finished as per IS code of practice.

Insulation

The whole switchboard shall be of a total insulation type as IS 8623 requirements. The clearances and insulation shall be such as to withstand the standard high voltage test on the switchgear. All insulation used shall be of the best quality and sufficiently strong to withstand all stresses that may be imposed on it in the ordinary erection and operation of the plant.

Glass-reinforced thermo set polyester or epoxy resin busbar support insulators shall be employed. Insulating materials that liberate smoke, injurious gases or corrosive substances under insulation failure or arcing faults must not be used. Arrangements must be made to ensure that metal parts attached to bushings are maintained at fixed potential under all conditions of operation.

All live parts shall be completely covered with insulation according to requirements IS 8623. Insulation plates shall be provided for segregation of compartments and cubicles.

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Interlocking of Main Circuit Breakers and Bus-Tie Breaker

The main circuit breakers and the bus-tie breaker shall be so interlocked, electrically and mechanically, that only two of the three breakers can be closed at any one time. The mechanical interlock shall be achieved by the use of "Castell" keys. The system shall be so arranged that the withdrawal of one circuit breaker in no way affects the operation of the other two.

Safety Measure

The Switchboards shall incorporate suitable protective measure such as partitioning between sections, subsections, shutters and interlock etc. for protection against internal arcing, contact with live parts etc.

Where insulation is cemented or jointed to metal parts such jointing shall be of such a nature that no dangerous stresses are set up in the insulation by the unequal expansion or contraction of the insulation and the metal through a range of temperature from 25 deg C to 90 deg C.

Phase distinguishing colors shall be RED, YELLOW and BLUE and the phase rotation shall be strictly maintained throughout the complete L.V. installation.

Bus bars and Jumpers

Bus bars shall comprise air-insulated, hard drawn high conductivity tinned copper of adequate rectangular cross sections as determined in accordance to IS 732, to carry continuously the currents required or as specified in the drawings. Current rating of copper busbar shall refer to the table A below. If laminated bus bars are used, appropriate de-rating factor according to IEC standard for the current capacity must be applied. The busbar shall be rigidly supported by means of heavy duty busbar holders of fiberglass reinforced polyester which are securely bolted to the framework so as to enable the bus bars to withstand the mechanical and thermal stresses to which they would be subjected under maximum fault conditions.

Busbar shall be tinned throughout and shall be painted to indicate phases with two (2) coats of non- glossy nitrocellulose lacquers for the entire length. The ends of the busbar shall be drilled and be ready for future extension. The main bus bars and earthing shall be to the full length of the switchboard. Access to the bus bars shall be through fixed doors and covers; suitable warning labels shall be fixed to the front of the busbar covers.

The main horizontal circuit bus bars must be located on the top most section of the switchboard, whereas the main earthing busbar must be located at the bottom of the switchboard.

The busbar shall be provided with facilities for connection to incoming and outgoing switchgear. All joints in the busbar shall be securely bolted or clamped, with contact surface suitably prepared to prevent oxidation in service and shall not cause any deformation or distortion of the busbar or connection rod.

Joints in copper busbar shall have tinned surfaces. Approved washer, screwed and locknut shall be used. Screw, locknut shall be of cadmium plated high tensile steel with ISO metric thread in accordance to IS 4218.

All jumpers from MCCB or fuse switches above 200 ampere frame (AF) to main bus bars shall be tinned copper bus bars. For cable to busbar termination, heat resistant cables with cable lug shall be used.

The cross sectional areas of the jumper bus bars shall be sized according to the Ampere Frame of the MCCB or fuse switches. Under no circumstances shall step busbar be allowed in the switchboards. All bus bars shall be constructed to allow for future extension without dismantling and modifying of the bus bars and busbar mounting. All bus bars shall be constructed in such manner as to allow for thermal expansion.

Self adhesive reversible temperature indicators of approved design shall be placed at all the joints along main busbar vertically or horizontally run and at the fixed contacts of all the air circuit breaker. The range of the temperature indicator shall be from 40 deg C to 70 deg C and shall be clearly legible when viewed from the rear panel. The

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insulation board between the rear panels and the bus bars where the temperature indicators are placed shall be transparent.

All clamps, screws, bolts, washers, and similar securing materials used for the construction of the switchboard shall be made of gunmetal, brass, and bronze or approved copper alloy. Spring washers shall be made of high grade of stainless steel or other approved material. Screws and bolts shall be tightened by torque wrench to be suitable as per the tested design. Vendor to submit the calculation details for the same.

Clearance For Air-Insulated Bus bars

The minimum busbar clearances between phases and between phases to earth in air shall not be less than **26 mm and 19 mm** respectively or as per the standard tested design. If the above mentioned minimum clearance cannot be met, bus bars shall be insulated by approved colour coded heat shrinkable tubing's.

Earthing

All metal parts of the switchboard and associated equipment shall be bonded and connected to an appropriate size of hard drawn high conductivity copper main earthing bar running at the bottom and throughout the entire length of the switchboard.

The minimum cross sectional area of switchboard main earth bar shall be as follows or unless otherwise specified:-

- i) 125 mm² for 22 kA
- ii) 240 mm² for 36 kA
- iii) 300 mm² for 43 kA
- iv) 350 mm² for 50 kA

Minimum two nos. of earthing cables /conductors of the same cross sectional area of the switchboard main earthing bar shall be provided for the connection of the switchboard main earthing bar to the low voltage system main earthing bar. These cables /conductors shall be connected to the both ends of the switchboard main earthing bar. All earthing conductors shall be permanently connected to the main earthing bar.

All earthing provisions shall be made strictly in accordance with the requirements of Singapore Standards and it shall be the Sub-Contractor's responsibility to fully acquaint him of all such requirements. All hinged doors shall be connected to the cubicle body by appropriate size of earth braids.

Neutral Links

Neutral links of incoming breakers shall be easily accessible and removable. Neutral links of all outgoing moulded case circuit breakers shall be removed and accessible from the front.

Ventilation

All switchboards shall be properly naturally ventilated. All vents shall be covered with a fine mesh net welded on the inside.

Cable Entries

The switchboards shall house all necessary cable boxes, glands, etc. mounted vertically or horizontally and arranged for front and rear access and connections.

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Except for bus ducts and unless otherwise stated, all incoming cables shall be at bottom entries and outgoing cables shall be of top entries.

Cable boxes for termination of incoming cables shall be mounted at the base. It shall be of the split type manufactured from good quality cast iron, free from blowholes complete with filling orifice, drain plugs, expansion dome, brass-core shaped wiping gland of appropriate size, armour clamp. Such design as is suitable for attachment to the equipment served and such as to permit cable conductors to be formed into equipment terminals without undue bending.

Connections from switchboards gears to the busbar trunkings shall be top entries and switchboard stubs shall be included in the switchboard design.

Outgoing cables shall be secured to the switchboard by approved suitable cable glands mounted on non-ferrous plate. The arrangement of the outgoing cables shall ensure no blocking of future outgoing cables terminations.

All cable terminations within the cubicle shall be in a satisfactory manner in a purpose made terminal and shall be neatly fastened to the purpose made metal channels. For all underground armoured cables, arrangement shall be made to have the sheath bonded and earthed through a special earthing system.

Terminal Strips and Wiring

All incoming and outgoing and control circuits shall be wired to an approved centralized terminal strip, and the equipment at the inside of the cubicle shall be run through wiring channels and wiring outside the channels shall be run neatly and taped to approval. All wires shall be terminated with approved cable lugs, and separate cable lugs shall be used for each individual wire.

All wires shall be colour coded and shall have numbered ferrules at both ends. The ferrules shall be of white insulating material with the characters indelibly marked in black. Additional red ferrules marked "Trip" shall be fitted to the wires interconnecting the relay trip contract and the shunt release coils.

All fuses and links shall be of the Bakelite HRC type category 415/AC 13 class Q to IS 13703.

All wiring shall be arranged in a regular manner with bends set at 90o and securely held in position with suitable clips and where convenient shall be installed in the uprights and/or secured, insulating bushes being used where necessary. They shall be formed in a neat and systematic manner.

Meter wiring of the switchboard shall be carried out in PVC insulated name-proof switchboard cables of size not less than 1.5 sq. mm and enclosed in flexible plastic conduit. All meter wiring shall be of similar colors to those of the respective bus bars etc. to which connections are made.

All terminals shall be fitted with brass washers and securely fixed with lock nuts to an approved type of terminal block placed in an easily accessible position for testing at site. No connectors or soldered joints shall be permitted in the wiring.

All terminals shall be completely insulated and potential circuits shall be suitably fused. Approved means shall be provided on the relay panels for the testing of protective relays and associated circuits.

Colour Codes and Labels

Corners and bases shall be coloured according to the following code:

<u>Colour</u>	<u>Function</u>
White	5A fuse
Blue	15A fuse

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Yellow

20A fuse

Red

link

Descriptive labels shall be fitted, near all fuses and links. The terminal strips shall be numbered and scheduled to identify the particular circuits without difficulty. The same numbers and reference letters identifying circuits and/or components of the equipment shall be shown on the wiring diagram that is to be supplied by the Sub-Contractor.

The interior of each piece of equipment shall be clearly marked to show the phases and to this end either colored plastic discs screwed to fixed components or identification by means of colour plastic sleeve shall be employed. Plastic tape will not be permitted.

Labels

All equipment shall be clearly labeled in accordance with regulations, and to indicate its functions, designation, ampere, etc. by means of engraved traffolyte ivory labels (Black in white lettering for normal supply, Red in white lettering for emergency supply).

Each circuit breaker, switch, switch-fuse, fuse, selector switch, indicating light, push button, instrument, etc. shall be labeled indicating its rating, function, designation. In addition warnings signs marked "415 400 volts Danger" manufactured to standard design and colour shall be suitably nominated and fixed on the back of each cubicles on the insulation plates and on the front of each switchboard and on the door of each switch room. The markings shall be according to IS 2026 Part 4.

The panel as well as feeders compartments shall be provided with name plates of anodized aluminium or hylam switch plates with engraving. These shall be properly secured with fasteners / rivets. The panel / feeder description shall be as indicated in the drawings / by owner / clients.

CURRENT TRANSFORMER (CT)

Current transformer shall comply with the requirement of IS 2705. The shall have ratios, outputs and accuracy as specified / required. Current transformers necessary for the operation of instruments and meters shall be of "straight through" type, with not less than 15VA burden and accuracy of class 0.5 for KWH meter, Class 1 for ammeter and class 5P20 for protection to IS 2705.

Current transformers shall be adequately rated in V.A. to carry the summation of all V.A. burdens of connected loads, and shall be capable of carrying currents of the corresponding circuit breakers and fuses. They shall be capable of operation, without damage, with open circuited secondary and full load current flowing in the primary. They shall comply with the latest EB requirements.

Current transformers shall be adequately supported and installed as to permit easy access and shall be readily replaceable, if necessary, without dismantling the adjacent equipment.

Current transformers shall comply with IS 2705 or IEC 60185. They shall be manufactured from high impact flame retardant moulded cases suitable for mounting on 105o C bus bars and to IP40.

All current transformers shall have the following characteristics :-

- i) Rated 660Vac max.
- ii) Dielectric strength --- 2.5 kV/min.
- iii) Temperature -20o C to +70o C ambient
- iv) Short circuit thermal current (Ith) --- 60 times rated primary current for 1 sec.
- v) Rated dynamic current --- 2.55 short circuit thermal current (Ith)

INDICATING / INTEGRATING METERS:

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All indicating instruments shall be of flush mounting type. Instruments shall have clearly divided indelibly marked scales and shall be provided with adjusting devices in the front.

Instruments and meters for external panel mounting shall be flush mounting, square or rectangular type with appropriate cover plates finished black and conform to the requirements shown on the drawings.

Reading scales in kilowatt hour meters shall be preferably in multiple of ten (10). All instruments shall be to IS 1248 1st grade, moving iron spring controlled with external zero adjustment, integrating meters shall be to IS 722 with cyclometer registers and shall be calibrated for use with their respective current transformers.

Voltmeters shall incorporate selector switches to enable phase to phase and phase to neutral voltage to be read. Ammeter shall have selector switches to read all the line current. Selector switches shall be of approved rotary type. Generally ammeters shall be 20% over scaled however, ammeters associated with motor circuits shall be 500% over scaled. All live terminals shall be insulated.

Instruments, meters and relays located on the front of the switchboard shall be segregated from the interior of the cubicle and so positioned that as far as possible, each instrument meter and relay is flush with the hinged dust proof access doors and is adjacent to the unit with which it is associated. Other relays more suitable for mounting inside the cubicle such as those required for back indication and tripping etc. shall be grouped conveniently in dust proof cases with removable covers to provide easy access for cleaning and adjustment without dismantling.

Meter panels shall be hinged to provide ready access to connections and small wiring shall be enclosed in flexible plastic conduit. All meters and relays shall be fully tropicallised.

The back of these instruments, meters and relays for external panel mounting shall be encased in a removable high heat resistant, high insulation, dust proof cover to prevent any accidental contact with any of the line terminals or connections. These removable covers shall be designed in such that it provides easy access for cleaning and adjustment/maintenance with proper labeling/identification 'LIVE TERMINAL' on the cover.

Over Current and Earth Fault Relays

The over current relays shall be IDMTL (electromechanical) type with adjustable current setting between 50% to 200% of rated values and adjustable time lag settings of 0 to 3 seconds at 10 times current setting; instantaneous high set elements adjustable between 1 to 10 times shall be provided for each main incoming circuit breaker. They shall be of 3/10 characteristic.

The relays shall be surface mounted and housed in a totally enclosed dust-proof switchboard module, tested and sealed by testing engineer. The operating coils and contacts shall be adequately rated to carry the necessary load. Operation indicator and reset facilities shall be provided.

The relays shall be heavy pattern, unaffected by external vibration, fully tropicallised and capable of operation in any position. The control voltage for the relays shall be 240 V. A.C. 50 Hz.

CABLE TERMINATION:

Cable entries and terminals shall be provided in the switch board to suit the number, type and size of aluminium conductor, power cables and copper conductors, control cables specified in the detailed specifications.

Provision shall be made for top or bottom entry of cables as required. Generous size of cabling chamber shall be provided with the position of cable gland and terminals such that cables can be easily and safely terminated.

Barriers or shrouds shall be provided to permit safe working at the terminals of one circuit without accidentally touching that of another live circuit.

Cable risers shall be adequately supported to withstand the effect of rated short circuit current without damage and without causing secondary faults. Cable sockets shall be tinned copper, crimping type.

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CONTROL WIRING:

In motor control centre, control voltage for all controls, indications and metering shall be derived by providing a control transformer of adequate capacity.

All control wiring shall be carried out with 1100 / 660 volts grade single core PVC cable having stranded copper conductors with minimum cross section of 1.5sqmm for potential circuits and 2.5sqmm for current circuits.

Wiring shall be neatly bunched, adequately supported and properly routed to allow for easy access and maintenance. Wires shall be identified by alpha numeric ferrules at each ends. The ferrules shall be of ring type and of non deteriorating material. They shall be firmly located on each wire so as to prevent free moment. All control circuit miniature circuit breakers (MCB) shall be mounted so as to be easily accessible.

TERMINAL BLOCKS:

Terminal blocks shall be of 500 volts grade and mechanically robust. Terminal blocks shall have minimum current rating of 10 amps and shall be shrouded. Provisions shall be made for label inscription.

Safety Notices Equipment

The Contractor shall provide and install the following notices and equipment in the consumer switch rooms/load centers.

- Copies of all statutory safety notices, regulations and instructions for resuscitation and treatment after electrical shock; all surface treated with clear varnish, in suitable wall mounted frames.
- Four languages danger signs in the switch rooms and elsewhere, all to PUB requirements.
- A varnished and mounted on suitable hard backing and framed (in glass panel) copy of the main single line diagram showing clearly the full details, dimensions, layout of the L.V. switchboards as supplied and installed.
- Solid rubber insulated mats of 1 meter wide and 10 mm thick complying with IS 5424 to the full length in front of every switchboard.
- A wall mounted key press housing all keys in the switch room/load centre with a B4 size hard cover log book for record purposes.
- A wall mounted or floor standing tool cabinet to house all the tools within the switch rooms.

TESTS:

Routine Tests

The Contractor shall submit certified test sheets /reports showing details of all routine test applied, during manufacture, to the switchboards and the individual components thereof. Without in any way affecting the generality of this Clause such test shall include the following clauses relating to switchgear;

- Operating test, consisting of fifty operations of the operating mechanisms performed with the closing device.
- Mill volt drop test, or resistance test at the rated current of the equipment across all contacts individually, and as a complete unit as a check against temperature rise type test if applicable.
- The record taken on the type test shall be taken as datum if applicable.
- Timing test, conducted on one of the air circuit breaker to be supplied, to obtain the times of closing and opening of the circuit breaker in relation to the results obtained under type test if applicable.
- Tests on each switching unit to determine the satisfactory operation of trip coil or coil at the minimum and the normal tripping voltage.

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- f) inspection of the switchboards including inspection of wiring and electrical operation test
- g) Dielectric test
- h) Insulation resistance of the main circuit between each pole and the earth and that between the poles shall be measured.
- i) Insulation resistance of all secondary wiring between phase and earth shall be measured. Insulation tests shall be carried out both before and after High voltage tests.
- j) Checking of protective measures and of the electrical continuity of the protective circuit.

Type Tests

The switchboards as a whole shall be capable of withstanding, without damage to it, the electrical, mechanical and thermal stresses produced under short circuit conditions equivalent to the interrupting capacities of RMS Symmetrical Amperes at 415 Volts A.C. of the incoming breakers for 3 sec.

All parts of the switchboard shall be subjected to type tests to verify compliance with the requirements laid down in the relevant British Standard Specification. The type tests shall be carried out on the same switchboard. The type tests shall include the following:

- i. Verification of temperature rise limit
- ii. Verification of dielectric properties
- iii. Verification of short circuit strength
- iv. Verification of the continuity of the protective circuit
- v. Verification of clearances and Creepage distances
- vi. Verification of mechanical operation
- vii. Verification of the degree of protection

The Contractor shall submit the test reports showing the result of all tests carried out in accordance with this section of the Specification to the Engineer in-charge/Consultant/ Client.

HIGH VOLTAGE TESTS:

A high voltage test with 2.5 KV for one minute shall be applied between each pole and earth and between poles. Test certificates shall be submitted along with panels.

All instruments / Meters used for testing should carry a calibration stamp not earlier than 6 months.

STORING, ERECTION AND COMMISSIONING:-

STORING:

The panel shall be stored in well ventilated dry place. Suitable polythene covers shall be provided for necessary protection against dirt and moisture.

ERECTION:

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Switch boards shall be installed over trench / on wall or floor as required. Suitable grouting holes shall be provided in the flooring. Suitable MS base channels shall be supplied and embedded in the flooring on which the panels can directly be installed.

The switch boards shall be properly aligned and bolted to the base channel by at least 4 bolts. Cables shall be terminated on the bottom plate or top plate as the case may be by using brass compression gland. The individual cables shall be led through the panel to the required feeder compartment for necessary termination. The cable shall be clamped to the supporting arrangements. The switch board earth bus shall be connected to the local earth grid.

The base channel used for erection of panels shall form part of cost of the panel and shall not be measured or paid separately.

PRE-COMMISSIONING TESTS:

Panels shall be commissioned only after successful completion of the following tests. The test shall be carried in the presence of consultant's representative and copy of the test report submitted before commissioning.

- i. All main and auxiliary bus bar connection shall be checked and tightened.
- ii. All wiring termination and bus bar joints shall be checked and tightened.
- iii. Wiring shall be checked to ensure that it is according to drawing.
- iv. All wiring shall be tested for insulation resistance by a 500 volt Megger.
- v. Phase rotation test shall be conducted.
- vi. Suitable injection test shall be applied to all the measuring instruments to establish the correctness and accuracy of calibration of working order, as agreed mutually.
- vii. All relays and protective devices shall be tested for correctness of setting and operation by introducing a current generator and ammeter in the circuit or by producing calibration / test certificate as required by the employer / inspectorate.
- viii. Rating of fuse, MCB shall be checked to ensure that it is according to the drawing.

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MEDIUM VOLTAGE DISTRIBUTION BOARDS

GENERAL

All distribution boards shall be rated at 415 Volt A.C. 50 Hz for three phase 4 wire supply and shall comply with the latest IEC60898 for distribution boards. Distribution Boards (DBs) shall be suitable for AC supply, 240V, 1 phase (SPN DB) as required. Distribution boards shall generally conform to IEC60898.

Three phase circuit breaker distribution boards shall be of the dead-front safety type equipped with thermal magnetic miniature circuit breakers of the frame sizes, types and ampere trip ratings specified on the drawings. All circuit breaker distribution boards shall be of the approved type.

All doors of the circuit breaker distribution boards shall be equipped with safety cylinder locks to prevent unauthorized personnel to switch ON or OFF the main and branch breakers. The number of locks depends on the length of the door.

Miniature circuit breaker (MCB) shall refer to the technical specification of miniature circuit breakers. Original blanking plates shall be used for space(s) (i.e. outgoing ways without miniature circuit breaker(s)).

TYPE AND CONSTRUCTION

The DBs shall be of type and rating as specified in the BOQ. DBs shall be branded / ready-made of approved make. Fabricated DBs shall be made to approval. The sheet steel/ PVC MCB DB shall be flush mounting type unless otherwise specified and shall consist of MCB/ MCB isolator /ELCB / MCCB as incomer and MCBs as outgoing. At least 20% spare ways shall be provided.

In case of HRC fuse DB, the incomer shall be a switch unit/ switch fuse unit with HRC fuses as outgoing of rating as specified in BOQ. The distribution boards shall conform to the following construction :

BUSBARS

Suitably de-rated bus bars made out of high conductivity copper strips only, color coded and mounted on non-hygroscopic insulating supports, shall be provided. In case of UPS power DBs, neutral bus/ terminal strip shall be twice the rating of phase bus bars.

CIRCUIT BREAKERS

MCB, Isolator, ELCB, MCCB shall be of approved rating and make with specified short circuit rating.

HRC FUSES

Rating of the fuses and carriers shall be as per drawings and schedule of quantities. Fuse carriers and bases shall conform to IS: 1300. They shall be non- inflammable and non-hygroscopic, with hard gloss finish.

SAFETY & INTERLOCKS

All the live parts shall be shrouded such that accidental contact with live parts is totally avoided. Distribution boards shall be provided with a front cover and/or hinged door. Unused ways shall be closed with PVC blanks. Distribution boards interior assembly shall be dead front with the front cover removed. Main terminals shall be shrouded. Suitable insulating barriers made of arc resistant material shall be provided for phase separation. Ends of the bus structures shall also be shrouded.

CABINET DESIGN

The Distribution Board cabinet shall be totally enclosed type with dust and vermin proof construction, with neoprene gaskets, to IP 43. The cabinet shall be made out of CRCA sheet and shall not deform during erection. The interior components shall be mounted on a separate steel sheet which is mounted and locked onto the studs provided inside the cabinet. Over this, a cover made of hylam or MS sheet shall be provided with slots for operating handle of

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breakers. If required, the cabinet shall be equipped with a hinged cover/ front door having a spring/magnetic latch and wherever asked for, with vault lock. Cabinets shall have knockouts for conduit / cable entry at both top and bottom.

Finish shall be as per 'Metal Treatment' enumerated elsewhere in these specifications. All visible, exterior surfaces shall be powder coated enamel paint. The interior surfaces shall be finished to an off-white shade.

TERMINALS

Distribution Boards shall be provided with separate brass/ copper terminal strips of adequate size to receive neutral and earth wires of mains and outgoing circuits. For non-linear loads, Neutral strip size is critical. The location of the terminal strips shall be such that crowding of wires in the proximity of live parts is avoided.

NAME PLATE & DIRECTORY

DBs shall have an engraved name plate outside. A directory indicating the area and loads served by each circuit, rating of MCB, size of outgoing cables, etc. shall be affixed on the posterior of the DB cover.

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MEDIUM VOLTAGE DISTRIBUTION SYSTEM

GENERAL

Medium voltage distribution system shall be applicable for wiring on 3 phase, 4 wire and earth conductor 415 volts, 50 Hz AC supply and single phase, 2 wire and earth 240 volts, 50 Hz, AC supply.

RIGID STEEL / PVC CONDUITS AND ACCESSORIES

Conduits of rigid steel shall be of welded sheet steel, threaded type construction. Conduits shall be black stove enameled outside. Conduits shall be of 1.6mm thickness (16G) and thickness tolerance limits shall be as per IS conforming to IS 9537, Part II, 1981 or latest revision.

Joints between conduits and accessories shall be securely made by standard accessories, as per IS-2667, IS-3837 and IS-5133 to ensure earth continuity. All conduit accessories shall be threaded type only. PVC conduits shall be of black or other color as specified and 2mm thick conforming to relevant IS. All conduits used shall be ISI-marked and Conduits of less than 19 mm diameter shall not be used.

Conduit accessories such as bends, collars, junction boxes for MS conduit work shall be of MS with threaded hubs ; for PVC conduit work only junction boxes shall be of MS with screws for conduit termination. Junction boxes shall be provided with MS/ oversize PVC covers. All junction boxes, fan boxes, chandelier boxes used in slabs for recessed conduit system shall be of MS.

INSTALLATION OF CONDUITS

a) OPEN / SURFACE CONDUIT SYSTEM

Wherever specifically called for, surface conduit system shall be adopted. Conduits shall be run in square and symmetrical lines. Before the conduits are installed, the exact route shall be marked at site and approval of the Owner / Consultant shall be obtained. Conduits shall be fixed by heavy gauge GI saddles, on MS spacers secured by wood screws and raw plugs, at intervals not exceeding 600mm. wherever couplers, bends, junction box or other fittings are used, saddles shall be provided on either side of the accessory.

Exposed conduit lying above false ceilings shall be executed in similar manner described above.

b) RECESSED CONDUIT SYSTEM

Conduits which are to be run in the ceiling slab shall be laid OVER the reinforcement kept on the prepared shuttering work of the ceiling slab before concrete is poured. The conduits shall be properly joined / terminated into sockets, bends, deep junction boxes, outlet boxes. The conduits in concrete slab shall be straight as far as possible to facilitate easy drawing of wires through them. Before conduits are laid in the ceiling the positions of outlet points, point controls, junction boxes shall be set out clearly so as to minimize off-sets and bends.

Conduits recessed in walls shall be secured rigidly by means of steel hooks / staples at regular intervals not exceeding 750mm. Conduits in slab shall be fastened firmly to the steel reinforcement to avoid movement during concreting. Before conduit is concealed in the walls, all chases, grooves shall be neatly made to proper dimensions to accommodate the required number of conduits. The outlet boxes, point control boxes, inspection and draw boxes shall be fixed as and when conduit is being laid. The recessing of conduits in walls shall be so arranged as to allow sufficient plaster cover on the same. All grooves, chases, etc, shall be refilled with cement mortar and finished up to the wall surface before plastering of walls is taken up by the civil contractor.

Where conduits pass through expansion joints in the building, adequate expansion fittings or other approved devices shall be used to take care of any relative movement. Running joints in conduits wherever necessary shall be rigidly held in aligned position by check nut tightened on running side. After conduits, junction boxes, outlet boxes, etc. are fixed in position, their outlets shall be properly plugged with PVC stoppers or so that water, mortar, vermin or any other foreign material do not enter into the conduit system.

Necessary steel pull wires shall be inserted into the conduit for facilitating easy drawing of conductors.

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c) CONDUITING PRACTICE

MS conduits shall be joined by means of threaded couplers and accessories only. PVC conduits shall be joined with couplers using PVC adhesive and to junction boxes by screws. Conduit shall be threaded for MS and/ or pushed to the full neck length of the couplers and accessories.

Cut end of conduits shall have neither sharp edges nor any burrs left to avoid damage to the insulation of the conductors during wire drawing. Bends in conduit shall be carried out using pipe bending fixture / machine for MS and heat bending for PVC as far as possible.

Bends which cannot be negotiated by pipe bends shall be accomplished by introducing solid/ inspection bends, junction/ MS box. At suitable intervals along the route of the conduit, not exceeding 10M, or wherever there is an abrupt change of direction / level, junction / MS boxes shall be provided so that wires can be pulled easily. Junction boxes shall have required number of ways only; any extra ways shall be plugged with PVC stoppers.

Wherever conduits terminate into point control box, outlet box, distribution board, etc. conduits shall extend into the box by 12 to 20mm and be rigidly connected to the box/board with check nuts on either side of the entry to ensure proper electrical and mechanical continuity. Bushes of PVC or rubber shall also be provided at such terminations after the conduit ends are properly filed to remove burrs and sharp edges.

MS conduits shall be painted with one coat of red oxide primer only at all such places where the metal has been exposed due to threading, etc. Exposed conduits shall be painted with a color band or letters for identification and easy maintenance; in concealed conduit system, the markings shall be inside junction boxes.

ENCLOSURE FOR ELECTRICAL ACCESSORIES

Enclosures for electrical accessories such as switches, sockets, fan regulators, etc. Shall be of MS/GI/PVC as mentioned in the Bill of Quantities. Enclosures shall be got approved before installation.

Sufficient number of knock-outs of 38 / 32 / 25 / 19 mm dia. Shall be provided for conduit entries. Enclosures shall be sufficiently strong to resist mechanical damage while under installation and normal service conditions. Provision shall be made for bonding steel enclosures to earth at two points. MS enclosures shall be adequately protected against rust and corrosion both inside and outside with suitable paint, as per the BOQ. Wherever different phase conductors or sources of supply are brought into the same enclosure, metal / hylam phase barriers shall be provided.

WIRING CONDUCTORS

All wiring conductors shall be PVC insulated, stranded /flexible COPPER conductors. All lighting/power wiring shall be done using PVC insulated, stranded / flexible copper conductor wires of 660/1100V grade. Wiring conductors shall be supplied in Red, Black, Yellow, Blue, Green, Gray colors for easy identification of wires. The wiring conductors shall be of approved makes and shall bear manufacturer's trade mark, name, voltage grade, etc.

Installation of Wiring Conductors / Cables the wiring conductors shall not be drawn into the conduits until all the works of any nature that may cause damage to the wires are completed. Proper care shall be taken in pulling the wires to see that no damage occurs to the insulation of the wires. The installation and termination of wires shall be carried out with due regard to the following:

- While drawing the wiring conductors, care shall be taken to avoid scratches and kinks which may cause breakage of strands. There shall be no sharp bends in the conduit system.
- Wire joints/splicing are permissible at switch boxes or light / power fixtures ONLY; wires shall otherwise be unbroken.
- Insulation shall be removed by means of a wire stripper tool; knife shall not be used.

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- d. Strands of wires shall not be reduced / cut to suit the terminals or lugs. The terminals shall have adequate cross section to take all the strands.
- e. All the strands shall be fully pushed into the terminal hole and the screw tightened fully to avoid loose terminations.

WIRING FOR POWER AND LIGHTING CIRCUITS

Wiring for power and lighting circuits shall be carried out in separate and distinct wiring systems. Wiring for emergency system shall also be carried out in a separate and distinct wiring system. Balancing of circuits in a three-phase system shall be arranged before the installation is taken up. The wiring system envisaged is generally shown on the layout drawings and line diagrams. However, a brief account of the general wiring system is given below:

- a. Sub mains wiring - Wiring from Main / Sub Main Switch Board to the individual MCB distribution boards.
- b. Circuit wiring - Wiring from MCB DB to the nearest switch/control box for Lighting, fans, sockets, switches, call bells for each circuit, and onward looping to the next switch / control boxes.

The sub-main wiring shall be either in 3 phase 4 wire or single phases 2 wires System. Each sub-main wiring circuit shall also have its own PVC insulated Copper earth continuity wire/s as per detailed drawings and specifications.

Circuit wiring shall be in single phase system. However, a maximum of 2 single Phase circuits belonging to the same pole/phase could be installed in the Same conduit. Not more than ten points - light, fan, and 5A socket shall be Grouped on one lighting circuit.

The maximum number of various size conductors that could be drawn into various sizes of conduits shall be as per table II of IS: 732 (Latest Edition). The wiring shall be colour coded for easy, positive identification of phases and neutral.

The following color codes shall be adopted:

Phases: R - Red	Neutral: N - Black
Y - Yellow	Earth: G - Green
B - Blue	Emergency: E - Grey

SWITCHES, SOCKETS & ACCESSORIES

GENERAL REQUIREMENTS

Light control switches shall be of a 6/16A rating for controlling light points as specified in bill of quantities. Light control switches shall be of plate type design with MS/GI/PVC boxes suitable for flush mounting for general lighting, as specified in BOQ.

All sockets 6A and 16A rating shall be of flush mounting type with control switches of plate type design of the same rating as that of the sockets. All sockets outlets shall be of 3-pin type with box.

INDUSTRIAL TYPE SOCKETS

Industrial type sockets shall be provided wherever specifically called for. Industrial sockets/plug shall be totally metal clad with 3 pins for single phase applications and 5 pins for 3 phase applications. Metal clad plug top shall be with suitable cable entry device. Socket shall be controlled by a suitably rated SP/TP MCB. Industrial sockets shall be housed in suitable sheet steel housing.

LAMP HOLDERS, CEILING ROSES, ETC.

Accessories for light outlets such as lamp holders, 3 plate ceiling rose, etc. shall be in conformity with requirements of relevant IS specification. Only approved make of accessories shall be supplied.

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INSTALLATION OF SWITCHES, SOCKETS & ACCESSORIES

All switches shall be wired on phases. Connections shall be made only after testing the wires for continuity, phasing, etc. With the help of an instrument. The arrangement of switches and sockets shall be neat and systematic. Outlets shall be terminated into a 3 plate ceiling rose for fan points. For sockets, the conductors shall be terminated directly into the switches and sockets. The outlets, point control boxes etc. shall be set out as shown on the drawings. Before fixing these, the contractor shall obtain clearance from the Owner/ Consultant with regard to their proper locations and height. The enclosure of sockets/and 3rd pin of the plug shall be connected to the ground through a proper size earth continuity wire. Whether mentioned or not, metal/hylam phase barrier be interposed between switches located in a common enclosure, but wired on different phases.

POINT WIRING

Point wiring shall commence from the first point control box for the points connected to the same circuit. Point wiring for lights, sockets etc. shall be carried out with PVC insulated copper conductor wires of 660/1100V grade. The point wiring shall be inclusive of suitable size conduits of standard and approved make (as specified herein before) along with approved quality of conduit accessories such as bends, reducers, deep junction boxes, ceiling roses, connectors, point control boxes with specified enclosure etc. Point wiring shall be provided with PVC insulated copper earth continuity wire for earthing 3rd pin of sockets/all points as specified in the BOQ.

TESTING OF ELECTRICAL INSTALLATION

Testing of installation shall be as per IS: 732 latest editions.

- The insulation resistance shall be measured by applying between earth and whole system of conductors or any part thereof with all fuses in place and all switches closed and both poles of the installation otherwise electrically connected together, a direct current pressure of not less than twice the working pressure provided that it need not exceed 500 volts for medium voltage circuits. Where the supply is derived from the three wire (AC or DC) or a poly phase system, the neutral pole of which is connected to earth either directly or through added resistance, the working pressure shall be deemed to be that which is maintained between the outer or phase conductor and the neutral.
- The insulation resistance measured as above shall not be less than 50 megohms divided the number of points on the circuits provided that the whole installation shall be required to have an insulation resistance greater than one megohm Control rheostats, heating and power appliances and electric signs may, if required, be disconnected from the circuit during the test but in the event of the insulation resistance between the case or frame work and all live parts of each rheostat appliances and sign shall not be less than that specified in the relevant Indian Standard Specification and shall not be less than half a megohm.
- The insulation resistance shall also be measured between all conductors of the supply and all the conductors connected to the middle wire or the neutral or to the other pole or phase conductors of the supply and its value shall not be less than specified in sub-clause

TESTING OF EARTH CONTINUITY PATH

The earth continuity conductor including metal conduits and metallic envelope in all cases shall be tested for electric continuity and the electrical resistance of the same along with the earthing lead but excluding any added resistance or leakage circuit-breaker measured from the connection with the earth electrodes to any point in the earth continuity conductor in the completed installation shall not exceed one megohm.

TESTING OF POLARITY OF NON-LINKED SINGLE POLE SWITCHES

- In a two wire installation the test shall be made to verify that all non-linked single pole switches have been fitted in the same conductor throughout and such conductor shall be labeled or marked for connection to an outer or phase conductor or to the non-earthed conductor of the supply.

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b. In a three wire or a four wire installation, a test shall be made to verify that every non-linked single switch is fitted in conductor which is labeled or marked for connection to one of the outer phase conductors of the supply.

MEDIUM VOLAGE ACCESSORIES

General

Electrical accessories shall be of the highest quality consistent with the required safety and shall comply with all the relevant standards. All accessories are required the type test certification by recognized testing authority. The colour of switches and switched socket outlets shall be selected by the Engineer in-charge-Clients / PMC.

All steel boxes shall comply with latest Indian Standard IS 14772 and with brass earth terminals fitted in base. For outdoors or wet locations, everything shall be corrosion-resistant including bolts, strips, etc. and the switches, isolator mounted and installed in the outdoor or wet location shall be of IP65.

Ferrous material shall be protected both inside and out by two coatings of approved corrosion-resistant material (e.g., zinc, cadmium, or enamel). Enamel shall not be used outdoors or in wet locations. For outdoors or wet locations, approved material and coating shall be used.

Unless otherwise stated, switches and switched socket outlets for outdoors or wet locations shall be mounted at 1200 mm above finished floor level. Other than shaver outlets, no switches and switched socket outlets shall be allowed to install inside bath rooms or toilets.

Unless otherwise stated, all switched socket outlets on the laboratory benches shall be surface-mounted on an approved purpose made cast alloy pedestal boxes with 38 mm diameter knockouts in both sides for conduit connection and earth terminal for connection of earth wire. Corners shall be rounded. Socket outlet fixings shall be in accordance with IS 14772.

All switch and socket outlet boxes, isolators, etc. shall be properly labeled according to the circuit number of the "As-built" drawings with approved label. All the switches, switch socket-outlets installed above ceiling, riser, plant rooms, maintenance room, and mechanical plant room shall be of metal clad type unless otherwise specified.

Standards

All electrical accessories shall comply with the following standards:-

a)	Switches	:	IS 3854/IS 3452
b)	Steel boxes	:	IS 14272
c)	Ceiling roses	:	IS 371
d)	Switched socket outlets and plugs	:	IS 1293
e)	Fused connection units	:	IS 13947
f)	Cooker units	:	IS 11879
g)	Shaver units	:	IS 302 Part 2, Sec 8
h)	Lamp holders and batten lamp holders	:	IS 1258 / IS 10276

Switches

Indication

Switches having contacts that are not visible shall be marked or provided with a device indicating clearly either the switch is at 'ON' or 'OFF' positions. Tumbler operated switches shall be so mounted that the tumbler knob is in the raised position when the switch is 'OFF' and in the depressed position when 'ON'. All tumbler operated switches shall

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be of the silent type and shall comply with BS 3676:1963. Switches controlling emergency supplies shall have 'red' colour tumbler knobs. They shall be rated minimum 10 Amp at reactive loads.

Sequence of Operation

No multi-pole switch or circuit breaker that includes a switch in a neutral conductor shall connect any live conductor before the neutral conductor is connected, or open the neutral conductor before all live conductors have been opened.

Lighting Switches

All flush mounted lighting switches shall be rocker-operated switch with impact resistance plastic flush plate switch type mounted on malleable iron or pressed steel boxes complete with brass earth terminals. Lighting switches shall comply with latest Indian Standard IS 3452 and Indian IS 3854. Whenever the number of switches at one location exceeds one, multi-gang switches shall be used. Where more than one phase of a supply are brought into a multi-gang switch box, the switches and accessories and wiring connected to one phase shall be adequately separated from those connected to other phases by means of rigidly fixed screens or barriers.

All lighting switches shall be capable of being used up to their full rating on fluorescent loads. Where switches are connected to normal as well as **emergency supplies of electricity "RED"** colored rocker switches shall be used.

Surface switches shall be heavy-gauge steel with conduit entries and shall have rocker-operated mechanisms. They shall have steel front plates of the single-switch or grid-switch type. Switches outdoors or otherwise exposed to damp conditions shall be of industrial pattern watertight type with galvanized steel or UV stabilized PVC boxes and waterproof gaskets.

Base Blocks

Every lighting fitting and accessory shall be mounted on a suitable base block or other device providing adequate wiring space except in the following cases:

- A lighting fitting or accessory mounted on a switchboard panel or a metal conduit box.
- An accessory completely enclosed in a metallic casing.
- A lighting fitting or accessory providing in its own base adequate space for wiring or one that incorporates a suitable fixing base.
- A tumbler switch mounted on a flat architrave that is not overlapped by the base of the switch.
- A flush plug-socket or flush switch.
- A lighting fitting or accessory that is securely attached to rigid conduit or piping or flexible cord.
- All base blocks or similar devices shall be securely fixed by at least two screws provided that a small base block accommodating only one accessory such a tumbler switch, ceiling rose etc. may be fixed by one screw only provided rotation of the base is effectively prevented by the manner of fixing.

Ceiling Roses

Ceiling roses shall be white of reputable manufacture according to the latest Indian Standard IS 371. They shall be of porcelain or of plastic with porcelain interiors and shall be fitted with plastic back plates or plastic mounting blocks semi-recessed where necessary to comply with the IS 732.

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Where they are of the three-plate type the live terminal shall be shrouded so as to prevent accidental contact when the cover is removed. No ceiling rose shall be used for voltage in excess of 250 V between terminals or for connection of more than two flexible cords unless the ceiling rose is specifically designed for multiple attachments. Brass earth terminals shall be provided for each continuity conductor.

Lamp holders

Lamp holders shall be of the bayonet-cap type for tungsten lamps up to and including 150 watt, and of the Edison screw type for larger lamps. Where they are integral with lighting fittings, they shall be brass with porcelain interiors. For use with flexible pendants, they shall be of white plastic with compression glands. Where batten lamp holders are installed the lamp holders shall be of white plastic. In damp situation, holders shall be approved by Engineer in-charge/ Consultant / PMC.

Lamp holders for fluorescent tubes shall be of the heavy pattern bi-pin type of white plastic construction. All lamp holders shall be lubricated with molybdenum disulphide to ensure easy removal of threaded rings and lamps.

Lighting Contactor

Lighting contactors shall be electrically held and shall be furnished in a general purpose, surface mounted enclosure, unless otherwise indicated. The contactors shall employ gravity dropout and shall employ double break silver alloy contacts, with full tungsten lamp rating, without the use of auxiliary arcing contacts. All contacts must be removable without disturbing line or load wiring. All coils shall be moulded construction, replaceable without removing the contactor from its enclosure. Coil must be suitable for continuous energisation and for silent operation. Refer to further details in the Specification on AC Contactor.

Plugs and Socket Outlets

All socket outlets and plugs shall comply with latest Indian Standard IS 14772 and generally, switched socket outlets shall be of 13 ampere, flush mounting type consisting of impact resistance plastic plate, 13 Amp S.P. rocker-operated micro break switch mechanisms mounted in a steel wall box with a suitable brass earth terminals and matted chromed plate.

Power outlets in offices and general areas shall be mounted on skirting boards or as directed by the Consultant / PMC. Socket outlets shall be so mounted that the plug is withdrawn in a horizontal plane. Socket outlets shall also be fixed on floor where so directed by the Superintending Officer and they shall be so arranged that no dust or water can accumulate therein.

Surface socket outlets shall be metal clad type with steel front plate for plant rooms, risers and car park areas. Skirting socket outlet is not allowed to be mounted lower than 150 mm above finished floor level.

Outlets in plant and machine rooms shall be metal clad protected type. These outlets shall be flush type where practicable, otherwise surface mounted. Outlets exposed to weather and in Basement shall be weatherproof type.

Switched socket outlets of 15 Amp 3 Pin and 13 Amp 3 Pin shall be flush or surface type as indicated and shall be provided with chrome plated brass plate. Where socket outlets are connected to normal as well as emergency supplies of electricity. Socket outlets with "red" rocker switch shall be used. Whereas socket outlets connected to stabilized voltage/uninterruptible power supply shall be with "red" indication lights.

Special socket outlets incorporating spark less mercury switch or explosion proof switches and socket outlets shall be used for explosion hazard areas. The socket outlets shall be tested and approved by the relevant testing authority.

3 Phase 415 V 50 Hz switched socket outlets shall be 5 pole 5 wires 415 V AC complete with equipment grounding and locking devices. The receptacles shall be heavy duty moulded of rugged arc resistant polyamide, positive locking

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and cannot be pulled apart accidentally. It shall be self closing and ensures protection from electrical hazards by closing off live connection when cap is removed. The plug shall be of the same make. The socket outlet and plug shall be mineral oils, greases and corrosion resistant and shall be splash proof.

Cooker outlets where used in kitchen shall be 32A double-pole flush type with 16 Amp switch socket contained in mild steel box and with impact resistance flush mounted plastic plate.

Shaver socket outlets shall be 230 V/110 V dual voltage operations, complete with isolation transformer and thermal overload device. The unit shall be enclosed in mild steel box for flush mounting and fitted with moulded ivory cover plate. A flush mounting double-pole switch similar to the lighting switches shall be installed outside the bathroom/toilet to control each shaver outlet.

Water heaters socket outlet shall be controlled by 20 Amp double-poles, flush mounted water heater switches with pilot light and labeled with the word "water-heater". These switches shall be installed outside bathroom/toilet and sockets installed near to the heater.

Isolators

All isolators shall comply with latest IS 13947 and mounted at 1200 mm above finished floor level unless otherwise stated or directed by Consultant / PMC.

Isolators shall be heavy-duty pattern with steel enclosures having cast-iron frame members, rust-protected and finished grey stoved enamel. Front access doors shall be fitted with dust-excluding gaskets and shall be interlocked so that they cannot be opened when the switch is 'on'. Operating handles shall be lockable in both the on and off positions and shall have visible on-off indication.

Isolators shall be 500 V rating and shall be clearly marked with their current rating. The moving contact assemblies are to be removable for inspection and maintenance. All steel doors shall be earthed to the enclosures by appropriate size of tinned copper earth braids. Isolators shall be approved by Superintending Officer. Isolators with lettering (FM) shall be flush mounted. For isolator at and above 100 Amp, refer the details of the Specification on isolators.

Switch fuses

Switch fuses shall be industrial pattern dust-proof type with HRC fuse links. They shall have enclosures fabricated from sheet steel finished grey stoved enamel with removable top and bottom endplates and shall have doors fitted with dust-proof gaskets. They shall have front-operated handles with visible on-off indication.

The interiors shall have vitreous porcelain bases fitted with plated non-ferrous conducting components. Switches shall be of the quick make-and-break type and have removable shields over the fixed contacts and removable moving contact bars.

Each switch fuse shall be supplied complete with the correct HRC fuse links. Switch fuses shall be 500 V rating and shall be clearly marked with their current rating.

Position of Wiring and Outlets

The location of outlets shown on the drawing is approximate only and the Contractor shall before installing outlet boxes study all pertinent drawings and obtain precise information from the Superintending Officer. It shall be understood that any outlet may be re-located 5 meters from the position shown on the drawings if so directed by the Superintending Officer. The Contractor shall be required to make any necessary adjustment of his work to fit conditions for recessed fixtures and for outlets occurring in glazed tile, wood paneling or other special finish and for centering such outlets properly.

Mounting Height

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The mounting height of all wiring devices, outlets shall be as indicated below with the provision that they shall be subject to alteration as per instruction by the Engineer in-charge / Consultant / PMC.

All switches	1200 mm above finished floor level
Socket outlets in switch room, mechanical plant room and work areas with wiring conduits	1200 mm above finished floor level
Socket outlets in common utility areas	300 mm above finished floor level
Switches and socket outlets on the office workstations	To be directed by the Engineer in-charge / Consultant / PMC
Wall mounted light	To be directed by the Engineer in-charge / Consultant / PMC

Extension Stud

Necessary extension stud shall be used for switches and switched socket outlet boxes that are concealed in the wall or column.

LUMINARIES

Standard

All light fittings shown and listed on the drawings and schedules shall be provided and installed. Fittings with non-standard suspension lengths shall be ordered to the correct lengths to suit mounting height as indicated on the drawings and schedules. The installation of light fittings shall include all necessary assembling, wiring and erection.

Surface mounted LED fittings shall be mounted either directly or on suspensions from two PVC junction boxes installed at the spacing required to suit the fitting. All luminaries shall be tested / approved by in accordance with the latest IS 10322.

Luminaries and associated electrical components and wiring shall comply with latest Safety Standard B.S. 4533 IEC 60598-1 or equivalent. All locally manufactured luminaries and control gear shall carry the ISI Mark.

Unless otherwise stated, all the lighting fixtures installed in outdoor area shall be IP65. All Driver and low voltage transformers shall be enclosed in approved, vented metal cabinets. (IP42). All low voltage transformers for tungsten halogen fixtures shall be supplied from the original lighting fixture manufacturer and shall be one transformer for each lighting fixture.

Approved tough PVC sheath flexible metal/rigid pvc conduit with approved type of connection glands and bushes shall be used for the connection between lighting fixtures to the ceiling outlet box. For all luminaries with more than one lamp within the fixture, one Driver shall only be used for one lamp. All indoor and outdoor spaces (including transition areas) LIGHTS comply with illuminance recommendations of NBC.

Sample Luminaries

The Contractor will be required to submit full catalogue and samples of each luminary to be used in this Contract for the approval of the. The manufacturer's catalogue sheets shall indicate input and load electrical characteristics, ambient temperature rating, noise level rating and mounting methods.

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The Contractor shall submit one sample of each type of "Approved" luminaries as indicated in the drawings to the site office for reference purpose. These samples shall be retained at the site office till the end of the project.

Performance Guarantee

The Contractor shall ensure all luminaries including all constructional materials; electrical components and wiring, supplied to this Contract are of the highest quality complying with the Specifications and specified standards. The Engineer in-charge/Consultants reserve his/her right to select fittings, components, and wiring at random for local testing. All cost incurred for such tests or analyses shall be paid by the Contractor if any work or material found to be defective OR of inferior quality, adulterated or otherwise unacceptable. Standard 5 year warranty to be provided for led light fixture in the project

Metal Work

Unless otherwise stated the body of the luminaries shall be pressed or rolled from quality electro-galvanized zinc coated steel sheet to form a rigid, robust, top quality body as a basis for the complete unit. The gauge of metalwork and material to be used shall be stated in the tender, however, it shall not be less than **20 gauge** electro-galvanized zinc coated sheet steel. Any metalwork, which in the opinion of the Superintending Officer is flimsy, inadequate and not of good quality shall be rejected and replaced with the appropriate gauge as requested by the Superintending Officer regardless of the gauge stated in the tender.

The luminary fixture shall be constructed with the minimum number of joints. All the unexposed joints shall be made by approved methods such as welding; brazing soldered joints shall not be approved. Mounting screws etc shall be spot welded to the body.

Unless otherwise stated, completely concealed hardware shall be applied to the fixture luminary. All the exposed metal at joints shall be welded, fill with weld materials, grind smooth and make free from light leaks by the inherent design of the fixture body and frame. Weld Driver support studs, socket saddle studs and reflector support studs to fixture body.

The luminary fixture shall be constructed with the minimum number of joints. All the unexposed joints shall be made by approved methods such as welding, brazing. Soldered joints shall not be approved. Self-tapping methods or rivets for fastening parts which shall be removed to gain access to electrical components required service or replacement or fastening any electrical components or their support shall not be used.

Electronic Drivers

Electronic Driver shall designed to operate Triphosphor LED tubes at full initial lumen output stated by LED tube manufacturer with the system power as stated below :-

- The electronic Driver shall full comply with the IEC 60921 IEC 928 and tested by CPRI.
- Each Driver shall consists of the following high quality components :
 - a) Low-pass filter coil to limit harmonic distortions and radio interference. It also protects the electronic components against high mains voltage peaks. Harmonic distortions should not exceed 28.8% for 3rd harmonic, 7% for 5th harmonic, 4% for 7th harmonic and 3% for 9th harmonic as per IEC 61000 IEC 555-2 standard. Radio interference suppression shall be within limits as defined in the CISPR 15/ IS 6873 Part 5. It shall meet with the requirements of magnetic field radiation. Conventional electromagnetic filter (IS 8880) shall only be used.
 - b) Rectifier.
 - c) HF power oscillator to transform the DC voltage to an HF voltage of over 25 KHz.
 - d) Lamp stabilization section.

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The electronic Driver shall automatically switch off when a lamp fails to ignite. It shall also be automatically operational when a new lamp is in place. No damage to the electronic Driver when any lamp has been removed and replaced with the electrical supply to the particular light fitting has not been isolated.

It shall be equipped with a built-in fuse to protect the power supply against any possible short-circuit in the Driver and/or excessive heating of the Driver.

It shall be incorporated a overvoltage detection circuit or equivalent system to switch off/protect the lamp(s) when the mains voltage rises above 280 VAC. The Driver shall withstand mains voltages up to 230 - 240 VAC 50 Hz without negative influences.

The open-circuit voltage of the Driver shall be less than 60% of the starting voltage for 1 to 2 second during the initial pre-heating period of the lamp electrodes to prevent a cold-start of the lamp, which can cause blackening of the electrodes and hence shortens the life-span of lamp.

The Driver loss shall not be greater than 4W per lamp way with power factor greater than 96% when operating under a main supply of 230 Volt 50 Hz.

For luminaries with more than one lamp, one Driver shall only be used for one lamp.

The manufacturer and the local sole agent of the Driver shall ensure that their products are able to interface 100% and work satisfactory with the self-contained emergency (battery powered) kit and the addressable module kit (lighting management system) to achieve optimum result.

The Driver manufacturer & local sole agent shall supply instruments to prove and test their Driver loss; voltage and pf. are fully complied with the specification.

The Driver manufacturer & local sole agent shall supply all documents instruments to prove that their Driver is tested and fully complied to the above mentioned standard.

The Engineer in-charge / Consultant /Client reserves the right to select not more than five (5) pieces of these Drivers at random from the LED fixtures on site to open up for thorough checking/investigation on the Driver components. The cost of replacement of these Drivers shall be included in the Sub-Contract. If any of this Driver does not comply with the Specification, the Contractor has to replace all the Drivers to another acceptable brand/make at his own cost.

Components and Suspension Accessories

LED lamp holders shall be bi-pin, spring contacts engaging effectively with the pins of the lamp and shall be constructed in such a way that the lamp is easily removable either for cleaning or replacement purposes. The holders shall be non-inflammable and non-conductive. No live parts of the lamp holders shall be exposed to touch. Holder shall comply with latest IS 3323.

All LED luminaries shall be completed with fuse terminal block with cartridge fuse of 5 Amps or approval equal. For bare batten LED, at least two (2) approved lamp retaining clips per LED lamp shall be provided for safety.

Power-factor correction parallel capacitors shall be of self-healing dry film construction. They shall correct the power factor of each luminaries to not less than 0.94 lagging two hours after the luminaries has operated continuously on site and shall be designed for 250 V r.m.s., 50 Hz a.c. and rated temperature of -40°C to + 85°C or better.

For those LED luminaries not installed with Driver, then the capacitors installed in these LED luminaries shall comply with latest IS 1569 and shall be mounted not less than 100 mm from any Driver.

For those LED luminaries not installed with Driver, they shall be completed with fuse terminal block with cartridge fuse of 5 Amps or approval equal.

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For those LED luminaries not installed with Driver, then the LED lamp glow-starters installed in these LED luminaries shall be unsurpassed for high quality and excellent reliability. The glow switch together with a radio-interference suppression capacitor shall be safely housed in a high quality polycarbonate canister. It shall comply with the performance requirements of IS 3723/ IEC 60155. The lamp holding sockets shall be rigidly and securely attached to the fixture enclosure or husk. Where pull-chains are included, and insulating joint shall be provided.

For all the connection between the ceiling outlet box and the light fitting fixture, liquid tight PVC covered/sheathed flexible metal conduit with approved type of brass adaptor and lock nut shall be used and the ceiling outlet box OR approved type of **plug-in** ceiling rose with 2.5 mm² 3-core flexible PVC/PVC cable and vermin tight/proof gland shall be used for the connection.

Inter-component Wiring

Inter-component wiring shall be of min. 105°C 250 volt 50 Hz rating PVC 24/0.2 mm and shall be neatly secured within the luminaries to prevent under looseness and contact with Drivers.

Cables with the maker's identification, voltage grade and temperature clearly printed on the cable sheath shall only be used. The only joints made shall be at the fuse terminal block provided on the luminaries.

Where wiring passes through or passes the edge of any metal section of the fitting, it shall be protected by an approved rubber grommet or be doubly insulated in an approved manner. All connections of wires to terminals shall be of approved types. All wiring shall be concealed from view with the fitting installed.

FANS AND ACCESSORIES

General

This section of the Specification covers the supply and installation of BLDC fans complete with accessories as indicated on the drawings.

Supply, Installation, Testing and Commissioning of 1200 mm sweep, BEE 5 star rated, ceiling fan with Brush Less Direct Current (BLDC) Motor, class of insulation: B, THD less than 10%, remote or electronic regulator unit for speed control and all remaining accessories including safety pin, nut bolts, washers, temperature rise=75 degree C (max.), insulation resistance more than 2 mega ohm, suitable for 230 V, 50 Hz, single phase AC Supply, earthing etc. complete as required.

Technical Specification	
Blade diameter (mm)	1200
Number of blades	3-Blade
Power Consumption(W)	30
Air Delivery (CMM)	230
Number of rotations (RPM)	380
Constant Airflow Control	upto 140V
Remote Control	Yes
No. of SPEED Control	5

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Off-timer	with (2h, 4h, 8h)
Sleep-mode	Yes

Regulator

Regulator shall be capable to regulate the speed of the fan from at least 10% to full speed at the rated operating voltage. This regulator shall be tapped choke type with OFF and five speeds control complied with IEC standards for radio interference, Harmonics and safety requirements.

CONDUIT INSTALLATION (CONCEALED OR EXPOSED)

General

All metal/ FRLS conduit shall be manufactured, tested and comply with Indian Standard IS 9537 / IS 14768 / IS 14930 and shall be of heavy-gauge galvanized screwed steel and have minimum Class 4 protection against corrosion.

All fittings shall be of the screwed pattern, and no solid or inspection elbows, tees or bends shall be installed. Generally, all conduit fittings shall be galvanized by the hot process both inside and out and coated with stove-enameled orange or other approved finish inside and out. All conduit fittings shall comply with IS 14930 and having Class 4 protection against corrosion.

Conduits shall be free from internal burns, fins and the like that may cause damage to cables. All rough edges shall be removed when the conduit is cut. When threaded in the field, a tapered cutting die 18 mm per 300 mm taper) shall be used.

Minimum size conduit shall be 20 mm diameter. Other sizes shall be as indicated on the plans, or as required by IS 732 for number and size of conductors installed. Pull wires shall be provided in telephone, and other low voltage equipment conduits/points.

Space factor for cable in conduits must strictly conform to IS 732. All PVC insulated cables, other than flexible, shall be protected throughout their length with heavy-gauge screwed welded conduit (enameled or galvanized as required) with the necessary approved loop-in, draw-in, angle and outlet boxes. No type of 'elbow' or 'tee' will be allowed on works under this Specification.

Where adaptable boxes are used they shall be of cast iron or heavy-gauge sheet steel of not less than 12 gauges. Conduits for extra low voltage cable shall be galvanized with words **"T"** for TELEPHONE, permanently printed onto the conduits to indicate the different services. All conduits shall be painted as per colour scheme stated in General Specification.

Accessories

All circular junction boxes, pull boxes, solid elbows and inspection elbows are to be malleable iron type and of standard pattern with spout to British Standard BS 4568.

Circular junction boxes pull boxes and inspection elbows shall be provided with gaskets and lids. Bushing shall be used at the point where the conduit goes into a box, fitting, or other enclosure.

All switch and socket outlet boxes shall be surface mounted galvanized steel type complying with IS 1293 with heavy protection both inside and outside. They shall have earth terminals.

All lids for draw-in boxes, etc., whether of the BS or adaptable type shall be of heavy cast-iron or 12 gauge sheet steel, and shall be fixed (overlapping for flush work) by means of two or four 2BA round-headed brass screws as required.

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Installation

The whole conduit system shall be installed to comply fully with clauses in IS 732.

The conduit shall be laid as far as possible in straight lines with easy sets or bends. Bends or offset shall be made with standard conduit benders, field bends made with an approved bender or hickey, hub-type conduit fittings.

Prior permission shall be obtained from the Engineer in-charge / Consultants / PMC for hacking and chasing on reinforced concrete structures. Any unauthorized hacking and chasing shall render the Contractor liable for penalty to be determined by Engineer in-charge /Consultants /PMC.

All conduit joints shall be cut square, threaded, reamed smoothly and drawn uptight. Conduit shall be clean, tune and free from all obstructions and painted with aluminum paint before being screwed into sockets and boxes, etc.

Conduit shall run parallel to each other and at right angles to building lines and painted with semi-glossy paint to match the colour of the walls and ceiling. Where the conduit is above the false ceiling, orange colour conduit shall be used for L.V. installation.

Conduits shall be continuous from outlet to outlet and from outlets to cabinets for switch gears, pull or function boxes, and shall be secured to all boxes with locknuts and bushing in such a manner that each system shall be electrically continuous throughout. Conduits' ends shall be capped to prevent entrance of foreign materials during construction.

All conduit system shall be installed complete before conductor/cables are pulled in. Conduits shall be supported at least every 3000 mm by approved spacer bar type of saddles or flat hangers and firmly fasten within 150 mm of each outlet, junction boxes, cabinet, or fittings, etc.

Conduits below false ceiling shall run vertically to each switch or socket outlet box. No horizontal conduit work shall be allowed.

The allowable bending radius for conduit is 12 times the diameter of conduit. No conduit installation work shall be allowed to run under the cement screed except for areas using under floor/flush floor trunking system.

A circular pull box shall be used to limit any pull to maximum 8000 mm. A sum of conduit between circular pull boxes must not have more than two 90o bends.

No conduit shall be installed with more than two right-angle bends without draw-in boxes and draw-in boxes shall not be more than 8000 mm apart.

All conduits, except where otherwise specified, shall drop not rise to the respective points. In no circumstances shall the conduit be erected in such a manner as to form a U without outlet, or in any other way that would provide a trap for condensed moisture.

Provision shall be made for draining all conduits or fixtures by a method approved by the Engineer in-charge /Consultants /PMC. Ceiling point boxes are to be of medium pattern malleable iron, with fixing holes at 50 mm centers and conforming to SS Specification.

All conduit systems shall be installed complete before conductors/cables are pulled in. Galvanized spaced bar saddles shall be used for securing conduits on surfaces other than in structural steel members for which an approved type of clamp shall be devised. Spacing of saddles shall not exceed 1200 mm (ft.) for conduit sizes up to and including 25 mm and 1.8 m for sizes 32 mm and above and within 1000 mm of each outlet box, junction box, cabinet or fitting, etc. Full saddle shall be used for all vertical run of conduit.

In addition, conduit fixing shall be located not less than 150 mm from each surface box or switch and shall be one per conduit to each such box or switch. Connections between conduits and trunking and conduit and steel boxes, or between conduit and steel cases of distribution gear or equipment, shall be made by means of a flanged coupling and brass smooth-bore entry bush. The lead washer shall be fitted on the inside of the trunking or box, etc.

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Conduits set through walls will not be permitted. When change of direction is required after passing through a wall an appropriate back outlet box is to be fitted. All joints between lengths of conduit, or between conduit and fittings, etc. are to be threaded home and butted. Sets and bends are to be made without indentation, and the bore must be full and free throughout. All screw-cutting oil must be carefully wiped off before joining up.

Conduit runs, as far as possible, are to be symmetrical and equally spaced. The Contractor shall take all precautions in situations likely to be damp to see that all conduits and boxes in the vicinity are rendered watertight. During the progress of the work all exposed ends of conduits shall be fitted with suitable plastic or metal / FRLS plugs. Plugs of wood, paper and the like will not be acceptable as sufficient protection.

All conduit fittings not carrying lighting or other fittings shall be supplied with suitable cast-iron covers with round-head brass screws. Where flush boxes are installed the covers shall be of the overlapping rustproof pattern. All conduit boxes, including boxes on and in which fittings, switches and socket outlets are mounted, shall be securely fixed to the walls and ceilings by means of not less than two countersunk screws, correctly spaced, and the fixing holes shall be countersunk, so that the screw heads do not project into the box.

Lighting, power and any other types of circuit shall be run in separate conduits and no circuit of any one system shall be installed in any conduit or box of any other system. Under no circumstances shall conduits from different distribution boards be connected to any one junction box and likewise cables from different distribution boards shall not be housed in the same conduit. The phase, neutral and earth conductors of the same circuit or circuits shall in all cases be drawn into the same conduit.

Where conduits are required to run across expansion joints, they shall be provided with a short-length of approved liquid-tight, nonmetallic, and sunlight-resistant PVC covered flexible metal / FRLS conduit sufficient to allow for a total movement of +50 mm. Where conduits are run in wet or damp location, conduits, clips, saddles, bolts and screws, etc., shall be corrosion resistant materials or protected against corrosion by corrosion resistant materials as required.

Short lengths of appropriate size of approved liquid-tight, nonmetallic, and sunlight-resistant PVC covered flexible conduits shall be used for final connections to motors, lighting fixtures, and other equipment subject to movement or vibration (maximum of 300 mm for motors or other equipment and 1500 mm for lighting fixtures). Earth continuity of all flexible conduits shall be maintained by 4mm² minimum copper conductors forming one of the cores of the cable.

Flexible conduits shall be terminated with couplings and connectors specially made for the purpose. Earth continuity of all flexible conduits shall be maintained by 4 sq.mm minimum copper conductors in addition to the number of cores of the cables.

Whenever the steel conduit passing through a full height fire wall or floor approved fire stop compound or approved equal material shall be used to seal the air-gaps between wall or floor and conduit.

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SURGE PROTECTION DEVICES

General

This section of the specification covers the supply, installation and the testing for the surge protective devices and is to read in conjunction with the drawings.

The system shall be installed according to the following standards. Where the Publications are referenced throughout this specification and shall apply when relevant.

- a) UL 1449-1987 Transient Voltage Surge Suppressers.
- b) ANS/IEEE C62.41-1991 IS 15086 Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
- c) ANS/IEEE C62.33-1982 IS QC 420100/1/2 Standard Test Specifications for Arrestor Surge Protective Devices.
- d) ANS/IEEE C62.45-1987 IEE IS 15086 Guide on Surge testing for Equipment connected to Low-Voltage AC Power Circuits
- e) CP 33 : 1996 IS 2309

All components shall be from the same manufacturer to ensure that system performance is fully coordinated. Surge Protective devices (SPD's) shall be installed at each main switchboard and at distribution switchboard supplying critical equipment (computers, PLC's etc.) and original devices as indicated in the drawings.

All labels shall be clearly shown at the side of the devices. The protective devices shall not interfere with the electrical system normal operation. It shall not :

- f) Corrupt the electrical system
- g) Break or shut down the electrical system
- h) Have an excessive earth leakage current.

Electrical Board Surge Protective Devices

The **Minimum** acceptable requirements for a electrical board SPD are as follows:-

- The maximum continuous operating voltage (MCOV) of the SPD must be 25% above nominal system voltage. For example, for use on a 240V AC (phase-neutral) system, the SPD's rated MCOV must exceed 300V AC.
- The maximum single withstand surge current, per phase of the SPD, is to be a minimum of 60kA (8μs rise time and 20 μs delay time to half peak amplitude) between any two live conductors.
- The complete SPD must be UL listed to UL 1449 or equivalent for 230/ 415V AC (phase-neutral) systems, the peak transient let-through voltage shall not exceed 600 V.
- The SPD must be modular in design. Surge protection circuitry, fusing mechanisms and diagnostics are to be housed in a replaceable module. Discrete modules are to be employed for each phase. Each surge protection component within a module is to be individually protected by thermal and short circuit fusing mechanisms that disconnect should a fault occur.
- The SPD must include full diagnostics, electrical (LEDs) and mechanical (a flag visible through a window) status indicators must be presented at the module level. Remote status indication is to be available through dry (or voltage free) contacts which to be connected to a PLC/Building Automatic System/Power Monitoring System.
- All surge carrying connections within the SPD are to be heavy duty bolted connections. Wires less than 8/AWG (10mm²) or friction contacts for replaceable modules are not to be used.

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- The SPD shall be installed to protect the line-ground (L-G), line-neutral (L-N) and Neutral-ground (N-G).
- Warning indication shall be provided for high neutral to ground voltage to be able for identification any potential wiring faults conditions which exists within the facility.

EARTHING SYSTEM

General

All non-current carrying metal parts of the electrical installation shall be earthed as per IS: 3043-2018. All equipment, metal conduits, rising main, cable armour, switch gear, distribution boards, meters, all other metal parts forming part of the work shall be bonded together and connected by two separate and distinct conductors to earth electrodes. Earthing shall be in conformity with the provisions of Rules 32, 61, 62, 67 and 68 of IER 1956.

The entire earthing installation shall fully comply with all relevant clauses of the current edition of IS 732 and IS 3043-2018. The earth continuity conductor shall be of high - conductivity copper continuous throughout its length and without joints except by approved mechanical clamps.

The metal parts of all switch gears, switches, metal boxes, switch-socket outlets, isolators, metal trunking, lighting luminaries, metal conductors and all metal work liable to become alive in the event of failure of insulation and the earth connection of all electrical fittings and appliances shall be effectively earthed by means of earth continuity conductor of adequate size.

The earth continuity conductor shall be of high - conductivity copper continuous throughout its length and without joints except by approved mechanical clamps or approved PVC (**GREEN/YELLOW**) insulated copper cables.

Earth Connections

The earth continuity conductor from all exposed metal parts of equipment required to be earthed including earth connections to plug sockets shall be connected by one of the following appropriate methods:-

- a) To earth connection at the distribution board supplying the equipment or plug socket.
- b) To any point on the sub-main or main earth continuity conductor supply the relevant distribution board.
- c) To residual current circuit breaker installed in accordance with CEIG / Power Grid's requirement.

Prohibited Connections

Neutral conductor, sprinkler pipes, or pipes conveying gas, water or inflammable liquid, structural steel work, metallic enclosures, metallic conduits and lightning protection system conductors shall not be used as a means of earthing an installation or even as a link in an earthing system. The electrical resistance measured between earth connection at the main L T panel and any other point on the completed installation shall be low enough to permit the passage of current necessary to operate or circuit breakers, and shall not exceed 1 ohm. All switches carrying medium voltage shall be connected with earth by two separate and distinct connections. The earthing conductors inside the building wherever exposed shall be properly protected from mechanical injury by running the same in G I pipe of adequate size. The overlapping in strips at joints where required, shall be minimum 75 mm. The joints shall be riveted and

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brazed in case of copper and by welding / bolting in case of GI in an approved manner. Sweated lugs of adequate capacity and size shall be used for termination of all conductor wires above 6 sq.mm size. Lugs shall be bolted to the equipment body to be earthed after the metal body is cleaned of paint and other oily substances and properly tinned. Equip-potential bonding of all metallic structures shall be done.

Main Earth Continuity Conductor

The main earth continuity conductor from switchboard to earth electrode shall be installed as directly as possible without looping into any accessory or equipment.

Maintenance free Earthing Electrode System/ Chemical Earthing

Maintenance free chemical earth pit of minimum bore dia. 150mm size , approved make Safe Earthing Electrode consisting Pipe-in-Pipe technology as per IS 3043-1987 made of corrosion free CU bonded steel rods with constant ohmic value surrounded by highly conductive compound with high charge dissipation suitable for effective and maintenance free earthing as mentioned below :With 3 mtr. Copper bonded Pipes having outer pipe dia of 50mm having 80-200 micron galvanizing, Inner pipe dia. of 25mm having 200-250 Micron galvanizing, connection terminal dia.of 12mm in nominal soil with 50 kg (Two Bag) Back filling Compound. Making of Earth-Stations as per IS3043 with funnel set etc., including making of 450 x 450 x 300mm brick masonry chamber with angle-iron hinged frame-work / RCC cover with handles etc., complete as required.

Earth rod offered shall have passed the test required of BS7430/ ANSI/ UL467 and confirm to the adhesion of the copper coating to the steel core (Design feature that prevents the ingress of moisture and subsequently the integrity of the rod.

Minimum 0.25 mm thickness of copper shall be deposited over the steel core as per BS 7430/ UL 467. Average life of the ground rod shall be 30 years in most soil.

Ground enhancement material shall be as per IEEE-80 clause 14.5d with a resistivity of less than 0.12 ohm-meter. The ground enhancement material shall be permanent and not leach any chemicals in to the ground. The pH value of the ground enhancement material shall be 6.9 to 7.2 of 100 gm/ lit @ 20 deg.C.

Minimum 30 Kg of ground enhancement material shall provide for each earth electrode.

Inspection chamber shall be of 450 x 450 mm with brick masonry chamber with angle-iron hinged frame-work with bitumastic paint.

PRECAUTIONS

Earthing system shall be mechanically robust and the joints shall be capable of retaining low resistance even after repeated subjections to fault currents.

Joints shall be tinned (if copper) and brazed / welded, double bolted / riveted. All the joints shall be mechanically and electrically continuous and effective. Joints shall be protected against corrosion.

TESTING

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On completion of the entire installation, the following tests shall be conducted:

- i) Earth resistance of electrodes.
- ii) Impedance of earth continuity conductors as per E-3 of IEE regulations.
- iii) Effectiveness of earthing as per E-4 and E-5 of IEE regulations

All meters, instruments and labour required for the tests shall be provided by the contractor. The tests results shall be submitted in prescribed tabulated form in triplicate to the consultants for approval.

Lightning Protection of the building and area adjacent to building

General

Lightning Protection System shall be in accordance with IS / IEC 62305-3

Zone of Protection

The zone of protection of a lightning conductor defines the space within which Air Terminal provides protection against a direct lightning strike with probability of protection as per LPL.

LPL (Lightning Protection Level)

LPL is a number associated with a set of lightning current parameters relevant to the probability that the associated minimum & maximum values do not exceed the normally occurring lightning. LPL can be determined by Risk analysis as explained in IS / IEC 62305-2.

LPL levels and probability of protection:

Lightning protection Class	Lightning current peak value MINIMUM	Lightning current peak value MAXIMUM	Interception probability
LPL 1:	3 kA	200 kA	98%
LPL 2:	5 kA	150 kA	95%
LPL 3:	10 kA	100 kA	88%
LPL 4:	16 kA	100 kA	81%

Components of External LPS

- 1.) Air terminal (as per rolling sphere or mesh or protective angle method or any combination thereof.)
- 2.) Down conductor

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3.) Earthing

Air termination system:

No drilling is allowed in the terrace for fixing the air terminal, if the roof is made of concrete. Parapet wall is exception to this.

Values of Rolling sphere radius, Mesh size and protection angle as per Class of LPL/LPS.

Class of LPL/LPS	Rolling sphere radius(m)	Mesh size (m)	Protection angle
1	20	5*5	Refer figure 1
2	30	10*10	Refer figure 1
3	45	15*15	Refer figure 1
4	60	20*20	Refer figure 1

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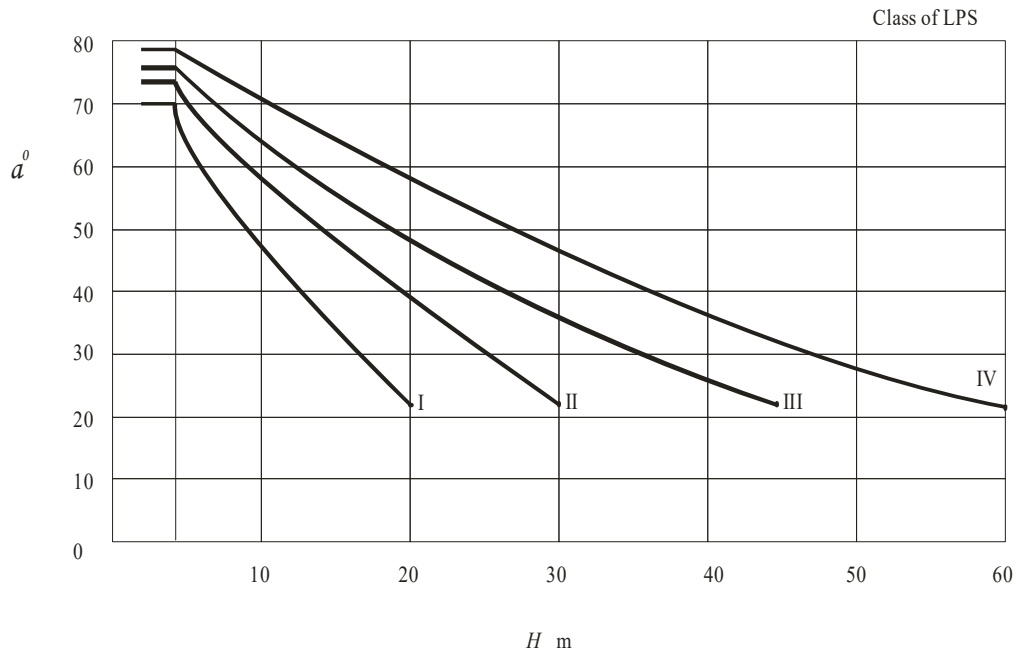


Fig 1. Class of LPS Vs Angle of protection.

If the structure height is more than 60 meters, top 20% of the height of the structure shall be protected with a lateral air termination system. This is needed because, the probability of flashes to the side is generally more for structures more than 60 meters in height. For structures of height more than 120 meters, ring has to be formed for every 20 meters height of the building above 60 meters height.

Material and Dimensions

Material of air terminal, down conductor, earth termination etc. shall be as below:

Material	May be destroyed by galvanic coupling with
Copper(Solid)	GI and Aluminium
Hot galvanized steel(Solid)	Copper
Stainless steel(Solid)

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Aluminium(Solid)	Copper
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Dissimilar metals (eg. Copper with Aluminium) must be connected only by using bimetal connectors. Minimum thickness of metal in air termination system for LPL /LPS

Material	Thickness (a) in mm	Thickness (b) in mm
Galvanized steel	4	0.5
Stainless steel	4	0.5
Copper	5	0.5
Aluminium	7	0.65

Prevents puncture. Allowed only if it is NOT important to prevent puncture or water leakage

Material, Configuration and Minimum cross sectional area of air terminal & down conductors

Material	Type	Minimum cross section area	Remarks
Copper	Solid tape	50 sq mm	2mm min thickness
Copper	Solid round	50 sq mm	8mm dia
Aluminum	Solid tape	70 sq mm	3 mm min thickness
Aluminium	Solid round	50 sq mm	8 mm dia
GI	Solid tape	50 sq mm	2.5 mm min thickness
Stainless steel	Solid tape	50 sq mm	2 mm min thickness

Air terminal holder:

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Concrete Roof structure: Conductors shall be securely fixed on the terrace by means of air terminal holder which is fixed on the roof by adhesive of good quality taking care of varying weather conditions. Air conductor holder is an insulator & should be of minimum 50 mm height so that even small amount of water logging on terrace is below the level of conductor holder.

Metal Roof structure: Conductors shall be securely fixed on the terrace by means of air terminal holder which is fixed on the roof by metal conductor holder of good quality which is tested for lightning current as per IEC standard. Vendor need to give proof. As metal roof structures are normally tapered at an angle, there is no min. height criteria for metal conductor holder.

Recommended distance between air terminal holders:

Arrangement	Recommended distance for SOLID TAPE	Recommended distance For ROUND conductors
Horizontal conductor on horizontal surface	500 mm	1000 mm
Horizontal conductor on vertical surface	500 mm	1000 mm
Vertical conductor from Ground to 20m height	1000 mm	1000 mm
Vertical conductor above 20m height	500 mm	1000 mm

If antenna, air cooler or any other electrical equipment is present above terrace level, the same have to be protected by using vertical air terminal after calculating the safety or separation distance. The vertical air terminal has to have suitable supports to hold it. Wind speed need to be taken into account. Vertical air terminal must be connected to horizontal air terminal by using suitable connectors the crossings of the horizontal air terminals, suitable Cross connector has to be used for secure connection which is tested for lightning current as per IEC standard. Vendor has to provide proof.

Safety or Separation distance:

It is must to calculate safety or separation distance in order to avoid flash over to the electrical equipment when the lightning current is passing through the vertical air terminal.

Safety/Separation distance (S) in m = $(k_i * k_c * L) / km$

Coefficient k_i depends on class of LPL/LPS

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$k_i = 0.08$ for LPL1,

$k_i = 0.06$ for LPL 2,

$k_i = 0.04$ for LPL3 and 4.

Coefficient k_c depends on no of down conductors:

$k_c = 0.66$ for 2 down conductors

$k_c = 0.44$ for 3 or more down conductors

Value of coefficient $k_m = 1$

Value of L is the total distance between the equipment to be protected (for e.g. Antenna) to the equi-potential bonding bar situated just above the ground.

Expansion piece

In order to take care the expansion of the metal in summer and contraction of the metal in winter, expansion piece with suitable connectors have to be used at every 20m distance of horizontal air terminal.

Joints and Bonds

The lightning protective system shall have few joints as far as possible & air terminal & down conductor have to be straight. Where it is not possible, it should NOT be bent at 90 degree (right angles) & should have a curved path of 45 degree bend.

Down conductor system

In order to reduce the probability of damage to electronic/electrical equipment, the down conductors shall be arranged in equi distance in such a way that from the point of strike to earth, several parallel current paths should exist & length of the current path should be minimum. Down conductors can be installed separately or more wisely it can be part of natural components of the building. Examples are steel reinforcement in RCC columns, metal facades, profile rails, metal doors & windows. Down conductors should be installed at each exposed corner of the structure as a minimum. Rebar used for lightning protection system shall be with high mechanical strength with anticorrosive treatment conforming to BS7430.

Value of distance between down conductors as per Class of LPL / LPS

Class of LPL/LPS	Typical distance (m)
1	10
2	10
3	15

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4	20
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Test joints:

At the connection of the earth terminal, a test joint should be fitted on each down conductor at a height of 1 m from the ground, except in the case of natural down conductors combined with foundation earth electrode. The purpose of test joint is to measure the earth resistance value. The remaining portion of down conductor (i.e., after the test joint should be mounted inside a plastic pipe of minimum 3 mm thickness.)

Earth Terminations

Earth mat is most preferable. Where earth mat is not possible, ring earthing is the next best method. Ring earthing must be 1 meter away from the building and 0.5m below the ground level.

The resistance of earthing system shall not exceed 10 ohm as per IEC 62305.

Lower earth resistance is more preferable.

For earth termination system, 2 basic types of earth electrode arrangements are applicable.

Type A & Type B arrangement.

Type A arrangement: Comprises of horizontal or vertical earth electrode installed outside the structure to be protected connected to each down conductor.

In type A arrangement, the total number of earth electrodes shall not be less than two.

Type A arrangement is suitable in places where electronic equipment are not located.

Type B arrangement: This type of arrangement comprises either a ring conductor external to the structure to be protected, in contact with the soil for at least 80% of its total length or a foundation earth electrode. Such earth electrodes can also be meshed. For structures with extensive electronic systems or with high risk of fire, type B earthing is most preferable method. Corrosion proofing band has to be used wherever down conductor is connected to earth termination system. Bitumen has to be applied at the point of inter-connection.

In potentially corrosive areas, Stainless steel must be used.

References:

IS / IEC62305 – PROTECTION AGAINST LIGHTNING:

Part 1: General Principles

Part 2: Risk Management

Part 3: Protection of structures

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Part 4: Protection of Electrical & Electronic equipment within structure

Product Specifications

Surge protector at Stage II / Class C (Final Distribution Board Protector)

The surge Protection manufacturer shall offer a complete line of surge Protection product to support the requirements for the Distribution Board. The surge protector at this stage shall be provided to protect the downstream electrical and electronics against any induced switching surges that may be passed on to the downstream electrical & electronic system.

The Protection unit shall be based on Single High Capacity Metal Oxide Varistors (MOV), capable of handling 8/20 μ s surges and shall be able to give an indication in the event module failure and be pluggable to facilitate the in-service replacement without distributing the lines. One extra set of replacement module shall be furnished to the job site.

Protection Network Configuration. The work required under this section consists of furnishing, installing and connecting SPD device as specified and as shown in the drawings. The SPD device shall be installed in a NETWORK configuration, consist of one set of SPD panel device at the service entrance of switchboard. All SPD device in this network configuration shall be of same manufacturer. All SPD device shall be modular, mountable on 35 mm DIN rail and be field replaceable without interruption of electrical distribution circuit.

Unit status indicator shall be provided to indicate the status of complete Protection unit on the product as well as provision for remote indication must be provided.

Protection shall be manufactured for the specific type and voltage of the electrical Service and shall provide clamping for both normal (L-N) and common (N-G) mode operation.

Protection shall be manufactured to withstand a maximum continuous operating voltage of not less than 115% of normal RMS Line voltage of 240 VAC.

The Protection shall be provided with internal safety fusing if required, to be connected in parallel between Line/s to neutral & neutral to earth as per the TNS configuration of wiring. It shall be testable on line for routine maintenance, module failure and in order to prevent catastrophic failure modes.

Protection shall be a fail-safe type device, shall have no follow through current shall have repeated surge capability, shall be solid state, shall be self restoring and be fully automatic in all mode of operation. It shall have thermal disconnection and indication against overloading of the device.

Protection shall comply with IEC 61643 standards.

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Protection shall have an operating temperature ranges from -20°C to + 60°C.

Protection Criteria

The maximum continuous operating voltage (Rated voltage) for SPD devices connected to phase-neutral shall not be less than the value as shown in table below:

Nominal Voltage Rating per phase	Maximum Continuous Operating Voltage
(Vrms)	(Vrms)
120	150
240	320
350	440
480	600

The surge protective device and associated hardware must comply with IEC 61643-

The Protection voltage of the complete rail mount surge protective device shall be type test to the figures as indicated in table below, which must not exceed the values shown.

Service Voltage / per phase	Protection Voltage @ In (Nominal discharge current) / Protection Level
240 V	1500 V

Nominal Withstand Surge Current.

Surge Protective device (including all fusing and over current protection) for application at sub-Distribution Panels shall have a Nominal surge current withstand capacity as shown in table below. The failure or operation of any fuse / over – current device during the test is not permissible.

Application Panel Location	Max. Single Withstand Surge Current Of 8/20 μ s Impulse)
Sub-Distribution Panel	10KA for 8 / 20 μ s (between Line to Neutral)
Final Distribution Board	25 KA for 10/350 μ s (between Neutral to Earth)

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Compliance to this specification must be provided in the form of a certificate from an independent testing laboratory.

Response time of Class C arrestor should not be <25 ns.

SPECIFICATION FOR UPS AND BATTERY SYSTEM

Smart-UPS On-Line provides High Density, True Double-Conversion On-line power protection for servers, and Emergency Light applications. The Smart-UPS On-Line family provides customers with a reliable source of uninterruptible power even in demanding power environments, Including very wide input voltage window, Extremely tight output voltage regulation, frequency regulation, Internal bypass, and input power factor correction.

Run time for load	Min-Max: 240-2400 Watts
Output power capacity	3 KVA / 2.4 KWatts
Output Connections	(2) IEC 60320 C13 (Battery Backup) (1) Hard wire 3-wire (H N + E) (Battery Backup)
Nominal Output Voltage	230V
Nominal Input Voltage	230V
Input Connections	Hard wire 3-wire (1P + N + E)

Features

- **Efficiency** Generally Smart Online UPS is of 92% / 93% Efficient (Double-conversion)
- **High-Power Charger:** 1000W max, allows up to 4 hrs backup without additional charger
- **SMF / Flooded** Battery selectable
- **Graphical LCD** Provides key UPS status at a glance. Multiple status indicators with load and battery bar graphs
- **SmartSlot** Customize UPS capabilities with management cards.
- **Genset compatible** Allows you to recharge your battery while on generator power.
- **Rack/Tower** convertible, 2U in rack
- **Paralleling** option available

1. Availability:

- **Scalable runtime** Allows additional run time to be quickly added as needed.
- **Automatic restart of loads after UPS shutdown** Automatically starts up the connected equipment upon the return of utility power.
- **Temperature-compensated battery charging** Prolongs battery life by regulating the charge voltage according to battery temperature.
- **Hot-swappable batteries** Ensures clean, uninterrupted power to protected equipment while batteries are being replaced
- **Intelligent battery management** Maximizes battery performance, life, and reliability through intelligent, precision charging.
- **Automatic internal bypass** Supplies utility power to the connected loads in the event of a UPS power overload or fault.

2. Adaptability:

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- **Flash upgradeable firmware** Install maintenance releases of firmware remotely using FTP.
- **Plug-and-Play external batteries** Ensures clean, uninterrupted power to the loads when adding extra runtime to the UPS.
- **Rack/Tower convertible** Protects the initial investment in the UPS when migrating from tower to rack-mount environment.

3.Serviceability

- **User-replaceable batteries** Increases availability by allowing a trained user to perform upgrades and replacements of the batteries reducing Mean Time to Repair (MTTR)
- **Automatic self-test** Periodic battery self-test ensures early detection of a battery that needs to be replaced.
- **Disconnected battery notification** Warns when a battery is not available to provide backup power.
- **Predictive failure notification.** Provides early-warning fault analysis ensuring proactive component replacement.
- **Audible alarms** Provides notification of changing utility power and UPS power conditions

4.Protection

- **Power conditioning** Protects connected loads from surges, spikes, lightning, and other power disturbances.
- **Resettable circuit breaker** Easy recovery from overloads; no need to replace a fuse. (Not available on Wall Tap SKUs)
- **Safety-agency approved** Ensures the product has been tested and approved to work safely with the connected service provider equipment and within the specified environment.
- **Cold-start capable** Provides temporary battery power when the utility power is out.
- **Frequency and voltage regulation** Gives higher application availability by correcting poor frequency and voltage conditions without using the battery.
- **Generator compatible** Ensures clean, uninterrupted power to protected equipment when generator power is used.
- **Input Power Factor Correction** Minimizes installation costs by enabling the use of smaller generators and cabling.

5.Marketing Features:

Low Operating and Maintenance Costs with Proven Reliability and Intelligent Battery Management

Intelligent battery management, pioneered by APC, maximizes battery performance and life through intelligent, precision temperature compensated charging. Automatic self tests insure battery reliability and warn customers in advance of battery replacement. Convenient, easy to connect, hot-swappable battery modules provide battery replacement without powering down.

Peace of Mind that comes with Full Equipment Compatibility and Reliability of a Leader

Provides pure sine wave output which is recommended by server manufacturers using active power factor corrected (PFC) power supplies. Safety agency tested and approved means that you can deploy Smart-UPS with confidence that they meet or exceed the industry's most rigorous standards.

Save Time with Easy and Convenient Remote/Network Accessibility

Network manageable via serial, USB or Ethernet. Includes Powerchute® Software for convenient monitoring and control, safe operating system shutdown, and innovative energy management capabilities.

Avoids Costly Power Problems by keeping your IT Equipment and Data Protected

Network grade power conditioning protects from damaging surges and disruptive noise. The double conversion architecture provides tight voltage regulation, frequency regulation, and zero transfer time to battery during power events.

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6.Manageability

- **InfraStruXure Manager Compatible** Enables centralized management via the APC InfraStruXure Manager.
- **LED status indicators** Quickly understand unit and power status with visual indicators.
- **Network manageable** Most models provide remote power management options of the UPS over the network. Many do not have NMC embedded.
- **Serial connectivity** Provides management of the UPS via a serial port.
- **SmartSlot** Customize UPS capabilities with management cards.

SAFETY REQUIREMENTS

The Contractor, his Sub-Contractors and nominated sub-contractors, shall comply with the safety precautions, protective measures, house keeping requirements, etc. The Project Manager with due intimation shall have the right to stop the work at site, if in his opinion proceeding with the work will lead to an unsafe and dangerous condition. The contractor shall get the unsafe condition removed or provide protective equipment. The contractor shall ensure that all workmen are aware about the nature of risk involved in their work and have adequate knowledge for carrying out their work safely.

The contractor shall be held responsible for non-compliance if any of the safety measures and delays, implications, injuries, fatalities and compensation arising out of such situations or incidents.

SAFE MEANS OF ACCESS

- Adequate and safe means of access and exit shall be provided for all work places, at all elevations shall be avoided.
- Suitable scaffolds shall be provided for workmen for all works that cannot safely be done from the ground, or from solid construction except such short duration work as can be done safely from ladders. Ladder shall be of rigid construction having sufficient strength for the intended loads and made of metal and all ladders shall be maintained well for safe working condition. Suitable footholds and handholds shall be provided on the ladder. The ladder shall be given an inclination not steeper than 1 in 4 (1 horizontal and 4 vertical).
- Scaffolding or staging more than 3.5m above the ground or floor, swung or suspended from an overhead support or erected with stationary support shall have a standard guard-rail properly attached, bolted, braced or otherwise secured at least 1m high above the floor or platform of such scaffolding or staging. The guardrail shall extend along the entire exposed length of the scaffolding with only such opening as may be necessary for the delivery of materials. Standard railing shall have posts not more than 2m apart and an intermediate rail half way between the floor and platform of the scaffolding and the top rail. Such scaffolding or staging shall be so fastened as to prevent it from swaying from the building or structure. Scaffolding and ladder shall conform to relevant IS specification (IS 3696-1966). **TIMBER/BAMBOO SCAFFOLDING SHALL NOT BE USED.**
- Working platforms of scaffolds shall have toe boards at least 15cm in ht. to prevent materials from falling down.
- A sketch of the scaffolding proposed to be used shall be prepared prior to start of erection of scaffolding. Safety engineer shall examine all scaffolds before using.
- Working platform, gangways and stairways shall be so constructed that they shall not sag unduly or unequally and if the ht. of the platform or gangway or stairway is more than 3.5m above ground level or floor level, they shall be closely boarded, shall have adequate width for easy movement of persons and materials and shall be suitably guarded.
- The planks used for working platform shall not project beyond the end supports to a distance exceeding four times the thickness of the planks used. The planks shall be rigidly tied at both ends to prevent sliding and slippage. The thickness of the planks shall be adequate to take load of men and materials and shall not collapse.

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- h. Every opening in the floor of a building or in a working platform shall be provided with suitable means to prevent fall of persons or materials by providing suitable fencing or railing, the minimum ht. of which shall be 1m, along with 15cm high sheet obstruction at floor level along the railing.
- i. Safe means of access shall be provided to all working platforms and other elevated working places. Every ladder shall be securely fixed. No single portable ladder shall be over 9m in length. For ladders, up to 3m in length the width between side rails in the ladders shall in no case be less than 300mm. For longer ladders, this width shall be increased by at least 20mm for each additional meter of length. Step spacing shall be uniform and shall not exceed 300mm.
- j. Adequate precautions shall be taken to prevent danger from electrical lines and equipment. No scaffolding, ladder, working platform, gangway runs, etc. shall exist within 3 meters of any un-insulated electric wire. Whenever electric power and lighting cables are required to run through (pass on) the scaffolding or electrical equipment are used, such scaffolding structures shall have minimum two earth connections with earth continuity conforming to IS code of practice.

DEMOLITION

Before any demolition work is commenced and also during the progress of the work: Before demolition operations begin, the contractor shall ensure that the power on all electric service lines is shut off and the lines cut or disconnected in or outside the demolition site. If it is necessary to maintain electric power during demolition operation, the required lines shall be adequately protected against damage.

Persons handling heavy materials/equipment shall wear safety shoes. No floor, roof or other part of the building shall be overloaded with debris or materials as to render it unsafe. Entries to the demolition area shall be restricted to authorized persons only.

PERSONAL PROTECTIVE EQUIPMENT

All necessary personal protective equipment shall be kept available for the use of the persons employed on the site and maintained in a condition suitable for immediate use. Also the contractor shall take adequate steps to ensure proper use of equipment by those concerned. The personal protective equipment are to be provided by the contractor are:

- a. **All persons employed at the construction site shall use safety helmets.**
- b. Workers employed shall use protective goggles, protective foot wear and hand gloves wherever necessary.
- c. Persons engaged in welding and gas-cutting works shall use suitable welding face shields. The persons who assist the welders shall use suitable goggles. Protective goggles shall be worn while chipping and grinding.
- d. Persons engaged in or assisting in shot blasting operations and cleaning the blasting chamber shall use suitable gauntlets, overalls, dust-proof goggles, boots and protective hood supplied with fresh air at the minimum rate of 9m/hr.
- e. All persons working at hts. more than 3.0m above ground or floor and exposed to risk of falling down shall use safety belts, unless otherwise protected by cages, guard railings, etc. In places where the use of safety belts is impractical, suitable net of adequate strength fastened to substantial supports shall be employed.

PAINTING

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The contractor shall not employ women on the work of painting with products containing lead in any form. Only men above the age of 18 years shall be employed on the work with lead paint. The following precautions shall be taken during the work:

- Supply air respirators for use by the workers when paint is applied in the form of spray, or a surface having lead paint is dry rubber or scraped.
- The workmen shall use overalls and adequate facilities shall be provided to enable the painters to wash at the cessation of work.
- All painting jobs, especially those in which lead paints are used shall be kept under industrial hygiene surveillance.
- Smoking, open flames or sources of ignition shall not be allowed in places where paints and other flammable substances are stored, mixed or used. A caution board, with the instructions written in national/regional language, **“SMOKING - STRICTLY PROHIBITED”** shall be displayed in the vicinity where painting is in progress or where paints are stored. Symbols shall also be used for caution boards.
- Suitable fire extinguishers/sand buckets shall be kept available at places where flammable paints are stored, handled or used.
- When painting work is done in a closed room or in a confined space, adequate ventilation shall be provided. If adequate ventilation cannot be provided, workers shall wear suitable respirators.
- Epoxy resins and their formulations used for painting shall not be allowed to come in contact with the skin. The workers shall use plastic gloves and/ or suitable barrier creams
- Adequate ventilation shall be provided especially when working with hot resin mixes.
- Increased personal hygiene shall be practiced to control inadvertent contact with the resin and eliminate its effects.
- Workers shall thoroughly wash hands and feet before leaving the work. Work clothes shall be changed and laundered frequently.

LIFTING MACHINES AND TACKLES

- Use of lifting machines and tackles including their attachments, anchorage and supports shall conform to the following standards or conditions:
- Lifting machines and tackles shall be of good mechanical construction, sound material and adequate strength and free from any defects and shall be kept in good repair and in good working order.
- Every rope used in hoisting or lowering materials or as a means of suspension shall be of good quality and adequate strength and free from any defect.
- Every crane operator or lifting appliance operator shall be properly qualified. No person under the age of 21 years shall be in charge of any hoisting machine or give signal to operator of such machine.
- In case of every lifting machine (and of every chain, ring, hook, shackle, swivel and pulley block used in hoisting or as means of suspension) the safe working load shall be ascertained and clearly marked. In case of a lifting machine having a variable safe working load, each safe working load and the conditions under which it is applicable shall be clearly indicated. No part of any machine or any gear referred to above in this paragraph shall be loaded beyond the safe working load except for the purpose of testing. The safety engineer shall approve this.

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- The safety engineer shall note the safe working load. Regarding other machines, the contractor shall notify the safe working load of the machine to the safety engineer, whenever he brings any machinery to site of work and get it verified by the safety engineer.
- Thorough inspection and load testing of lifting machines and tackles shall be done by a competent person at least once every 2 months and records of such inspection and testing shall be maintained.
- Motors, gearing transmission, couplings, belts, chain drives and other moving parts of hoisting appliances shall be provided with adequate safeguards. Hoisting appliances shall be provided with such means as will reduce to the minimum the risk of any part of a suspended load becoming accidentally displaced or lowered.

WELDING AND GAS CUTTING:

- Welding and gas cutting operations shall be done by qualified and authorized persons and as per IS specifications and code of practice.
- Welding and gas cutting shall not be carried out in places where flammable or combustible materials are kept and where there is danger of explosion due to presence of gaseous mixtures.
- Welding and gas cutting equipment including hoses and cables shall be maintained in good condition.
- Barriers shall be erected to protect other persons from harmful rays from the work. When welding or gas cutting is done in elevated positions, precautions shall be taken to prevent sparks or hot metal falling on persons or flammable materials.
- Suitable type of protective clothing consisting of fire resistant gauntlet gloves, leggings, boots and aprons shall be provided to workers as protection from heat and hot metal splashes. Welding shields with filter glasses of appropriate shade shall be worn as face protection.
- Adequate ventilation shall be provided while welding in confined space or while brazing, cutting or welding zinc, brass, bronze, galvanized or lead coated materials.
- Welding and gas cutting shall not be done on drums, barrels, tanks or other containers unless they have been emptied cleaned thoroughly and it is made certain that no flammable material is present.
- Fire extinguisher shall be available near the location of welding operations. Fire safety permit shall be obtained for working at vulnerable areas and operating areas before flame cutting/welding is taken up.
- For electric (Arc) welding the following additional safety precautions shall be taken:
 - When electrical welding is undertaken near pipelines carrying flammables, such pipelines shall not be used as part of earth conductor but a separate earth conductor shall be connected to the machine directly from the job.
 - Personnel contact with the electrode or other live parts of electric welding equipment shall be avoided.
 - Extreme caution shall be exercised to prevent accidental contact of electrodes with ground.

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- The welding cable shall not be allowed to get entangled with power cables. It shall be ensured that movement of materials does not damage the cables.

GRINDING:

- All portable grinders shall be used only with their wheel guards in position to reduce the danger from flying fragments should the wheel break during the use.
- Grinding wheels of specified diameter only shall be used on a grinder – portable or pedestal - in order not to exceed the prescribed peripheral speed.
- Goggles shall be used during grinding operation.

HOUSE KEEPING:

- The contractor shall at all time keep his work site, site office and surroundings clean and tidy from rubbish, scrap, surplus materials and unwanted tools and equipment.
- Welding and other electrical cables shall be so routed as to allow safe traffic by all concerned.
- No materials on any of the sites of work shall be so stacked or placed as to cause danger or inconvenience to any person or the public.
- At the completion of the work, the contractor shall ensure removal from the work premises all scaffoldings, surplus materials, rubbish and all huts and sanitary arrangements used/installed for workmen on the site.

FIRE SAFETY:

All necessary precautions shall be taken to prevent outbreak of fires at the construction site. Adequate provisions shall be made to extinguish fires, should they still break out.

- Quantities of combustible materials like timber, coal, paints, etc. shall be the minimum required in order to avoid unnecessary accumulation of combustibles at site.
- Containers of paints, thinners and allied materials shall be stored in a separate room, which shall be well ventilated, and free from excessive heat, sparks, flame or direct rays of the sun. The containers of paint shall be kept covered or properly fitted with lid and shall not be kept open except while using.
- Fire extinguishers shall be located at the construction site at appropriate places.
- Adequate number of workmen shall be given education and training in fire fighting and extinguishing methods.

MEDICAL FACILITIES

- The contractor shall arrange for medical aid and treatment for his staff and workers engaged on the work site including the first-aid facilities if they are not available at the project site.
- First-aid appliance including sterilized dressing, cotton wool and antiseptic cream shall be made available at readily accessible places at every work site. These shall be maintained in good order under the charge of a responsible person.

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- At large work places where hospital facilities are not available within easy reach of the work, first-aid posts shall be established. Ambulance availability shall be identified during the entire period of work for attending to injury cases.
- The contractor shall arrange for weekly two visits of Doctors to site.

REPORTING OF ACCIDENT:

- All accident leading to property damage and/or personnel injuries shall be reported to the concerned authorities' viz. Insurance Co. Police, Head Office, Regional Office, etc.
- The contractor shall also submit a monthly statement of accidents to the Project Manager by 4th of every month showing details of accident, nature of injury including disability, days lost, treatment provided, etc., and the extent of property damage.

PUBLIC PROTECTION:

The contractor shall make all necessary provisions to protect the public. He shall be held responsible for defense of every action of other proceedings at law that may be brought by any person for injury sustained owing to neglect of any precaution required to taken to protect the public.

OTHER STATUTORY PROVISIONS:

All operations involving the transport, handling, storage and use of explosive shall be as per the standing instructions and conform with the latest Indian Explosives Act and the explosives Rules. Handling, transport, storage and use of compressed gas cylinders and pressure vessels shall conform to the latest Gas Cylinder Rules and Static and Mobile Pressure Vessels (Unfired) Rules. In addition, The Indian Electricity Act and Indian Electricity Rules - latest, the Atomic Energy Act, the Radiation Protection Rules - latest, Radiation Protection Manual of Nuclear Facilities and the Atomic Energy (Factories) Rules – latest, and various latest rules and Act related to mining shall also be strictly complied with.

The contractors shall make a provision of dining table/s and chairs for the workers.

GUIDELINES AND GENERAL PROCEDURES FOR SUPPLY AND USE OF ELECTRICITY AT SITE:

GENERAL :

Following safety requirements shall be complied with before the contractor uses the power supply.

- The contractor shall submit a list of licensed electrical staff to be posted at Site.
- It shall be the responsibility of the contractor to provide and maintain complete installation on the load side of the supply point with regard to the safety requirements at Site. All cabling and installation shall comply with the appropriate latest statutory requirements given below and shall be subject to approval of the Project Manager:
 - Indian Electricity Act.
 - Electricity (Supply) Act.
 - Indian Electricity Rules.
 - National Electricity Code.
 - Other relevant rules of Local Bodies and Electricity Boards.
- The power supply shall be regulated as per the terms and conditions of the supply of the respective electricity boards.

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- a. Where distribution boards are located at different places the contractor shall submit schematic drawing indicating all details like size of wires, Over head and Cable feeders, earthing etc. The position and location of all equipment and switches shall be given.
- b. The contractor shall make his own arrangement for main earth electrode and tapings thereof. The existing earth points available at site can be used at the discretion of Project Manager with prior permission. Method of earthing, installation and earth testing results shall conform to relevant I.S. Specifications (IS-3043).
- c. All three phases equipment shall be provided with double earthing. All light fixtures and portable equipment shall be effectively earthed to main earthing.
- d. All earth terminals shall be visible. No gas pipes and water pipes shall be used for earth connection. Neutral conductor shall not be treated as earth wire.
- e. The Contractor shall not connect any additional load without prior permission of Project Manager.
- f. Joints in earthing conductors shall be avoided. Loop earthing of equipment shall not be allowed. However, tapings from an earth bus may be done
- g. The entire installation shall be subjected to the following tests before energisation of installation including portable equipment :
 - Insulation resistance test.
 - Polarity test of switches.
 - Earth continuity test.
 - Earth electrode resistance.

The test procedures and their results shall conform to relevant standards.

Following guidelines are provided for general observations :

INSTALLATION :

- Only persons having valid wireman's license/competency certificate shall be employed for carrying out electrical work and repair of electrical equipment, installation and maintenance at site. A qualified licensed Supervisor shall supervise the job.
- Electrical equipment and installations shall be installed and maintained as to prevent danger from contact with live conductors and to prevent fires originating from electrical causes like short circuits, overheating etc. Installation shall not cause any hindrance to movement of men and materials.
- Materials for all electrical equipment shall be selected with regard to working voltage, load and working environment. Such equipment shall conform to the relevant standards.
- The minimum clearance to be maintained for all overhead lines along roads and across roads shall be as per the statutory requirements.
- Grounding conductor of wiring system shall be of copper or other corrosion-resistant material. An extra grounding connection shall be made in appliances/equipment where chances of electric shock are high.
- Electric fuses and/or circuit breakers installed in equipment circuits for short circuit protection shall be of proper rating. It is also recommended that high rupturing capacity (HRC) fuses are used in all circuits. For load of 5 kW or more earth leakage circuit breaker shall be provided in the circuits.
- Wherever cables or wires are laid on poles, a guard wire of adequate size shall be run along the cables/wires and earthen effectively. Metallic poles as a general rule, shall be avoided and if used shall be earthen individually. Anti climbing guards and danger notices shall be provided on poles. Each equipment shall be a individual isolating switch.
- Wires and cables shall be properly supported and an approved method of fixing shall be adopted. Loose hanging of wires and cables shall be avoided. Lighting and power circuits shall be kept distinct and separate.
- Reinforcement rods or any metallic part of structure shall not be used for supporting wires and cables, fixtures, equipment, earthing etc.

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- All cables and wires shall be adequately protected mechanically against damages. In case the cable is required to be laid under flooring, it shall be adequately protected by covering the same with bricks, Plain Cement Concrete (PCC) tile or any other approved means.
- Using suitable cable glands shall properly terminate all armoured cables. Using cable lugs/sockets shall connect multi-stranded conductor cables. Cable lugs shall preferably be crimped. They shall be of proper size and shall correspond to the current rating and size of the cable. Twisted connections will not be allowed.
- All cable glands, armoring and sheathing of electric cable, metal circuits and their fittings, metallic fittings and other non-current carrying parts of electrical equipment and apparatus shall be effectively grounded.
- All the Distribution Boards, Switch Fuse Units, Bus bar chambers, ducts, cubicles etc. shall have MS enclosures and shall be dust, vermin and waterproof. The Distribution Boards, switches etc. shall be so fixed that they shall be easily accessible. Changes shall be done only after the approval of the Project Manager.
- The contractor shall provide proper enclosures/covers for protection of the entire switchboard, equipment etc. against rain. Exposed live parts of all electrical circuits and equipment shall be enclosed permanently. Crane trolley wires and other conductor which cannot be completely insulated shall be placed such that they are inaccessible under normal working conditions.
- Ironclad industrial type plug outlets are preferred for additional safety.
- Open type distribution boards shall be placed only in dry and ventilated rooms; they shall not be placed in the vicinity of storage batteries or otherwise exposed to chemical fumes.
- Isolating switches shall be provided close to equipment for easy disconnection of electrical equipment or conductors from the source of supply when repair or maintenance work has to be done on them.
- In front of distribution boards a clear space of 90 cm shall be maintained in order to have easy access during an emergency.
- Adequate working space shall be provided around electrical equipment, which requires adjustment or examination during operation.
- As far as possible electrical switches shall be excluded from a place where there is danger of explosion. All electrical equipment such as motors, switches and lighting fittings installed in workroom where there is possibility of explosion hazard shall be explosion proof.
- All connections to lighting fixtures, starters or other power supplies shall be provided with PVC insulate, PVC sheathed twin/three/four core wires to have better mechanical protection for preventing possible damage to equipment or injury to personnel. Taped joints shall not be allowed and the connections may be made in looping system. Electric starter of motors, Switches shall not be mounted on wooden boards. Only sheet steel mounting or iron framework shall be used.
- All the lighting fixtures and lap holders shall be of good quality and in good condition. Badly repaired or broken holders, etc. shall not be used.
- Only PVC insulated and PVC sheathed wires or armoured PVC insulated and sheathed cables shall be used for external power supply connections of temporary nature. Weatherproof rubber wires shall not be used for any temporary power supply connections. Taped joints in the wires shall not be used.
- The bulbs/lamps used for illumination and testing purpose shall have cover or guard to protect them from accidental breakage. Only 24 V supply system shall be used for hand lamps etc. while working inside metallic tanks or conducting vessels.

OPERATION & MAINTENANCE :

- All persons, who work with electrical installation/equipment, shall be aware of the electrical hazards, use to protective devices and safe operational procedures. They shall be given training in fire fighting, first aid and artificial resuscitation techniques.
- The contractor shall instruct the workers in the proper procedure, specify and enforce the use of necessary protective equipment such as adequately insulated pliers, screw drivers, fuse pulleys, testing lamps and similar hand tools. Only wooden ladders shall be used to reach the heights in electrical work.
- No material or earthwork shall be allowed to be dumped below or in the vicinity of the bare overhead line conductors.
- Before any maintenance work is commenced on electrical installations/equipment, the circuits shall be de-energized and ascertained to be dead by positive test with an approved voltage-testing device. Switches shall be tagged or the fuse holders withdrawn before starting the work. Adequate precautions shall be taken in two important aspects viz.
 - i. That there shall be no danger from any adjacent live parts and

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- ii. That there shall be no chances of re-energisation of the equipment on which the persons are working.
- While working on or near a circuit, whenever possible the use of one hand may be practiced even though the circuit is supposed to be dead. The other hand may preferably be kept in pocket.
 - When it is necessary to touch electrical equipment (for example when checking for overload of motors) back of the hand may be used. Thus, if accidental shock were to cause muscular contractions, one would not 'freeze' to the conductor.
 - Operations of electrical equipment shall be avoided while standing on wet floor or when hands are wet.
 - Before blown fuses are replaced, the circuit shall be locked out and an investigation shall be made for the cause of the short circuit or overload.
 - When two persons are working within reach of each other, they shall never work on different phases of the supply.
 - When structural repairs, modification or painting work are to be undertaken, appropriate measures shall be taken for the protection of persons whose work may bring them into the proximity of live equipment/circuit.
 - It shall be ensured that the insulation and wire size of extension cords are adequate for the voltage and current to be carried.
 - While tapping electricity from the socket, plug top must be used. It shall be ensured that no extension boards are overloaded while tapping. Only standard three pin plugs shall be used for tapping electricity. Broken sockets/plugs shall be replaced immediately with good ones. Only joints free cables shall be used for connecting equipment/ apparatus.
 - Floors shall be kept free from trailing electrical cables to avoid tripping hazard.
 - Power supply to the entire machines and lighting fixture shall be switched off when not in use.
 - Temporary electrical connections shall be removed as soon as the stipulated work is over. After completion of the works, the contractor shall dismantle the distribution boards and the other facilities erected at site.
 - Unauthorized tapping of power by others from distribution boards under the control of the NCC shall be prohibited at all circumstances.
 - No flammable materials shall be stored in any working area near the switchboards.
 - "MEN ON LINE" "DO NOT SWITCH ON" "DANGER" OR "CAUTION" boards as applicable shall be used during maintenance works on the electrical equipment.

PORTABLE ELECTRICAL EQUIPMENT

- Portable electrical equipment shall be regularly examined, tested, and maintained to ensure that the equipment and its leads are in good order. Register shall be maintained for inspection recording the testing dates and results of the equipment.
- All portable appliances shall be provided with three core cable and three-pin plug. The third pin of the plug shall invariably be earthen. It shall be ensured that the metal part of the equipment shall be effectively earthen.
- All connections to portable equipment or machines from the panel/distribution board/extension board shall be taken using 3 core double insulated PVC flexible copper wire in one length. No joints shall be allowed in this flexible wire. In case single length of wire is not sufficient for a particular location then the supply can be tapped by providing another extension board comprising of switch and socket.
- Flexible cables for portable lamps, tools and apparatus shall be regularly examined, tested periodically and maintained to ensure safety.

SAFETY CODES IN CONSTRUCTION INDUSTRY

a. SCAFFOLDING (IS 4014 (PART II))

- Clear the area of unwanted materials.
- Erection under proper supervision.
- Ensure ropes & cables are in good condition.
- Ensure that all structural members and all connections are adequate.
- Supports strong – adequate cross bracing.
- Ensure the ground is safe and provide proper foot hold.
- Keep ladder/working area free of grease/oil.
- Passerby's are protected.
- Provide guardrails & toe board.
- Wear safety belt, helmet while working on scaffolding.
- Do not use the scaffolding for more than 15 days without rechecking.

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- Frequent inspection.
- Excavation is not permitted near base of scaffolding.

b. LADDERS (IS 3696 (PART 11))

- Proper inspection – rungs/steps are not spliced.
- Properly secured – top & bottom.
- Side rails on fixed ladders to extend above top landing.
- Build up ladders of sound material.
- Rungs not to exceed 12 inches.
- Step ladders fully open during use.
- Metal ladders – prohibited near electrical lines.
- Proper maintenance and storage after use.

c. BARRICADES

- Floor openings covered/barricaded properly.

d. HOISTS, CRANES, DERRICKS

- Inspect – cables, slings, chains, hooks, eyes.
- Equipment stability/supports.
- Out riggers used if required.
- Power lines removed/inactivated (cranes).
- Signals understood and observed.
- Experienced operators.
- All equipment properly lubricated/maintained.
- Protective head gears.
- If a person climbs on a derrick installed for lifting material, special precautions should be taken.
- Gas cylinders are kept in properly designed cages.
- Periodical test/inspection of hoists, cranes.
- Mark “safe working loads” on hoists/cranes.
- Cranes to be operated by certified operator.
- Ensure that slings are vertical.
- Do not drag chains, slings, hooks, and load over the floor.
- Know the load before lifting.

e. HOUSE KEEPING & SANITATION

- General neatness in working area.
- Regular disposal of waste/trash.
- Pathways and walkways clear.
- Adequate lighting.
- Sanitary facilities – clean.
- Adequate drinking water.

f. EMERGENCY PROCEDURE

- First aid station – properly manned.
- First aid boxes – with items.
- Injuries reported promptly.
- Safety belts are used for heights.
- Adequate escape facilities.
- Proper storage of tools when not being used.

g. WELDING – CUTTING

- Qualified operators.
- Proper screen, shield, goggles, gloves, clothing, equipment.
- Electrical equipment – grounded – inspected.
- Power cables are protected & in good condition.
- Fire extinguishers – available.
- Inspection of fire hazards.

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- Flammable materials – protected (40 feet away).
- Gas cylinders – upright & chained.
- Gas line, torch in good condition.
- Trolleys for moving cylinders.
- Proper covering of mezzanine holes or barricades for cut portion.
- Barricades/notices below mezzanine being cut – work permit (spl).
- Helper also to use goggles.

h. FLAMMABLE GASES – LIQUIDS

- “No smoking” signboard.
- Containers clearly identified/marked.
- Proper storage practices.
- Proper storage temperature – protection.
- Fire hazards to be checked.
- Proper & adequate fire extinguishers.
- Neat storage area – clear passages.
- Material firmly stacked – not too high.
- Entry restricted.
- Store in separate enclosed area.

i. HANDLING AND STORAGE

- Proper number for operation.
- Person picking up leads correctly.
- Materials protected from heat/moisture.
- Protection from falling into hoppers/bins.
- Dust protection observed.
- Extinguishers/fire protection available.

j. POWER TOOLS

- Good housekeeping where used.
- Tools - cords - earthing - in good condition.
- Proper instructions for use.
- Proper mechanical safe guards.
- Tools nearly stored when not in use.
- Right tool for job.
- Proper wiring.
- Proper training to operator.
- Proper supervision.
- Use of safety appliances - goggles - face shield

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SCHEDULE OF DEVIATIONS

(TO BE ENCLOSED WITH TECHNICAL BID)

All deviations from this specification shall be set out by the Bidders, clause by Clause in this schedule. Unless specifically mentioned in this Schedule, the tender shall be deemed to confirm the purchaser's specifications:

S.No.	Clause No.	Details of deviation with justifications

We confirm that there are no deviations apart from those detailed above.

Seal of the Company:

Designation

Signature