SPECIFICATIONS FOR LOW VOLTAGE ELECTRICAL PANELS

DMRC ELECTRICAL STANDARDS & DESIGN WING (DESDW)

SPECIFICATION NO.
DMES /E/0008/DMRC-LOW VOLTAGE ELECTRICAL PANELS

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<th>Date</th>
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DELHI METRO RAIL CORPORATION LTD.
7th Floor, B-Wing, Metro Bhawan, Fire Brigade Lane,
Barakhamba Road, New Delhi –110 001
**Previous Record of specification**

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</table>


# Table of Content

1. DETAILED DESCRIPTION OF THE EQUIPMENT AND ITS APPLICATION IN DMRC: LOW VOLTAGE ELECTRICAL PANELS ................................................................. 5
2. GOVERNING SPECIFICATIONS .................................................................................................................. 6
  2.1 STANDARDS ....................................................................................................................................... 6
  2.2 ABBREVIATIONS .................................................................................................................................. 9
3. TECHNICAL AND INSTALLATION REQUIREMENT .................................................................................... 10
  3.1 GENERAL AND TECHNICAL REQUIREMENTS OF ELECTRICAL PANELS ............................................. 10
  3.2 ELECTRICAL PANEL CONSTRUCTION ............................................................................................. 11
  3.3 ELECTRICAL PANEL EARTHING AND SAFETY ARRANGEMENT ..................................................... 14
4. EQUIPMENT INSTALLED INSIDE ELECTRICAL PANELS ........................................................................ 15
  4.1 BUSBAR .............................................................................................................................................. 15
  4.2 POLARITY .......................................................................................................................................... 16
  4.3 CONTROL SUPPLY .............................................................................................................................. 16
  4.4 INSTRUMENTATION ............................................................................................................................. 17
  4.5 RELAYS .............................................................................................................................................. 19
  4.6 EMERGENCY PUSH BUTTON (EPB) .................................................................................................... 19
  4.7 INTERLOCK AND PADLOCKING FACILITIES .................................................................................. 20
  4.8 INTERNAL AND CONTROL WIRING ................................................................................................. 20
  4.9 TERMINAL BLOCKS ............................................................................................................................. 22
  4.10 MARSHALING UNIT ........................................................................................................................... 23
  4.11 BMS INTERFACE ............................................................................................................................... 25
  4.12 INDICATING LAMPS .......................................................................................................................... 26
  4.13 LOW VOLTAGE SWITCHGEAR .......................................................................................................... 26
  4.14 DESCRIMINATION ............................................................................................................................. 35
  4.15 REMOTE MONITORING ....................................................................................................................... 36
  4.16 MOTOR STARTER ............................................................................................................................... 37
  4.17 CONTACTORS ................................................................................................................................... 46
  4.18 AUXILIARY SWITCHES AND CONTACTS ............................................................................................ 48
  4.19 POWER FACTOR CORRECTION EQUIPMENT ..................................................................................... 48
SPECIFICATIONS FOR LOW VOLTAGE ELECTRICAL PANELS

4.20 DETUNED FILTER ............................................................................................................ 50
4.21 AUTOMATIC LOAD TRANSFER SWITCHES ..................................................................... 50
4.22 DISTRIBUTION BOARDS ................................................................................................. 52
5. FINISHES ........................................................................................................................... 54
6. NAMEPLATES AND LABELS .............................................................................................. 55
6.1 NAMEPLATES .................................................................................................................. 55
6.2 LABELS ............................................................................................................................ 55
7. FOUNDATION (IF REQUIRED) AND INSTALLATION ......................................................... 56
8. Other Provisions .................................................................................................................. 58
9. SPECIAL CONDITION: ......................................................................................................... 58
10. RELIABILITY, MAINTENANCE, SPARES AND LIFE ...................................................... 59
11. MATERIAL AND MANUFACTURING: ............................................................................. 59
12. TESTING ............................................................................................................................ 59
13. TRAINING .......................................................................................................................... 60
14. INDICATIVE LIST OF ITEMS TO BE INCLUDED IN FAT PLAN FOR ELECTRICAL PANEL ......................................................... 60
15. DATA SHEET ..................................................................................................................... 68
1. DETAILED DESCRIPTION OF THE EQUIPMENT AND ITS APPLICATION IN DMRC: LOW VOLATGE ELECTRICAL PANELS

1.1 Metro stations namely Rail corridor stations, Under-ground stations as well as on-grade stations and Depot are provided with Electrical Panels for receiving and distribution of power supply to various usages as defined in various clauses at voltage level of 415 V/50 Hz. The usages are generally lighting, air conditioning system, ECS system, PD area and all other type E&M work which come under stations coverage. Switch boards and panels as per following list are provided for power supply distribution at metro stations and in depots.

1.2 The bidders shall refer the BOQ and drawing for incoming feeders, outgoing feeders, indications, metering and protection details along with quantity and type of each.

1.3 The panels are generally named as follows:

- Main Distribution Board (MDB)
- Sub-main Distribution Board (SMDB)
- Essential power panel (EPP)
- Emergency Power Panel (EMLP)
- Local Motor Control Panel (LMCP)
- Main Lighting Panel (MLP)
- Air conditioning Power panel (ACPP)
- Fire pump panel (FPP)
- Water pump panel (WPP)
- Passenger Amenities Panel (PAP)
- Light Distribution Boards (LDB)
- APFC Panel
1.4 The manufacturing, testing, installation and commissioning of complete 415 V, 3 phase, 4 wire and 50 Hz low voltage main switchboard is as defined in IEC/EN 61439-1, built up from compartments to house busbars, terminal blocks, internal and control wiring, instrumentation, relays, interlock and padlocking facility, emergency push buttons, equipment for BMS/SCADA/RS 485/Mod bus connectivity of communicable ACB/MCCB interface, indication lamps, control and auxiliary switches, contacts, control power supply, air circuit breaker, MCCB, MCB, CTs and PTs, APFCs and any other items considered necessary to deliver the functions of incoming and outgoing power supply as detailed in BOQ and drawing.

1.5 The equipments installed in each of the Electrical Panel are defined in the BOQ.

2. GOVERNING SPECIFICATIONS

Electrical Panels along with equipments shall conform to the latest standard or harmonize as per the respective standard as given below or specified along with the equipment in the specification.

In case of any conflict between specifications & the standards, the instructions/decision of the Engineer's or Employer's authorized representative shall be binding.

2.1 STANDARDS

Low voltage Electrical Panels shall satisfy the following requirements and shall also comply with standards in force when Electrical Panel units are manufactured, particularly which are in the following table (Unless otherwise stipulated in the specification, the latest version of the standards shall be applicable)
<table>
<thead>
<tr>
<th>STANDARD</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ISO STANDARD</strong></td>
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</tr>
<tr>
<td>ISO 9001</td>
<td>Quality systems- model for quality assurance in design/development, production, installation and servicing</td>
</tr>
<tr>
<td><strong>IEC STANDARD</strong></td>
<td></td>
</tr>
<tr>
<td>IEC 60228</td>
<td>Conductors of insulated cables</td>
</tr>
<tr>
<td>IEC 60255</td>
<td>Measuring relays and protection equipment</td>
</tr>
<tr>
<td>IEC 60529</td>
<td>Degrees of protection provided by enclosures (IP Code)</td>
</tr>
<tr>
<td>IEC 60831</td>
<td>Shunt power capacitors of the self-healing type for a.c. systems having a rated voltage up to and including 1000 V</td>
</tr>
<tr>
<td>IEC 60871</td>
<td>Shunt capacitors for a.c. power systems having a rated voltage above 1000 V</td>
</tr>
<tr>
<td>IEC 60898</td>
<td>Electrical accessories – Circuit-breakers for over current protection for household and similar installations</td>
</tr>
<tr>
<td>IEC 60947-6-1/EN 60947-6-1</td>
<td>Specification for low-voltage and control gear. Multiple function equipment. Automatic transfer switching equipment.</td>
</tr>
<tr>
<td>IEC 60947-2/EN 60947-2</td>
<td>Specification for low-voltage switchgear and control gear circuit breakers</td>
</tr>
<tr>
<td>IEC 61008</td>
<td>Residual current operated circuit-breakers without integral over current protection for household and similar uses (RCCBs)</td>
</tr>
<tr>
<td>IEC 61439-3/EN 61439-3</td>
<td>Specification for low-voltage switchgear and control gear assemblies. Particular requirements for low-voltage switchgear and control gear assemblies intended to be installed in place.</td>
</tr>
<tr>
<td>IEC 61439</td>
<td>Specification for low-voltage switchgear and control gear assemblies</td>
</tr>
<tr>
<td>IEC 62262</td>
<td>Degrees of protection provided by enclosures for electrical equipment against mechanical impacts (IK code)</td>
</tr>
<tr>
<td>IEC 61641</td>
<td>Enclosed low-voltage switchgear and control gear assemblies - Guide for testing under conditions of arcing due to internal fault</td>
</tr>
<tr>
<td>IEC 61869/BSEN 61869</td>
<td>Instrument transformers</td>
</tr>
</tbody>
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# SPECIFICATIONS FOR LOW VOLTAGE ELECTRICAL PANELS

<table>
<thead>
<tr>
<th>IS STANDARD</th>
<th>BS STANDARDS</th>
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<tbody>
<tr>
<td>IS 13779</td>
<td>ac Static Watt-hour Meters, Class 1 and 2</td>
</tr>
<tr>
<td>IS 13947-5-2</td>
<td>Low-Voltage Switchgear and Control gear, Part 5: Control Circuit Devices and Switching Elements, Section 2: Proximity Switches</td>
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<tr>
<td>IS 13947-5-1</td>
<td>Low-Voltage Switchgear and Control gear, Part 5: Control Circuit Devices and Switching Elements, Section 1: Electromechanical Control Circuit</td>
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<tr>
<td>IS 13947-4-1</td>
<td>Low-Voltage Switchgear and Control gear : Part 4 - Contractors and Motor-Starters</td>
</tr>
<tr>
<td>IS 13947-3</td>
<td>Low voltage switchgear and control gear, part 3: switches, disconnectors, switch-disconnectors and fuse combination units</td>
</tr>
<tr>
<td>IS 13947-2</td>
<td>Low-Voltage Switchgear and Control gear, Part 2: Circuit Breakers</td>
</tr>
<tr>
<td>IS 13947-1</td>
<td>Low-voltage switchgear and control gear, Part 1: General rules</td>
</tr>
<tr>
<td>IS 5553</td>
<td>Reactors – Specification</td>
</tr>
<tr>
<td>BS 381 C</td>
<td>Colour chart</td>
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<tr>
<td>BS 4800</td>
<td>Colour</td>
</tr>
<tr>
<td>BSEN60742/BS 61558</td>
<td>Isolating Transformers</td>
</tr>
<tr>
<td>BS 1432</td>
<td>Specification for Copper for electrical purpose high conductivity copper rectangular conductor with drawn or rolled edges.</td>
</tr>
<tr>
<td>BS 951</td>
<td>Electrical earthing. Clamps for earthing and bonding. Specification</td>
</tr>
<tr>
<td>BS 7430</td>
<td>Code of practice for protective earthing of electrical installations</td>
</tr>
<tr>
<td>BS EN 13601</td>
<td>copper and copper alloys - copper rod, bar and wire for general electrical purposes</td>
</tr>
<tr>
<td>BS EN 10025</td>
<td>Hot rolled products of structural steels</td>
</tr>
<tr>
<td>BS EN 50525</td>
<td>Electric cables. Low voltage energy cables of rated voltages up to and including 450/750 V (U0/U)</td>
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2.2 ABBREVIATIONS

ACB-Air circuit breaker
ALTS- Automatic load transfer switch
APFC-Automatic power factor correction
ATS- Automatic transfer switch
DB- Distribution board
EMC- Electromagnetic compatibility
LEP- Local Electrical Panel
LMCP- Local motor control panel
LT- Low Tension
LVDB-low voltage distribution board
ELECTRICAL PANELS- Low Voltage main switch board
MCB- Miniature circuit breaker
MCCB-moulded case circuit breaker
MFM- Multi function meter
MPCB-Motor protection circuit breaker
RCCB- Residual current circuit breaker
RTU- Remote terminal unit
SELECTRICAL PANELS- Sub Main Distribution Board
TB- Terminal block
VFC- Volt free contact
3. TECHNICAL AND INSTALLATION REQUIREMENT

3.1 GENERAL AND TECHNICAL REQUIREMENTS OF ELECTRICAL PANELS

3.1.1 The Electrical Panel shall be same as low-voltage switchgear and control-gear assemblies defined in IEC 61439-1 or EN 61439-1 built up from compartments housing circuit breakers, control gear, relays, bus bars, controls and other equipment as defined in BOQ.

3.1.2 All panels should be factory built of proven design with OEMs as well as switchboard manufacturer approved as covered by clause 3.10 of IEC 61439-1.

3.1.3 The Electrical Panel shall pass the internal arc fault containment tests in accordance with IEC 61641 for fault current ratings as defined in BOQ for a minimum time of 0.3 sec.

3.1.4 The degree of Ingress Protection for Electrical Panels shall be IP 54 for underground and IP 42 for Elevated/Depot unless otherwise specified in BOQ, as defined in IEC 60529 which shall not deteriorate with time.

3.1.5 The Electrical Panels and the associated equipment, including switchgear and control gear assemblies shall be certified for the category of duty specified as per Annex A of IS/IEC 60947-1.

3.1.6 The main circuit as defined in vide clause 3.1.3 of IEC 61439-1 shall have an insulation voltage of 1000 V AC or as specified in the BOQ.

3.1.7 The ambient temperature and ambient humidity for Electrical Panel shall be as per IEC 61439-1 (clause 7.1.1 and 7.1.2 of IEC 61439-1) and Switchgear shall be as per IEC 60947(Clauses 6.1.1 and 6.1.3 of IEC 60947).

3.1.8 The secure service life of Electrical Panels shall be at least 30 years as defined in General Scope of Work. The design features to secure the service life of 30 years shall be submitted at the time of design approval.

3.1.9 The Electrical Panel shall have a rated short time withstand current of 70 kA, 65 kA, 50 kA and 35 kA for 1 second as per BOQ.

3.1.10 The Electrical Panels shall be a minimum of Form 4b Type 5 in accordance with BS EN 61439-2/IEC 61439-2 & Eiema’s Guide To Forms Of Separation.
3.2 ELECTRICAL PANEL CONSTRUCTION

3.2.1 The panels shall be of the approved design to suit local conditions as prevailing at different metro stations.

3.2.2 The Electrical Panel (other than DB) shall be designed for indoor use in the form of free standing, floor mounting extendible, self contained, flush fronted cubicles and sectionalized as necessary to face easy transportation and erection, containing all the equipment indicated on the Drawing, BOQ and specified hereinafter.

3.2.3 The cubicle section shall be constructed of angle iron types frames or folded sheet steel or fully welded/bolted construction with all necessary removable covers. Removable lifting lugs shall be provided on the top of the cubicles. Cubicle sections shall be provided with bolts or devices for insuring that they are correctly aligned when being coupled together. The bus bar chamber shall be fitted with removable end cover plates secured by mild steel captive screws.

3.2.4 It shall be finished to provide a rigid shell type of enclosure in accordance with BS EN 10025.

3.2.5 The load bearing parts of the entire electrical panel assembly shall be 2 mm CRCA thick sheet whereas other partition parts shall be constructed of minimum 1.6 mm CRCA thick sheet steel.

3.2.6 The Electrical Panels shall be mounted on a robust base frame made up of steel channel with a minimum height of 100mm and the maximum height of Electrical Panel shall not exceed 2.40 meter including base frame. The base frame shall be able to withstand the static and dynamic loads of the Electrical Panels. The steel channels shall be painted with epoxy polyester paint. The main contractor shall ensure that the maximum height of the Electrical Panel at the site of installation shall not exceed 2.6 meter including foundation if any.

3.2.7 Electrical panel shall have provision for top/bottom in-coming and bottom/top out-going to suit site conditions of cable entries.
3.2.8 Non-magnetic gland plates of not less than 5 mm thick of suitable size shall be provided at the top and bottom of the LV main switchboards for the termination of incoming and outgoing power cables of size 120 sq. mm or more or bus ways and 3 mm thick for cables of size less than 120 sq. mm. Where armoured multi-core cables terminate inside the switchboard enclosure, glancing plates or glancing brackets shall be provided for securing the cables to the switchboard.

3.2.9 Glanding plates, glancing brackets and extension boxes shall be removable and shall be of adequate size for the particular cables to be terminated. The cables shall not put any stress on to the glancing plate and shall be secured adequately.

3.2.10 All relays and indicating instruments shall be at least 300 mm and not higher than 1.8 m from base frame. The clearance in front, back and side of all assemblies of switchgear and control gear shall be as per IE Rule 51.

3.2.11 Various units comprising a complete Electrical Panels shall be grouped in a multi-tier arrangement including a cabling and wiring chamber of ample dimensions to accommodate terminal blocks, cable boxes and gland plates.

3.2.12 The equipment shall be arranged within each compartment such that all normal maintenance can be carried out through hinged access doors or removable covers, and where possible from the front.

3.2.13 Adequate maintenance access shall be provided to equipment within the Electrical Panels. Demountable panels shall be provided at the back of the Electrical Panels that can be handled by a single person. Every demountable panel shall be provided with a pair of handles for easy removal and fixing.

3.2.14 Front access door shall be fixed with concealed hinges and interlocked with the switch mechanism. The door panel can be opened only if the switchgear is in the “OFF position” or the switchgear should switch off if the panel door is opened.

3.2.15 Ventilating louvers along with filter, where required, shall ensuring compliance of IP 54. It shall be provided in such a way that it is easily accessible for cleaning or self cleaning filters shall be proved.
3.2.16 Anti-condensation heaters shall be provided at the rate of 60 W for each vertical of the Electrical Panels, incase the volume is greater than 1 cubic meter of one vertical then 2x60 W heater shall be provided. The heaters shall be of an enclosed tubular pattern, each separately fused/ MCBs and switch. Each heater shall be controlled by means of a step adjustable humidistat.

3.2.17 Adequate arrangements for air circulation shall be made within each compartment of the Electrical Panels, if required. The Contractor shall ensure that the internal temperature of the Electrical Panels will be well within the operating ranges as specified by IEC 61439-1 of all electric components including switchgear, control gear, bus bars, relays, wiring and timers inside the Electrical Panels.

3.2.18 All the incoming / outgoing terminations shall be extended via copper connections into a separate termination chamber adjacent to the switchboard. When busbars are used between switchboards, the internal busbars of the switchboard shall be of tinned copper bars sizes of copper shall be as per tested design. No linking of busbar or incoming/outgoing terminals with switchgeras/functional units shall be permitted with cable except in case of MCCBs./MCBs below or equal to 100 Amps rating.

3.2.19 The switchgear assembly/sub-assemblies or panels shall be termite and rodent proof.

3.2.20 The switchboard shall have sufficient space to house all electrical equipment allowing spare Space capacity of 10% for the future expansion if specifically asked in BOQ.

3.2.21 Spare feeder shall be provided as per BOQ. Any Panel which comprises an assembly of similar modules shall be constructed such that further similar modules can be added at either end.

3.2.22 All similar items of the Electrical Panels and their component shall be interchangeable. Spare parts shall be manufactured to originals and shall fit all similar items of the Electrical Panels. Where machining may be needed before fitting renewable parts, the machining fits and the associated tolerances shall be shown on the drawings accompanying the instruction manuals.

3.2.23 The Electrical Panel shall operate without excessive vibration and with a minimum of noise as per best of engineering practice and shall also operate without excessive temperature rise at the rated load conditions.
3.2.24 The style and finish of the workmanship shall be consistent throughout the Works. Unless otherwise specified, Engineer shall decide the final colours for all paintwork and other finishes to be applied to the Electrical Panels.

3.3 ELECTRICAL PANEL EARTHING AND SAFETY ARRANGEMENT

3.3.1 All non-current carrying metallic components shall be permanently connected to earth.

3.3.2 Material used for the earthing busbar shall be same as the main busbar.

3.3.3 The tin-plated copper/aluminium earthing busbar inside the panel shall have cross-sectional area as per calculation given in Annex B.

3.3.4 A continuous earthing busbar shall be provided along the whole length of each Electrical Panels and shall be provided with terminals for connection to the metal housing of incoming busways, cable trunking and cladding or armouring of all incoming and outgoing cables and to the substation earth.

3.3.5 Switchboards shall be provided with two earthing terminals, one at each end, for the connection of external earth conductor for earthing. The earthing bars shall be fixed at rear interior bottom portion throughout the length of the switchboard, bonding all gland plates, and other component parts of the switchboard to a main earth point adjacent to the intake position in accordance with BS 951 and BS 7430.

3.3.6 All terminals, connections, relays and other components which may remain live when access doors are open shall be screened. It shall not be possible to obtain access to an adjacent cubicle when any door is opened.

3.3.7 Where several outgoing circuits occupy a common cabling chamber, all copper work, cable lugs, terminations and terminal blocks shall be fully segregated by compartmentation to enable work on any one circuit to be carried out with other circuits remain live.

3.3.8 Protection against shock in normal service shall be achieved by the provision of barriers or enclosures both vertical and horizontal and between adjacent units to ensure segregation and prevent accidental contact with live parts, or by complete insulation of all live parts Control cables shall be segregated from primary conductors.

3.3.9 The protective earthing configuration shall be TN-S unless otherwise specified.
4. EQUIPMENT INSTALLED INSIDE ELECTRICAL PANELS

Electrical panels consist of Low Voltage Switchgear, control wiring and all other parts which are defined below.

4.1 BUSBAR

4.1.1 Busbars shall be of rectangular section hard drawn high conductivity tinned copper bare type conform to BS 1432/13601 or aluminium as per BOQ, adequately rated for designed value and fault level of load as per BOQ and supported by non-tracking moulded insulators spaced at suitable intervals. The complete assembly shall be capable of withstanding the maximum mechanical stresses to which it may be subjected to under fault conditions.

4.1.2 Sizing of the busbar shall comply with IEC 60890 for temperature rise assessment by extrapolation and in case of copper busbar temperature rise as per Copper Development association latest formula, may also be used.

4.1.2.1 Bus bar rating shall be same throughout the length of panel and shall be as per BOQ type tested design and recommendation of IEC 61439. The bus bar shall be designed for easy extension in future at either end.

4.1.3 Busbars and busbar connections shall be constructed in accordance with the requirements of IEC 61439-1. The short-time withstand current rating shall be as mentioned in BOQ for 1 second at 415 V.

4.1.4 Connection in Bus bars shall be made as approved and proven design of original manufacturer.

4.1.4.1 The maximum temperature of the bus bars and the bus connections shall be as per IEC 61439 standard.

4.1.5 The main busbars shall be so positioned and arranged that all busbar risers and droppers can be brought onto the main busbars without undue bending. Busbars shall be and supported with appropriate clearances in air to the requirement of providing full insulation.

4.1.5.1 Busbar chambers of similar rating shall be capable of coupled together using busbar coupling links, in accordance with the manufacturer's recommendation. Coupling links shall be approved by the Engineer before use.
4.1.5.2 Interconnecting conductors between busbar chambers and switchgear shall be as per rating of switchgear and type tested design.

4.1.5.3 Switchgear shall be joined to busbar chambers by means of properly designed busbar chamber connection flanges or conduit couplers and male bushes. Connection flanges shall be manufactured from galvanized sheet steel or CRCA and finished grey.

4.1.6 Busbars shall be coloured for phase identification at location of bus inspection points with the approval of site Engineer. The material for phase identification shall be non-fading colour of proven design to be decided by the Engineer and use of adhesive label shall not be acceptable.

4.1.6.1 The front cover and end plates of busbar chamber shall be removable and normally held in position by non-ferrous metal screws.

4.2 POLARITY

4.2.1 The polarity of all apparatus shall be arranged as follows when viewed facing the front of the Electrical Panels:

a) For two pole apparatus, phase pole and neutral pole when reading from top to bottom or left to right; and

b) For three or four pole apparatus, red, yellow and blue phases and neutral when reading from top to bottom or left to right.

4.2.2 All cables shall be so connected within the Electrical Panels such that the correct sequences are preserved throughout.

4.3 CONTROL SUPPLY

4.3.1 Separate control bus of suitable rating made of copper shall be provided throughout the panel length, and the control bus should be accessible from the front/back of the panel. Control voltage taping for different feeder shall be done with proper clamp.

4.3.2 The control circuit shall be separated from other auxiliary circuits, i.e. indicating circuit, heater and lighting circuits, with dedicated circuit protective devices.

4.3.3 240V control supply will be available from the station UPS with standby utility or as decided by engineer at site. DP MCB protection shall be provided at incoming.
SPECIFICATIONS FOR LOW VOLTAGE ELECTRICAL PANELS

4.3.4 240V Volt sensing relay with volt free contacts shall be provided for sensing the control supply for local and remote indication to BMS/SCADA.

4.4 INSTRUMENTATION

4.4.1 Electrical meters shall conform to IS 13779 / IEC - 1036, 687, 1286 suitable for single phase /three phase supply system in all respects. Accuracy of meters shall be of class as specified in BOQ.

4.4.2 All meters shall be digital type and multifunction meters should be with RS 485 connectivity to suit BMS System wherever mentioned in BOQ. Suitable memory and software for logging the information along with real time metering information must be available. The meters must have required level of protection and sufficient number of auxiliary contacts.

4.4.3 Meters shall be suitable for continuous operation as per IEC 898.

4.4.4 Meter shall be suitable for 3 phase, 4 wire systems, balanced as well as unbalanced load. All instruments and associated apparatus shall be capable of carrying their full-load current without undue heating. They shall not be damaged by the passage of fault currents up to the rating of the associated switchgear through the primaries of their associated instrument transformers. The instrument meter shall be earthed by a conductor of not less than 2.5 mm² cross-sectional area.

4.4.5 Energy meters shall be two / three element, switch board mounting type suitable for unbalanced loads. In case of two incoming feeders, a summation C.T. shall be provided with the meter.

4.4.6 The display for meters i.e. ammeter, voltmeters or multifunction meter shall be auto-ranging type.

4.4.7 Selector switches shall be inbuilt in Voltmeter such that voltmeters can read voltages between phase and phase and between phase and neutral.

4.4.8 Ammeters shall normally be suitable for 5 A secondary of current transformers

4.4.9 Voltmeter circuits shall be provided with protection through MCB as required.

4.4.10 Separate current transformers for a feeder shall be provided for protection device and for instrumentation.

4.4.11 Current Transformers (CTs) and Voltage Transformers (VTs)
4.4.11.1 CTs and VTs shall comply with IEC 61869/BSEN 61869 and CTs shall be of the epoxy resin encapsulated ring type. The ratings specified on the Drawings are indicative only and it shall be contractor/manufacturer's responsibility to ensure that the ratings offered are adequate for the relays/meters provided considering lead resistance, etc.

4.4.11.2 Current transformers shall comply with approved standard and shall be compatible with and provide the necessary accuracy, over current factors, characteristics, performance and VA rating for the satisfactory operation of the relevant protection devices, instruments and meters.

4.4.11.3 All CTs shall have a short-time current rating as specified in IEC 60044-1.

4.4.11.4 CTs for protection shall be compatible with the protection relays to ensure that the CTs will not be saturated up to the maximum prospective fault current.

4.4.11.5 CTs designed for unit protection schemes shall be able to withstand a stability of not less than the maximum through-fault of the units.

4.4.11.6 In balanced circuits, the spill current with maximum stability conditions shall not exceed one quarter of the operating current of the relay.

4.4.11.7 CTs for use in conjunction with protection relays shall be of class 5P accuracy or better. CTs for use in conjunction with measuring instruments shall be of Class 1 accuracy. The product of rated accuracy limit factor and rated output of the protection CTs shall not be less than 20 times the total rated burden of the trip circuit including the relay, connection leads and O/C release where applicable.

4.4.11.8 All CTs shall have output ratings adequate to cater for the burden connected to them. The Contractor shall demonstrate to the satisfaction of the Employer representative. By calculation or by test, that each group of the CTs, when installed and having the secondary burden connected, is capable of operating the relays and other measuring instruments in accordance with the manufacturer's published characteristics and the requirements of the system, with a reasonable margin of safety.

4.4.11.9 Measuring CTs shall be connected to test terminal block. The test blocks shall be provided with easily removable links and designed to facilitate connection of testing instruments on load without open-circuiting the CTs.
4.4.11.10 The secondary circuit of each set of CTs shall be earthed at one point only through a disconnectable copper link at a readily accessible position for testing.

4.4.11.11 Multi-ratio CTs (where used) shall have a label clearly indicating the connections required for the alternative ratios. These connections shall be shown on panel wiring diagrams.

4.4.11.12 Identification labels shall be fitted, mentioning type, ratio, rating, output and serial numbers.

4.4.11.13 VTs shall be provided with adequately rated primary and secondary fuses.

4.4.12 Instruments shall be similar in appearance throughout the whole of the Electrical Panels. All instruments, meters shall be of flush pattern, dust and moisture proof, suitable for the environment in which they are installed.

4.4.13 All instruments and meters shall be completely segregated in instrument compartments. Compartments containing these devices shall not contain any terminals or equipment operating at higher voltages with the approval of site Engineer.

4.4.14 The housing shall be of steel or phenolic mould. Design and manufacture of meters shall ensure prevention of fogging of instrument glass. Selector switches shall be provided for ammeters and voltmeters used in three-phase system. This selector shall be of built-in type with meters.

4.5 RELAYS

4.5.1 The relays are having in-built function with protective gears such as ACB, MCCB and MCB and MPCB etc. In case any relay is required for additional protection as stated in BOQ or otherwise, the same shall be provided to ensure full protection to the system.

4.6 EMERGENCY PUSH BUTTON (EPB)
4.6.1 Emergency lock and key type push buttons shall be installed wherever required or specified in BOQ to de-energize the Electrical Panels in the event of an emergency. The EPB shall be button type with flat surface protection guard ring and pressed-in design with key reset so that accidental triggering and vandalism shall be avoided as far as possible. Transparent hinged cover shall be provided in front. Unless otherwise specified on the Drawings, the EPB shall be mounted at 1300 + 100 mm above finish floor level. The button design and the installation details shall be submitted for approval.

4.7 INTERLOCK AND PADLOCKING FACILITIES

4.7.1 Mechanical key interlocks shall be provided wherever applicable or as specified in BOQ and shall be so designed as to avoid mal-operation at the point of manual application. The scheme shall be such that attempts to remove a captive key shall not result in tripping or opening of the device.

4.7.2 The tripping of the ACB(s) shall be via local hard wiring control and in Signal(s) shall also be generated from circuit breaker(s) upstream of the corresponding Electrical Panels and the switchboard interconnected section ACB.

4.7.3 Electrical interlocks on withdrawable equipment shall be so arranged that if the equipments are withdrawn, the complete operation of the withdrawn equipment shall be independent of the remote interlocking contacts. In addition, interlocks shall not be defeated leading to damages or unsafe operations of Electrical Panels due to the withdrawing of equipment.

4.7.4 Locking facilities shall be provided where appropriate for switches and isolators in order that they may be locked in the open position. Switchgear cubicle access doors shall be equipped with integral type locks, preferably incorporated in the handles of the equipment.

4.7.5 Where locking facilities are of the integral barrel type, the key for each lock shall be unique to the associated lock unless otherwise specified.

4.7.6 Two keys shall be provided for every lock supplied. The keys shall be fitted with rings with identification labels, and cabinets with glazed front-opening doors shall be provided. The cabinets shall be adequate in size and equipped with hooks to house all keys when not in use, and shall be mounted in positions to be decided.

4.8 INTERNAL AND CONTROL WIRING
4.8.1 All equipment shall have adequate provision for the entry and termination of all associated power and auxiliary cables.

4.8.2 Cable entry shall in all cases, except where otherwise specifically approved, and be at the base of the equipment. All cabling and wiring within the Electrical Panels shall be neatly run and fitted in or upon such cable trays, trunkings and conduits as may be appropriate to the layout and equipment. Cable trays, trunkings, conduits and cleats shall be non-metallic and shall be of the low smoke halogen free material. Metallic cleats is acceptable with the approval of the site Engineer.

4.8.3 LSZH and Fire Survival Cables shall be as specified in Section E02 (BS 6724-multicore cable and BS 7211 for single core cable) of this Specification. All internal and control wiring shall be Low Smoke Zero Halogen (LSZH) copper conductor wires rated at 450/750 V complying with BS EN 50525 for this Specification. All control wiring within the Electrical Panels shall be with single core minimum 2.5 mm² for CT and balance as per approved manufacturer design. Insulation shall have a glossy finish, be resistant to oil and be incapable of supporting combustion. Fire Survival wires shall be provided as per BOQ.

4.8.4 Wiring from the fixed part of the switchboard to the movable part such as hinged door shall be enclosed by flexible tubing made of Low smoke Zero Halogen material. Exposed live terminals shall be suitably shrouded or covered.

4.8.5 Wiring passing out to fully accessible positions shall be run in non-metallic low smoke halogen free flexible tubes or conduits.

4.8.6 All internal wiring shall be neatly run and securely fixed in non-metallic cleats in such a manner that, wherever practicable, wiring can be checked against diagrams without removal of the cleats.

4.8.7 Access opening shall be fitted with a suitable long grommet where inter-panel wiring passes through panel side sheets etc.

4.8.8 Bus-wires shall be fully insulated. Bus-wires terminals shall be fully accessible from the point of entry to each enclosure. MCB and links shall be provided to enable all control circuits within the Electrical Panels to be isolated from the bus-wires.

4.8.9 All control circuits shall be protected by a MCB.

4.8.10 There shall be no joint in conductors between terminal points.
4.8.11 Terminations for terminals shall be of the crimped-on ring type. Terminations of stranded conductors to clamp type terminals shall be of the crimped-on solid rod type.

4.8.12 No more than one core of either internal or external wiring shall terminate on any outgoing terminal. Where duplication of terminal blocks is necessary, suitable solid bonding links shall be incorporated in the design of block selected.

4.8.13 Wiring for all known future equipment shall be provided and all wires shall be terminated.

4.8.14 All wires between the terminals of two equipment shall be given a unique number according to an approved system. A wire number shall not change solely by virtue of passing through, say, a marshalling terminal block.

4.8.15 In the interests of uniformity, the wire-numbering system shall be approved by the Engineer.

4.8.16 Identification markers shall be fitted to all wires and multicore cable tails within enclosures in accordance with the diagram for apparatus concerned. Cable and core makers shall be of insulation material, colored according to the wire numbering system with a glossy finish, be resistant to oil and be incapable of supporting combustion. Numbers shall not be duplicated unless the corresponding wires are directly in series or parallel.

4.8.17 Different insulation colours shall be provided to distinguish the various circuits. All wiring shall conform to the colour and ferrule codes to be approved by Engineer.

4.9 TERMINAL BLOCKS

4.9.1 Both incoming and outgoing cable shall have top or bottom entry depending on site requirement.

4.9.2 Each terminal block compartment shall have not less than 20% or 4 spare terminals whichever is greater.
4.9.3 Terminal blocks for low voltage wiring shall be moulded from high-grade non-hygroscopic melamine, comprise bank of rail-mounted blocks with all live parts fully shrouded, screw-clamp, spring loaded insertion, solder-lug or stud type terminals as appropriate to the design and duty of the cables to be terminated. Pinch-type screws, where the screw is in direct contact with the conductor, shall not be used.

4.9.4 Each terminal shall be provided with claw-type washers, crimp lugs or other approved means for connection of the wires. Plain and spring washers, nuts and lockouts shall be electro-tinned.

4.9.5 Terminals shall be assembled in banks and each terminal shall be complete with marking tags to fit into moulded tag slots.

4.9.6 Terminals for final connections for indication, instrumentation and metering circuitry shall have test probe facilities and an integral disconnecting device to facilitate testing.

4.9.7 Terminations shall be grouped according to function and no more than two wires connected to one terminal. Labels shall be provided adjacent to the terminal block to identify the function and voltage of each group.

4.9.8 All terminals to which 240 V or 415 V AC circuits are connected, where they are in individual terminal blocks, shall be provided with a transparent insulated cover which in addition to any other form of identification and shall have a label engraved suitably indicating the voltage.

4.9.9 Terminals for the control supply which may be still alive when the main equipment is isolated from the mains supply shall be suitably labelled to reduce the risk of accidental contact.

4.9.10 All terminals shall bear a permanent identification number or letter.

4.10 MARSHALING UNIT

4.10.1 In main distribution Electrical Panels separate marshalling chamber shall be provided for BMS interfaces terminals or wherever required as per BMS requirement.
4.10.2 Single location interface for different LV components of main distribution panel (DB100, DB200) or other Electrical panel where ever necessary or as per BOQ shall be provided through marshalling chamber for BMS interface.

4.10.3 All interface terminals and ports for BMS shall be wired up to the marshalling chamber. Necessary marking and ferruling shall be provided for individual termination.

4.10.4 Control command interface and other terminals having potential should have due separation from VFC interface terminals. Control and signal cable wiring from different relays, sensors, transducer, controller and contactor releases shall be through separate wiring bunch to avoid fault current or external magnetic/electric interface.

4.10.5 Necessary multi dropping and single point interface provision shall be done through suitable short links. Communicable devices using standard protocol communication shall be looped as per BMS requirement.

4.10.6 Marshalling chamber should have provided with necessary mounting arrangement or space provision for BMS remote I/O module/ PLC equipment along with its associated interface equipment and power supply unit or as per BOQ.

4.10.7 Connecting cable with connector between ACB communication unit and junction box shall be provided.

4.10.8 24V DC source unit or as required (Incoming supply shall be taped form the control supply available in the panel) for communication of ACB/MCCB with SCADA/BMS system.

4.10.9 Panel manufactures shall provide the required termination and interface detail for BMS work. In case of requirement of supervision and guidance during BMS commissioning, same shall be inclusive to the panel manufacture's scope of work. It is the responsible of panel manufactures to provide necessary interface detail such as data point register address during BMS commissioning or supervise as appropriate during installation and testing of BMS system.
4.10.10 Marshalling box shall comply with EMC (electromagnetic Compliance) and protected from any electrical or magnetic interface. Required protection against any BMS or panel component has to be inclusive to respective contractor’s scope of work.

4.10.11 Any specific interface requirement not specified here will be wired up to the marshaling chamber interface terminal. BMS/SCADA interface point should only confine to marshalling box.

4.11 BMS INTERFACE

4.11.1 Electrical contractor shall cross reference the requirement of BMS remote control and monitoring interface as required for electrical equipments and shall provide the necessary volt free contact and remote control interface for BMS.

4.11.2 Serial interface as applicable for ACB/MCCB and digital meters or MFMs shall be strictly on standard protocol communication (preferable with MODBUS-RTU, RS485, 2 wire communication). Necessary interface detail and drawing shall be provided to BMS contractor during commissioning.

4.11.3 All terminals and BMS interface terminal and ports shall be wired to a separate chamber with adequate number of ITBs and with proper marking as per interface document.

4.11.4 No such change in contact or pseudo signal shall be provided for critical alarms control interface.

4.11.5 BMS and PLC interface for control command shall be pulse type close contacts for single command output / double command output or a variable voltage/current (i.e. 0V - 10V or 4mA - 20 mA) for analog output command.

4.11.6 There shall be one interface for control open and one for control close operations. The Contractor shall provide appropriate equipment to sense and latch the remote control signal for performing the open/close control function. The BMS digital output (DO) & analog output (AO) signal shall be as stipulated.

4.11.7 Contacts shall be rated to adequately make and break and carry continuously not less than 5A at 250V AC or 2A at 110V DC. Volt-free contacts for sequence of event (SOE) and alarms shall firmly close and seat in position once activated. The contacts shall not bounce or vibrate due to internal or external causes.
4.11.8 Required data point as per BMS requirement shall be configured in respective controller or equipment by panel manufacturers as required with necessary hardware and software for above said serial link communication.

4.12 INDICATING LAMPS

4.12.1 Indicating lamps shall be multiple LED type. All indicating lamps shall be suitably rated so that the indication is clearly visible from the side and front at a distance of not less than 3 m in a room.

4.12.2 The colours of indicating lamps for red, yellow, blue phases, ACB on, off and trip shall be red, yellow, blue, red, green and amber respectively.

4.13 LOW VOLTAGE SWITCHGEAR

4.13.1 AIR CIRCUIT BREAKERS

4.13.1.1 ACB should be mechanically robust of compact design, air break horizontal and withdrawable type, confirming to IS/IEC 60947-2 and EN 60947-2.

4.13.1.2 Air Circuit Breaker is provided in transformer incomer, outgoing feeder, Interconnector Bus-Section and essential/semi-essential circuit breaker as defined in BOQ.

4.13.1.3 Manual charging as well as by 240 V AC motor with charged spring closing mechanism complete with anti-pumping relay, discharge resistor, auxiliary switch, etc.

4.13.1.4 240 V A.C shunt-trip coil shall be operable, within operational voltage range of 70% to 110% of rated voltage as per Clause 7.2.1.3 of IEC 60947-1.

4.13.1.5 The operating mechanism shall be trip-free.

4.13.1.6 Maximum number of circuit breaker auxiliary switches, spare auxiliary switches to be equally divided between normally open and normally closed. At least 4 spare pairs of N.O. and N.C. volt free contacts shall be provided.

4.13.1.7 Indicating lamps for on, off, tripped on fault and trip supply healthy with all necessary push buttons, panel wiring, bus wiring, terminals, fuses, etc.

4.13.1.8 Power and control cable terminals with undrilled gland plates for outgoing power cables and multi-core cables.
4.13.1.9 Electrical connection between the breaker and switchboard shall be of plug and socket type with automatic screening shutters. An interlock to prevent withdrawal when the breaker is closed.

4.13.1.10 Number of Poles shall be as per BOQ.

4.13.1.11 Local/auto control selector switch shall be lockable in all positions. The automatic control shall be defeated when the selector switch is put at local or OFF position as per drawing and BOQ.

4.13.1.12 Remote indication and alarm facilities shall be provided for Circuit-breaker open, Circuit-breaker closed, Circuit Breaker is ready to close, Circuit-breaker tripped on fault, and Switch position of local/remote control selector switch.

4.13.1.13 Control switch for air circuit breakers shall be as follows:

4.13.1.13.1 Air Circuit breakers shall be fitted with operative switches of the pistol grip type. The handles of control switches for air circuit breakers shall turn clockwise for closing and anti-clockwise for tripping.

4.13.1.13.2 The control switch shall be clearly labelled as CIRCUIT BREAKER OPEN - NEUTRAL - CLOSE, with spring return to the neutral position. Mechanical interlock shall be fitted to prevent repetitive closing without moving first to the trip position, and shall be capable of padlocking in the neutral or trip position.

4.13.1.14 Set of terminals wired to provide for connection to the following:

4.13.1.14.1 Automatic changeover and interlocking as shown on the drawing

4.13.1.14.2 Operation of emergency push button as per requirement or as per BOQ.

4.13.1.14.3 Signal cables wired to terminal block for remote monitoring to SCADA.

4.13.1.15 Electrical Characteristics:

4.13.1.15.1 Rated Insulation Voltage: 1000 V

4.13.1.15.2 Rated Frequency: 50 Hz

4.13.1.15.3 Rated ambient temperature: As per Clause 6.1.1 and 6.1.3 of IEC 60947

4.13.1.15.4 Utilization category: B or as per drawing or BOQ.
4.13.1.15.5 Rated uninterrupted current: as shown on Drawings, however the contractor must provide breaker after taking into account of the installation conditions and derating for ambient temperature, based on selected make during preparation of working drawings.

4.13.1.15.6 Current Ratings shall be as follows:

4.13.1.15.6.1 Rated short-time withstand current \( (I_{cw}) \): 70/65/50 kA for 1 second (minimum)

4.13.1.15.6.2 Rated ultimate short circuit breaking capacity \( (I_{cu}) \): 70/65/50 kA based on actual fault level or as per BOQ.

4.13.1.15.6.3 Rated service short-circuit breaking capacity \( (I_{cs}) \): 100% of \( I_{cu} \), and

4.13.1.15.6.4 Rated short-circuit making capacity: shall be at least 2.1 times of ultimate short circuit breaking capacity at 0.25 power factor or as per BOQ.

4.13.1.16 Protection

4.13.1.16.1 ACB shall have microprocessor based protection releases for type of faults with selective over current (long time, short time & instantaneous) & earth fault protection, measurement of electrical parameters and with communication capability with SCADA/BMS system. Any other additional protection as mentioned in BOQ. ACB shall have an LED/LCD display to show true RMS current in all the three phases and highest current among these phases. The release shall be equipped with self diagnostic feature with indication. The release shall have zone selective interlocking and be capable for communication through Modbus over Serial (RS 485 port) as per the requirement of design or as defined in BOQ. The overload and short circuit characteristics should be front adjustable and password protected.

4.13.1.16.2 The release should have an internal fault indication for faster fault diagnosis/self diagnostic feature is required.

4.13.1.16.3 The release should have fault indications by which discrimination of fault is possible.

4.13.1.16.4 Control relays and wiring for automatic changeover interlocking and other breaker operation as shown on the Drawings.
4.13.1.16.5 Fire resistant transparent covers shall be provided over ACB’s to achieve IP-54 protection and door interlock so that ACB access door shall not open if ACB is ON otherwise it will automatically OFF if Door is opened.

4.13.1.16.6 Electrical interlock for the two incoming circuit breakers and interconnector bus-section circuit breaker to prevent paralleling of different power supply sources at any one time as shown on the Drawings.

4.13.1.16.7 Following shall be provided for ACB connected to the transformer incomer:
   a) Four Protection Current Transformers (three in panel, one in loose to be mounted in transformer neutral), a Restricted Earth Fault Relay and a Standby Earth Fault relay as specified for the interface with high voltage switchgear.
   b) Two ways inter-tripping relay shall be provided with the associated HV feeder circuit breaker by interfacing with the Power Supply Contactor.
   c) Voltage sensing relay and associated relays for automatic changeover and interlocking operation as detailed on the Drawings.
4.13.1.16.8 Interlocks and Test Operation Facilities

All ACBs shall be provided with interlocks to ensure that:

a) The ACB cannot be plugged in or isolated while it is closed,

b) The ACB cannot be closed until it is fully plugged in or completely isolated

c) The ACB cannot be closed in the service position without completing the auxiliary circuits between the fixed and moving portions

d) With manual charged and motor charged spring mechanisms the springs cannot be discharged until they have been fully charged and until the means for charging has been removed or disconnected,

e) Facilities shall be provided for testing the ACB operation when in the isolated and withdrawn positions by the normal means as in service, and

f) Where control circuits are provided and interlock circuits are broken via plugs on withdrawal of the ACB, a minimum of one jumper lead and plug assembly of each size and type shall be provided to facilitate testing in the withdrawn position.

g) The neutral shall be rated for 100%

4.13.1.16.9 Safety Shutters

4.13.1.16.9.1 A set of shutters with padlocking facilities shall be provided to cover each three phase group of stationary isolating contacts. The shutters shall be independent and operated automatically by a positive drive from the ACB withdrawal mechanism

4.13.1.16.9.2 In order to prevent unauthorized operation, the withdrawable air circuit breakers shall be provided with padlock facilities to secure them in their connected, test and isolated positions.
4.13.2 MOULDED CASE CIRCUIT BREAKERS

4.13.2.1 MCCBs shall comply with and be type-tested to IS/IEC 60947-2 or EN 60947-2. Each MCCB shall be of fixed or withdrawable type, as specified in the BOQ and have all the mechanical and live parts completely enclosed in an insulated moulded case. Withdrawable pattern circuit breakers shall be designed that their electrical equipment can be safely disconnected from or connected to the main circuit whilst the circuits are live.

4.13.2.2 MCCB shall be suitable for isolation as per Annexure 7.1.2 of IEC 60947-2

4.13.3 MCCBs shall meet the following requirements:
   a) Number of poles: double-pole, triple-pole or four poles as specified on the Drawings or Design or BOQ
   b) Rated operational voltage: 240 / 415 V AC, as per drawing or BOQ
   c) Rated insulation voltage: 660 V AC, higher voltage acceptable
   d) Rated uninterrupted current (In): as shown on the Drawings or BOQ, but after taking into account the installation conditions and temperature deration.
   e) Rated frequency: 50 Hz,
   f) Rated short-circuit making capacity (Icm): shall be at least 2.1 times of ultimate short circuit breaking capacity at 0.25 power factor,
   g) Rated ultimate short-circuit breaking capacity (Icu): 65/50/35 kA (min),
   h) Rated: service short-circuit breaking capacity (Ics): 65/50/35 kA Further, Ics must be equal to 100% Icu for the selected breaker,
   i) Utilization category: A or B as appropriate,
   j) Degree of protection: IP 3X to IEC 60529 or EN 60529, and
   k) Rated ambient temperature: As per IEC 60947-2
   l) Impulse Withstand Voltage - 8KV
   m) 0 - t - CO - t - Co type of Duty i.e. Ics=Icu.
4.13.3.1 MCCB's to be provided in LV Main Switchboard shall be stored energy type motorized and Suitable for Remote Closing by BMS.

4.13.3.2 All MCCB's should have front adjustable microprocessor based releases with adjustment in the range of 40 - 100% for nominal overloads and adjustable setting for short circuit faults. MCCB's for network/feeder Protection shall have releases with earth Fault Protection features, wherever and as indicated in Bill of quantities or drawings.

4.13.3.3 In case of 4 pole MCCB, neutral shall be defined and capable of offering protection up to full rating with possibility of adjustment at site in the neutral setting.

4.13.3.4 Mechanical endurance shall be as specified in latest IEC standard.

4.13.3.5 MCCB's shall have an electrical endurance operation cycles as per latest IEC standard 60947.

4.13.3.6 All MCCB's shall be arranged for padlocking in OFF positions with lock provided. A shunt trip coil shall be provided to facilitate automatic tripping and local manual tripping. The manual trip device shall be fitted with the means of padlocking. The shunt trip coil shall be suitable for operation within a voltage range of 70% to 110% of the rated AC power supply voltage.

4.13.3.7 Electronic trip units shall comply with the requirements as specified in Appendix F (EMC/EMI Compatibility) of IEC 60947-2 or EN 60947-2.

4.13.3.8 The trip unit shall be easily replaceable in the same MCCB without changing the MCCB.

4.13.3.9 The time delay on overload tripping shall be inversely proportional to the over current up to a threshold value of approximately six to seven times the rated current at rated working temperature.

4.13.3.10 Handle position shall give positive indication of 'ON' 'OFF' or 'TRIPPED', thus qualifying to disconnection as per IEC 60947-3 indicating true position of all the contacts.
4.13.3.11 The operating mechanism of MCCB's shall be Independent of the operating speed of the over centre toggle and the MCCB shall be of current limiting type and comprise of Quick make and Quick break switching. Contacts shall be non-welding type. The operating mechanism should be trip-free and provided with mechanical "ON", OFF" and "TRIPPED" indicator. The MCCB shall be designed for both vertical and horizontal mounting, without any adverse effect on electrical performance.

4.13.3.12 Remote closing and tripping coil should be of continuous duty cycle.

4.13.3.13 MCCB's shall have common field fittable auxiliaries for the entire range and above 250 A the accessories like copper spreaders and phase barriers should be the integral part of the MCCB's.

4.13.4 MINIATURE CIRCUIT BREAKERS (MCB)

4.13.4.1 MCBs shall comply with and be type-tested to IEC 60898 or EN 60898.

4.13.4.2 MCBs shall meet the following requirements:

a) Number of poles: single-pole, double-pole, triple-pole or four-pole as specified in the BOQ or Drawings

b) Protection against external influences: Enclosed-type,

c) Method of connection: Bolted type or clip-on type,

d) Rated operational voltage and frequency 240 / 415 V AC and 50 Hz.


f) Range of instantaneous tripping current: MCB's shall be current limiting Type Class 3 with range of instantaneous tripping current B, C or D type as appropriate or as specified,

g) Rated short-circuit breaking capacity: not less than 10 kA (M3) unless otherwise specified in BOQ.

h) I^2t characteristic: suitable for load and circuit being protected,

i) Degree of protection: IP-20 for MCB's
j) Reference ambient temperature: as per IEC 60898.

k) MCB’s shall have minimum power loss (Watts) per pole as per the IEC and should be proven by published value by manufacturer.

4.13.4.3 The load handling contacts shall be silver/tungsten or proven material and the contacts and operating mechanism shall be designed so as to give a wiping action both at make and break. The breaker operating mechanism shall be of trip-free type. The breaker operating dolly shall be clearly indicated for the "ON" and "OFF" positions. It should be of Quick make and Quick break type.

4.13.4.4 Circuit protection against overload and short-circuit conditions shall be provided by means of thermal-magnetic device. Double-pole, triple-pole, and four pole MCBs shall be integral units and interlocked internally so that an over current through any pole shall trip all the poles of the MCB simultaneously. An assembly of two or three or four single-pole units mechanically strapped together is not acceptable.

4.13.4.5 Housing shall be heat resistant and having high impact strength. All DP, TP and FP circuit breaker shall have a common trip bar and should be mechanically coupled through a pin. It shall have an electrical endurance of the order of 10000 operation cycle for current rating of up to 50A.

4.13.5 RESIDUAL CURRENT CIRCUIT BREAKER

4.13.5.1 RCCBs shall be double pole or four-pole current-operated, housed in a totally enclosed moulded case, manufactured and tested in compliance with IEC 61008 or EN 61008.

4.13.5.2 RCCBs shall meet the following requirements:

a) Number of poles: double-pole or four-pole as specified on the Drawings,

b) Rated current (In): as shown on the Drawings,

c) Rated residual operating current: 30 mA or 100 mA or 300 mA as shown on drawings or as per approval of the Engineer.

d) Rated voltage: 240/415 V AC,

e) Rated frequency: 50 Hz,
SPECIFICATIONS FOR LOW VOLTAGE ELECTRICAL PANELS

f) Rated short-circuit capacity: not less than 1.5 kA unless otherwise specified in BOQ

g) Operating characteristics in case of residual currents with DC components: as specified,

h) Method of mounting: distribution board type,

i) Method of connection: connection shall be made with proper size of thimbles and number ferruling for circuit identification,

j) \( I^2t \) characteristic: suitable for equipment and circuit being protected

k) Degree of protection: IP 3X to IEC 60529 or EN 60529, and

l) Reference ambient temperature: As per IEC.

4.13.5.3 The tripping mechanism shall be of trip-free so that the unit cannot be held closed against an earth fault. Tripping devices utilizing electronic amplifiers or rectifiers are not acceptable.

4.13.5.4 Provision shall be made for testing the automatic earth - leakage tripping by an integral test device. A device shall be fitted for prevention against reclosing after the device has tripped on earth leakage.

4.13.6 RCBO (RESIDUAL CURRENT CIRCUIT BREAKER WITH OVER-CURRENT) PROTECTION

4.13.6.1 RCBOs shall be double pole or four-pole current-operated, housed in a totally enclosed moulded case, manufactured and tested in compliance with IEC 61009 -1, IS 12640(part 2) 2008 and ISI marked.

4.13.6.2 RCBOs shall meet the following requirements:

a) Number of poles: double-pole or four-pole as specified on the Drawings,

b) Rated current (In): as shown on the Drawings,

\( c) \) Rated residual operating current: 30 mA or 100 mA or 300 mA as shown on drawings or as per approval of the Engineer.

d) Rated voltage: 230/415 V AC,

e) Rated frequency: 50 Hz,

f) Rated short-circuit capacity: 10kA
g) Operating characteristics in case of residual currents with DC components: as specified,

h) Method of mounting: distribution board type,

i) Method of connection: connection shall be made with proper size of thimbles and number ferruling for circuit identification,

j) I2t characteristic: suitable for equipment and circuit being protected

k) Degree of protection: IP 2X, and

l) Reference ambient temperature: As per IS 12640-1

4.13.6.3 The tripping mechanism shall be of trip-free so that the unit cannot be held closed against an earth fault. Tripping devices utilizing electronic amplifiers or rectifiers are not acceptable.

4.13.6.4 Provision shall be made for testing the automatic earth leakage tripping by an integral test device. A device shall be fitted for prevention against reclosing after the device has tripped on earth leakage

4.13.6.5 A mechanical flag indicator on RCBO for faster identification of fault trip condition i.e. earth leakage or over-current for faster fault diagnosis and preventive measures.

4.14 DESCIRMINATION

4.14.1 Selection of ACB, MCCB and MCB shall be of same make. Total discrimination up to the design fault level must be available between the various elements of switchgear (ACB, MCCB, MCB etc) selected. Supplier must provide test certificates from acceptable, accredited and reputed laboratories or submit published discrimination charts/tables to prove the same. In view of Standardization and Uniformity, mixing of two series of switchgear (even from the same manufacturer) for either MCCB or ACB will not be permitted.

4.14.2 In case higher frame sizes rating of switchgear (than those specified in the BOQ) is required to be provided to achieve the above requirement, due to selection of a particular make, the same shall be provided at no extra cost if other makes are able to achieve the same with the specified frame size.

4.15 REMOTE MONITORING

The following critical status and alarms for each Electrical Panels shall be sent to BMS for remote monitoring via volt-free contacts or serial interface over standard protocol communication as approved but not limited to:
a) Individual ACB/MCCB open/close status,

b) Common alarm for ACBs/MCCBs trip on fault/lock out,

c) Common alarm for any local/remote or local/auto selector switch in local mode

d) Control supply failure,

e) ACB ready to close indication.

f) Emergency push button (EPB) operated, and

g) Busbar voltage, current, frequency and energy parameter

h) Electrical Panels under voltage alarm and cause of tripping.

4.16 MOTOR STARTER

4.16.1 Every motor starter shall be designed to perform the following functions efficiently and safety:

a) To start the motor without damage to the drive or driven equipment whilst regulating the starting current to the satisfaction of the requirements of this Specification and ensuring that at all stages of starting, the motor will develop sufficient torque to accelerate the load.

b) To stop the motor.

c) To prevent damage to the motor due to overload, disconnection of one phase etc..

d) To prevent damage to reduced and danger to personnel due to resumption of the electricity supply following a failure.

e) To prevent the damage to the motor due to stalling or internal electrical or mechanical faults by quickly disconnecting the supply.

f) To prevent damage to the motor or the starter itself due to improper, unskilled or hesitant operation or failure to complete a starting sequence once it is connected.
g) To enable the motor and starter to be completely isolated from the main supply and from all control supplies for inspection and repairs by means of fixed type unit for each starter circuit.

4.16.2 Each motor starter assembly shall comprise MCCB/MPCB, contactors, protection relays, electronic circuitry, control switches, lamps and instruments and accessories as specified hereinafter. It shall include control devices for automatic control systems. The whole unit shall be enclosed in the cubicle, from which no access can be gained to adjoining cubicles.

4.16.3 The specified starter types are based on estimated motor ratings. The final selection of starter shall be based on the installed motor rating. Starters and associated over-load devices shall be selected in accordance with the run-up time of the associated motor driven load, the maximum thermal capacity of the motor and frequency of starting, and the duty cycle. All starters shall have suitable protection for phase-to-phase, phase-to-neutral and phase-to-earth faults, over-loads, and single phasing, with additional protection measures as specified. Overload relays releases as specified shall have inverse time delay characteristics compatible with the motor drive to which they are applied for all protective devices the short-circuit capacity (Isc) shall be capable of withstanding a fault current of the panel, as a minimum. The specifications of incoming and other circuit breakers (ACB/MCCB etc.) shall be as per clause 4.13, as relevant.

4.16.4 All starters shall be in accordance with section 7.2 of IEC 60947-4-1 or EN 60947-4-1, and shall be adequately rated for conditions in which it shall operate.

4.16.5 All starters shall be type tested by a competent and internationally recognized testing authority for type 2 co-ordinations in accordance with IEC 60947-4-1 or EN 60947-4-1.

4.16.6 All contactors shall be electro-magnetic type with utilization category AC - 3 to IEC 60947-1.

4.16.7 All starter shall be of electrically held on pattern and shall not release until the over voltage falls below 70% of nominal.

4.16.8 Control circuits shall generally be operated on main supply derived from the LMCP, suitably protected by MCB type 2, as specified in clause 4.13. The control circuit shall be of self-holding and latching design.
4.16.9 Where the control voltage is not 240V it shall be derived from transformers to BS 3535/BS 61558. Transformers shall be rated at the total control circuit load plus a minimum of 10% spare capacity. Transformer primary windings shall be protected by MCB's in the line connection(s) and a removable neutral link shall be provided where the neutral is required. The supply shall be taken from downstream of the main incoming Circuit Breaker. One end of the transformer secondary shall be connected directly to the main earth bar. This connection shall be upstream of the control circuit neutral link. The supply from the other end-of the winding shall be protected by MCB.

4.16.10 The type of starters for other mechanical equipment such as plumbing, drainage, fire services pump and other motor circuits shall be as specified in this clause subject to rating of the motors selected during working drawing production as per clause 4.16.3. The starters shall also comply with the requirements laid down in the Code of Practice of electricity(Wiring) Regulations. Voltage for motors shall be 415V 3-phase or 240V 1-phase, as required. Motors rated 0.37kW and larger shall have a rated voltage of 415V, 3 phase, 50Hz. Motors rated smaller than 0.37 kW shall be operated at 240V 1-phase. Direct-online motor starters shall be used for motors up to and including 3.75 kW at 415 volts, 3 phase. All motors over this limit shall be equipped with reduced voltage starters of the star-delta or soft starter type as indicated in BOQ.

<table>
<thead>
<tr>
<th>Motor size (M)</th>
<th>Maximum starting current in multiple of full load current (phase of motors)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M ≤ 0.37 kW</td>
<td>6 (single phase motor)</td>
</tr>
<tr>
<td>0.37 kW &lt; M &lt; 3.75 kW</td>
<td>6 (three phase motor)</td>
</tr>
<tr>
<td>3.75 kW ≤ M</td>
<td>6-7 (three phase motor)</td>
</tr>
</tbody>
</table>

(Tolerance in the above currents shall be of the order of ±20%)

4.16.11 The direct-on-line starters shall be provide based on condition given in Clause 4.16.10 and shall include, but not be limited to, the following:

a) MPCB as specified,

b) Triple pole air break contactor,
c) MPCB wherever specified or required shall be provided with inbuilt Thermal/Magnetic and single-phasing protection. MCCB, wherever specified/required shall be of Electronic Trip Unit type with single phasing preventer unit.

d) All Current transformers with suitable ratio, output and accuracy for motor protection,

e) Local/off/remote control selector switch lockable in each position,

f) Set of start and stop push button,

g) Set of indicating lamps for motor running, off and tripped on fault,

h) Set of digital input (dry contacts) interface wired to terminals for wiring connection to station building services controllers,

i) One set of terminals wired to the following:

   a. Emergency stop push button, effective in all positions of the local/remoteswitch if any.

   b. Remote start/stop of the motor, effective only in the remote position of the selector switch.

   c. Hour run meter,

   d. Lamp test button,

   e. Any other items required to affect satisfactory motor starting and control as specified in this Specification, and

   f. double pole contractor and motor protection unit for single phase DOL type starter.

j) Interposing relays/contactor for remote close and remote open whenever required.

k) Leakage Protection for DOL starters shall be provided with 25 / 40 A, 4 Pole RCCB with sensitivity of 100/300 mA as specified.
4.16.12 Based on criteria given in Clause 4.16.10 or wherever specified on the Drawings, star-delta starters shall be provided to limit the maximum starting current within 2.5 times the rated motor full load current. The star-delta starters shall be equipped as per direct-on-line starters specified above, with the following additional provisions:

a) Star-delta starters shall be of the automatic type and shall comply with BS EN60947-4-1. Triple pole air break star and delta contactors shall be electrically interlocked so that they cannot close or be closed at the same time. In all types of star-delta starters the correct phase relationship between the star and delta connections to minimize disturbance on changeover shall be maintained.

b) Rated and adjustable solid state timer for automatic star-delta transition, and

c) Automatic changeover timers shall be adjustable from 1 second to 30 seconds. Timers shall incorporate a fixed delay of between 20 ms between the star contact or opening and the delta contactor closing.

d) MPCB /MCCB as specified in drawings /Schedules shall be used. MCCB shall be as specified in clause 4.13 with the difference that the Electronic trip Units shall be suitable for Motor Protection against Over Load (Adjustable) and Short Circuit. For requirement of Earth fault/Earth Leakage protection, Clause 4.16.15 referred to.

4.16.13 **Reversing Starters**

Forward and reverse contactors will be mechanically and electrically interlocked. Reversing starters will be in accordance with BS EN 60947 and be suitable for AC 4 utilization category.

4.16.14 **Incoming Supplies**

The isolation devices for assemblies with duplicated supplies shall be interlocked (electrically and mechanically) to prevent simultaneous closure.

4.16.15 **Earth Leakage/Earth Fault Protection**
For Earth Leakage / earth fault Protection for Circuits with Star-delta starters (wherever required, based on calculations done during working drawings Production Stage). Add-on Modules to MCCB (based on current rating of MCCB) shall be provided with continuous adjustment from 30 mA to 10 A range with adjustable time delay.

4.16.16 Status/Alarm

a) Indicating lamps shall be provided on each phase of the main incoming supply.

b) All assemblies incorporating automatic control systems shall be equipped with suitable status/alarm annunciation facilities. If these are not available directly from the automatic control system then a separate status/alarm annunciator shall be provided. Status/alarm enunciators shall provide indications for all starting devices of 'ON', 'OFF' and 'TRIPPED' conditions.

c) The status/alarm annunciator equipment shall be mounted in the same cubicle as the automatic controls. Volt-free contacts shall be provided for each condition in each starter cubicle, which shall be wired internally to the status/alarm annunciator, via terminals at each end.

d) The schematic diagrams as indicated in the Working Drawings shall be shown and the operating status of all equipment shall also be indicated. Status indicating lights shall exhibit run/stop or open/close and fault conditions. The Contractor shall provide test buttons for the indicating lights. The layout, color, symbols and arrangement of the mimic diagram shall be submitted to the Engineer for review prior to manufacture.

e) Suitable interfaces shall be built into each channel to relay signals to remote locations, by means of volt-free contacts.

f) Hours-run meters shall be fitted as specified and not be resettable.

4.16.17 Control Circuits

a) In each individual starter, the control circuit shall be provided with MCB, a neutral link, a means of disconnection and, where specified, a disconnection over ride switch.
b) Neutral links shall comprise a solid copper link mounted in a white coloured fuse base and carrier, which shall not be interchangeable with control or power fuse carriers.

c) The control circuit supply shall be connected via an auxiliary contact on the starter isolator.

d) Where automatic changeover systems are specified for duty/standby operation, the control circuit for the changeover controls shall be independent of both starters.

e) Start delay timers shall be incorporated for sequential operation of starters where specified. The failure of one timer or starter to operate shall not prevent operation of the remaining starters.

4.16.18 Interlocking

a) The control circuit of a dependent starter shall be wired via auxiliary motor contactor in the lead starter. In the case of reduced voltage starter, the contacts shall be on the full voltage contactor.

b) Should the lead starter be shut down either intentionally or by a fault condition, the dependent starter shall drop out immediately.

c) A time delay shall be incorporated in the interlock circuit to delay the operation of the dependent starter where specified. Such time delays shall be in addition to the interlock circuits.

4.16.19 Auxiliary contacts

Two normally open and two normally closed auxiliary contacts shall be provided for each starter as spares unless otherwise specified. These contacts shall be in addition to contacts used for the control of the starter.

4.16.20 MPCB (MOTOR PROTECTION CIRCUIT BREAKER)

Motor circuit breakers shall comply with the general recommendations of standard IEC 60947-1,-2 and -4-1.

1. The devices will be in utilization category A, conforming to IEC 60947-2 and AC3 conforming to IEC 60947-4-1.
2. Rated operational voltage of 690V AC (50/60 Hz)
3. Rated insulation voltage of 690V AC (50/60 Hz)
4. Isolation conforming to standard IEC 60947-2,
5. Rated impulse withstand voltage (Uimp) of 6 kV.

4.16.20.1 **MPCB shall meet following requirement:-**

4.16.20.1.1 Mounting:

The motor circuit breakers will be designed to be mounted vertically or horizontally without derating Power supply will be from the top or from the bottom.

4.16.20.1.2 Contacts:

In order to ensure maximum safety, the contacts will be isolated from other functions such as the operating mechanism, casing, releases, auxiliaries, etc, by high performance thermoplastic chambers.

4.16.20.1.3 Operating mechanism

The operating mechanism of the motor circuit breakers must have snap action opening and closing with free tripping of the control devices. All the poles will close, open, and trip simultaneously.

4.16.20.1.4 Button:

The motor circuit breakers will be actuated by a rotary operator clearly indicating the position ON (I), OFF (O), trip

4.16.20.1.5 Isolation:

In order to ensure isolation with clearly visible breaking conforming to standard IEC 60947-2 paragraph 7.2.7:

1. The mechanism will be designated so that the different types of operator will only be in position (O) if the main contacts are physically separated,

2. In position (O) the operating devices will indicate the isolated position.
3. Isolation is enhanced by the double break of the main circuit.

4.16.20.1.6 Padlocking

Motor circuit breakers will accept a padlocking device in the "isolated" position.

4.16.20.1.7 Trip

The motor circuit breakers will be equipped with a "PUSH TO TRIP" device on the front enabling the correct operation of the mechanism and poles opening to be checked.

4.16.20.1.8 Limitation, Durability

1. The motor circuit breakers will be current limiting for a mains voltage of 400 V, the maximum let-through energy ($I^2t$) on short circuit being extremely low.

2. The motor circuit breakers will have a high electrical and mechanism durability of at least 5 times that required by the standard.

4.16.20.1.9 Protection functions

**General recommendations:**

a) The motor circuit breakers will be equipped with releases comprising a thermal element assuring overload protection and a magnetic element for short-circuit protection.

b) In order to ensure safety and avoid unwanted tripping, the magnetic trip threshold (fixed) will be factory set to an average value of 12 Ir.

c) All the elements of the motor circuit breakers will be designated to enable operation at an ambient temperature as per IEC without derating.

d) The thermal trips will be adjustable on the the front by a rotary selector.

e) The adjustment of the protection will be simultaneous for all poles.

4.16.21 SWITCH FUSE UNITS & DISCONNECTS/ISOLATORS (WHERE APPLICABLE)
4.16.21.1 Switch fuse units shall have quick-make, quick-break silver plated preferably double break contacts with operating mechanism suitable for rotary operation in the case of cubicle mounting. All switches shall be rated according to the equipment schedule or drawings and shall withstand the system prospective fault current let through. Cam operated rotary switches with adequate terminal adaptors up to 25A are acceptable but for all higher rating switch fuse units shall be heavy-duty type.

4.16.21.2 Fuses shall be HRC cartridge type conforming to IS: 13703 - 1993 with a breaking capacity corresponding to system fault level. Fuses shall be link type with visible indication. Screw type fuses are not acceptable for any ratings.

4.16.21.3 All disconnects shall consist of switch units quick-make, quick-break type with silver plated contacts. The switches shall preferably have double breaks. The switches shall preferably have sheet steel enclosure, which in turn is mounted on suitable angle iron frame work. In wet locations enclosures shall be IP56 rated. Disconnects shall have a minimum breaking capacity of 5KA at 415 Volts.

4.16.21.4 Switch contacts shall be designed with arc repelling features to extinguish the arc quickly to provide long contact life.

4.16.22 ISOLATORS

4.16.22.1 Isolators shall be fixed on wall, on self-supported galvanized angle iron frame work as required and mounted as near to the motor as possible. Where several motors are installed, isolators if required shall be provided at a central location on a common frame work with prior approval at site. The Isolator shall be provided in IP 65 enclosures from the Isolator manufacturer only.

4.16.22.2 Painting, earthing and labels shall be provided as generally indicating for MV Switchgear and as shown on drawings.

4.17 CONTACTORS

4.17.1 Contactors shall comply with IS/IEC 60947-4-1 or EN 60947-4-1.

4.17.2 Contactors shall be electro-magnetically controlled, double air-break type. Contactors shall be four-pole, triple-pole, double-pole or single-pole as shown on the Drawings.
4.17.3 The mechanical endurance of the contactors shall not be less than 3 million no. load operating cycles.

4.17.4 Contactors shall be silver-faced.

4.17.5 The contactor should be modular in design with minimum inventory requirements and built-in mechanically interlocked wherever required. They should be suitable for the addition of auxiliary contacts and other electrical auxiliaries without any compromise on the performance or the operation of the contactors. The contactors from 4kW to 400kW shall be associated with the same 10 auxiliary contact block range or as per BOQ.

4.17.6 The control contactors for power factor correction equipment shall be of quick break and have a high arc resistance during switching operation. Contactors shall be of utilization category AC-6b for this application and specifically designed for switching directly connected capacitor banks.

4.17.7 The contactors for other applications shall have an un-interrupted rated duty and utilization category of at least AC3 at 415V and 50 Hz. The contacts should be of fast opening and fast closing type.

4.17.8 The making and breaking capacity values of the contactors should be as follows (as per IEC 60947-4)

a) For AC3 duty:
   - Making capacity equal to or more than 10 Ie
   - Braking Capacity equal to or more than 8 Ie

b) For AC4 duty:
   - Making capacity equal to or more than 12 Ie
   - Braking Capacity equal to or more than 10 Ie

4.17.9 The contactors should be capable of frequent switching and should operate without derating at 60°C for AC3 applications. They should be climate proof. The coil of the contactor should have class H insulation to support frequent switching. Class F insulation is also acceptable with the consent of the site Engineer.
4.17.10 The rated voltage of the contactor and the rated insulation voltage shall be 690V. The rated Impulse voltage of the contactor should be at least 8 KV.

4.17.11 Wherever DC control is required, the contactor should have wide range (0.7 to 1.25 \( U_c \)) DC coil with built in interference suppression as required.

4.17.12 The control and power terminals should be at separate layers preferably with colour coding (black for power and white for control). All contactors power connection shall be finger safe (IP 2X)

4.17.13 They should be capable of being integrated into automated system (PLCs) without any interposing components in the minimum operating conditions.

4.17.14 Contactors used with surge suppressor.

4.18 AUXILIARY SWITCHES AND CONTACTS

4.18.1 Auxiliary switches provided for indication, protection, metering, control, interlocking supervisory purposes shall be readily accessible at the front of the Electrical Panels. Adequate secondary contacts shall be included to enable the auxiliary switch to be wired to the fixed portion of the equipment.

4.18.2 For each control compartment, spare auxiliary contacts with a minimum of two NO and two NC contacts shall be provided and wired to suitably identify spare terminals.

4.18.3 Auxiliary contacts for all applications shall be rated at 240 V AC or 110 V DC with contact rating of at least 6 A AC or DC and operating life of at least one million on-on-load operations at 0.4 power factor inductive load.

4.19 POWER FACTOR CORRECTION EQUIPMENT

4.19.1 Power factor correction equipment and its installation shall comply with IEC 60831/IS 13340. Each power factor correction equipment shall consist of capacitors, switchgears, cables, cable gland, micro-processor based intelligent power factor control relays, CTs and contactors etc.

4.19.2 Capacitor banks shall consist capacitors of variable capacity i.e. 5 kVAR, 10 kVAR, 15 kVAR, 25 kVAR or fixed type as per BOQ. Capacitor bank with total capacity as shown on the drawings or BOQ shall be provided and connected to the designated switchgear in the LV main switchboard to improve the overall power factor to not less than 0.98 lagging. The system shall ensure that a leading PF does not occur.
4.19.3 The Contractor shall ensure that the power factor correction equipment shall not cause harmonic resonance in the LV electrical network.

4.19.4 The capacitor bank shall be of floor standing type built up from static primary capacitor units. The capacitor shall be mounted on the lower and de-tuned inductor on the upper part of the panel so that the temperature of capacitor environment is lower than the average temperature in the panel. In case, ventilating fan is required to maintain the desired temperature in the capacitor panel, the same shall switch on and off depending upon the set temperature and only when at least one capacitor is in service. The thermostat temperature shall be provided with step adjustment features if considered necessary as per design.

4.19.5 Each three phase capacitor unit shall be MPP self healing type with total losses not greater than 0.5 W/kvar. The primary capacitor unit shall comply with the requirement of IEC 60871-1 or BS 1650.

4.19.6 The capacitor unit shall be usable for indoor application with permissible overloads as below:

- Voltage overloads shall be 10% for continuous operation and 15% for 30 minutes in a 24 hours cycle.
- Current overloads shall be 15% for continuous operations and 50% for six hours in a 24 hours cycle.
- Over load of 35% continuously and 45% for six hours in a 24 hours cycle.

4.19.7 All capacitors involved shall be disconnected instantaneously, and reconnected step by step at intervals after the supply is restored.

4.19.8 Each capacitor bank shall be fitted with an automatic discharge assembly which shall discharge the entire capacitor bank from the peak alternating voltage to a voltage level not exceeding 50 V measured at the capacitor bank terminals one minute after disconnection from the supply.

4.19.9 The automatic power factor control relay (APFCR) shall be a microprocessor based static unit with output relays equal to the no. of capacitor steps. Minimum no. of relays shall be six/eight (6/8) or as specified in BOQ. The switching ON and OFF of the capacitor unit shall be done in a sequence so that even wear takes place on the contactors and relays over one week of operation.
4.19.10 The APFC relay shall be intelligent to ensure balancing of duty cycle of the capacitors.

4.19.11 APFC relays shall provide all necessary function of relay, controls, protection, annunciation and condition monitoring. A no-volt and single phasing protection shall be provided.

4.19.12 Local/off/auto selector switch and visual indication of energized capacitor with red lamps, etc shall be provided.

4.19.13 Type tests for the equipment shall include operating voltage, temperature cycling and repeated switching as per IEC 60831-2

4.19.14 Overcurrent shall be 1.8 x \(I_n\).

4.19.15 Peak inrush current withstand capacity shall be 250 x \(I_n\).

4.20 DETUNED FILTER

4.20.1 Detuned harmonic filter reactors shall be used as per BOQ along with power capacitors to mitigate harmonics amplification and to avoid electrical resonance in LV electrical networks.

4.20.2 The reactors shall be made of high grade copper windings, having a three phase, iron core construction suitable for indoor use. The reactors are air cooled and the layout shall be in accordance with IEC 60289 / IS 5553.

4.20.3 The permitted tolerance of inductance is ± 3% of rated inductance value.

4.20.4 Reactor tuning factor shall be 7 % (189 Hz) and the current rating of the reactor shall include the effects of harmonics and other possible over-currents.

4.20.5 The limit of linearity of inductance of the filter reactor is: \(1.8*I_n\) with \(L=0.95*L_N\).

4.20.6 All reactors shall be fitted with a temperature sensitive micro-switch in the centre coil (normally open) for connection to trip circuits in case of high operating temperatures.

4.21 AUTOMATIC LOAD TRANSFER SWITCHES

4.21.1 Automatic load transfer switches shall be composed of paired ACBs or MCCBs. ACBs and MCCBs used in Automatic Load Transfer switches shall be used as specified in this specification.
4.21.2 Paired ACBs or MCCBs (as specified above) shall be provided with motorized mechanisms for "ON/OFF" operation.

4.21.3 Each automatic load transfer switch shall be equipped with, but not be limited to, the following:

a) Illuminated indicator for "Normal Supply On" and "Standby Supply On" to be provided at the front cover of the compartment housing the changeover switches.

b) Transfer mechanism to facilitate automatic/ manual changeover from the normal source to the standby source.

c) Automatic/manual change-over selector switch shall be provided. It shall be possible to manually operate the circuit breakers in the event of absence of control voltage.

d) ALTS should have electrical interlocking along with mechanical interlocking through base plate to ensure that two MCCBs shall not be ON simultaneously.

e) Interlocking facility to insure that normal breaker tripped on fault will not cause standby breaker to close or vice versa, unless the breaker are reset manually.

f) A test switches to simulate mains power failure and indicate the changeover sequence to allow on load testing.

g) Auxiliary relay and contacts to facilitate main power source failure for routine testing of the automatic change-over operation.

h) 2 nos. each NO and NC volt free dry contacts shall be provided for each change-over circuit breaker unit.

i) The change-over function shall work without auxiliary power supply with fail safe operation.

j) All indications for all operations viz. ON, OFF, TRIP.

4.21.4 The changeover system between the normal and standby sources shall be as follows:
a) 3 phase sensing circuits with adjustable time delay facility in the range of 0 to 15 seconds shall be provided to monitor the voltage condition of the normal and standby source.

b) Failure of one or more phases of normal main supply or are reduction of voltage to a value of 90% to 70% (adjustable) of nominal value shall initiate the timing device. If the failure persist at the expiry of this present time delay, the changeover section will be effected provided that the voltage of the standby source reaches 90% of the nominal value.

c) Upon restoration of the normal power supply, which has been determined stable after a time delay, the changeover switch shall automatically be restored to the normal supply. It shall also be able to switch the load back to the normal supply under manual control.

4.22 DISTRIBUTION BOARDS

4.22.1 Distribution boards for miniature circuit breakers shall be of sheet steel construction with a minimum thickness of 1.6 mm, suitably braced to form a rigid structure. Exterior corners and edges shall be rounded to give a smooth overall appearance. Hinged swing doors shall be fitted with gaskets and shall be easily removable to simplify installation. DBs shall be provided with suitable size of surge protection. DBs shall be fixed with bottom at 1200 mm from finished floors. DBs shall be fixed properly, fitted square with the frame and with holes correctly positioned. DBs shall be fastened to the walls with suitable grouted studs of not less than 12-mm diameter.

4.22.2 IP ratings for distribution boards shall be IP 54 (used for Lights & small power).

4.22.3 All boards shall be meggered phase to phase and to neutral using 1000/500V megger with all switches in closed position. The megger value should not be less than 2.5 M Ohm between phases and 1.5 M Ohm between phase and neutral. Testing of minimum 10 kA short circuit current otherwise specified in BOQ required.

4.22.4 Each distribution board shall be arranged for top and bottom cable entry and shall be provided with ample cable termination plates and chambers to enable cables to be neatly glanded with tails grouped and terminated on to appropriate internal terminations.
4.22.5 Distribution boards shall be wall mounted and shall, where specified, incorporate doublepole or triple pole all insulated switches as appropriate, which shall be front of panel operated with an "ON/OFF" indicator and capable of being padlocked in the "OFF" position. Distribution boards shall incorporate combinations of single pole, double pole, triple pole and four pole miniature circuit-breakers (MCBs/MCCBs) as specified in drawings.

4.22.6 Each bank of MCB's shall be clearly identified with its appropriate phase colours code, and the mounting framework for the banks of MCB's shall be easily removable to simplify installation. Adequate phase barriers and shields shall be fitted to ensure that after installation and wiring, all bare terminals and wires are covered to prevent accidental contact with live conductors during the normal procedure of resetting MCB's.

4.22.7 Each distribution board shall be supplied complete with as built drawing /chart, preferably mounted within the front door. This chart shall be permanently and legibly filled in as circuits are completed, including the circuit description, the MCB rating and the identification of upstream source of the distribution board.

4.22.8 Each distribution board shall be clearly labeled indicating its service and all 3-phase distribution boards shall be fitted with standard labels as per relevant IS.

4.22.9 In the top and bottom, of each distribution board a 32 mm clear hole in addition to other requirements shall be provided. These spare holes shall be fitted with 32 mm stopping plugs and locknuts.

4.22.10 Spare MCB's shall be provided on the basis of one per four ways or part thereof for every distribution board ensuring that spares are provided in numbers and rating proportional to the numbers and ratings in the installation or as per BOQ.

4.22.11 Distribution boards shall comply with best industry practice.

4.22.12 All busbars shall be of hard drawn tinned copper having ratings as specified complying to relevant clauses given under clause 4.1 as relevant, and shall be electro-tinned. Neutral busbars shall be of the same cross-sectional area as the phase busbars and shall have adequate number of terminals for all outgoing circuits including spare ways.
4.22.13 The configuration of the busbars, busbar supports and busbar mounting arrangement) shall be rated at 415 V. It shall be certified to a short time withstanding current which is not less than 10 kA for 1 sec at voltage of 415 V as per design.

4.22.14 Multi-terminal connectors shall be provided within the distribution board for connection of protective conductors of all outgoing circuits including spare ways.

4.22.15 Size of the DB shall be optimized precisely by proper utilization of points on MCB. Proper utilization of points reduces the space acquired by DB as well. If the numbers of points are few on MCB then it shall be avoided by adjusting the same on other MCB having sufficient free points. MCB rating shall be as per the number of points to be included. Circuit for areas other than critical rooms e.g. SER, TER, SCR etc. shall be clubbed according to the rating of MCB. While designing DBs, efforts shall be made in such a way that each circuit shall have not more than 800 Watts connected load or more than 10 points, which ever is less. However, In case of LED Points where load per point may be less, number of points may be suitably increased.

5. **FINISHES**

5.1 Sheet Steel materials used in the construction of these units should have undergone a rigorous rust proofing process comprising of alkaline degreasing, descaling in dilute sulphuric acid and a recognized phosphating process. The steel work shall then receive two dip-coats of oxide filler/primer before final painting. Castings shall be scrupulously cleaned and fettled before receiving a similar oxide primer coat. The manufacturer is required to have 7 tank treatment facility for this.

5.2 All exposed metal surfaces, both internal and external, shall be thoroughly cleaned of all dust, oil, grease, scale, rust or any other contaminants and shall be epoxy powder coated immediately at the manufacturer’s factory. In case of any doubt, the painting procedure, paint samples and process shall be approved prior to commencement of painting.

5.3 The epoxy powder coating shall be not less than 50 micron thick and with colour in accordance with BS 381C or BS 4800 as approved by Engineer.
5.4 Every care shall be taken to protect the surface of the panel from damages during transportation and installation. In case, there is any damage, the same shall be made good by the method as approved by the site engineer which may also include change of the panel.

6. NAMEPLATES AND LABELS

6.1 NAMEPLATES

6.1.1 Each Electrical Panel shall have permanently attached to it in a conspicuous position labels upon which shall be engraved or stamped with the manufacturer's name, type and serial number, date of manufacture, designation of each Electrical Panel, details of the loading and duty at which the item of the Electrical Panel has been designed to operate. Such labels shall be of non-hygroscopic material.

6.2 LABELS

1. Labels shall be provided for every panel to describe the duty of or otherwise identify every instrument, relay or item of control equipment mounted externally and internally.

2. The designation on these labels shall be clear and shall, where applicable, incorporate the device number along with concise descriptive wording in English.

3. Externally fitted panel labels shall be of perspex or other approved transparent plastic with letters and numbers rear engraved and filled with black.

4. Internally fitted panel labels shall be finished in white with engraved letters and numbers filled with black, laminated material such as Traffolyte or rear engraved and filled plastic may be used. Embossed materials and techniques will not be accepted or any latest technology which provides same result as mentioned above shall be applicable.

5. Labels shall be provided in conformity with the above requirements or by other approved means wherever necessary to designate panels or panel sections. To describe or identify circuits or circuit components, to provide warnings or reminders of dangerous or potentially dangerous circumstances and wherever called for elsewhere in this Specification.
6. Safety labels "Danger 415 V in both English and Hindi shall be provided on both the front and rear of the Electrical Panels. The safety labels shall have graphic symbols - exactly as per IS standards. The design of all such signs shall be submitted for approval. Similar labels shall be provided for other panels at different voltages.

7. Labels shall not be less than 45 mm high. Lettering shall be of not less than 10 mm high. All labels shall be securely fixed to the panels by bolts and nuts.

8. Details of proposed inscription, including the English and Hindi wordings, and samples of the labels shall be submitted for approval before any labels are manufactured.

9. Circuit labels, one on the front of the panel and one on the rear of the panel suitably engraved.

7. FOUNDATION (IF REQUIRED) AND INSTALLATION

7.1 The location of each foundation shall be correctly set out in accordance with the approved foundation layout drawing. Base channels shall be grouted, leveled in cement concrete pad for switchgear and other cubicle panels, etc. with reference to a bench mark in the building. Pedestal type panels and superstructures shall be erected by grouting foundation bolts into the foundation in cured holes left in foundation blocks. For concreting on existing floors, a proper bonding surface shall be made by chipping the floor. The final finish to the surface of the floor shall be given after all equipment has been installed. If floor is broken for installation of equipment, it shall be restored to original finish after completion of installation.


7.3 Suitable grooves or niches shall be provided in the foundation block at the time of casting to enable embodiment of earth strips without calling for chipping of the blocks. Subsequently conduits of appropriate size shall be embedded in the foundation blocks for cabling, in the first instance, wherever required.
7.4 All foundations shall be cast in the presence of the Employer's representatives. All foundation and grouted bolts shall be cured for a minimum period of 48 hrs.

7.5 Foundations shall be prepared as per manufacturers drawing, shall be leveled, checked for accuracy and the switchboards installed. Busbar connections shall be checked with a feeler gauge after installation. Tightness of accessible bolted bus joints shall be checked using calibrated torque wrench. Sealing of cable and boxes to prevent moisture entry shall be checked. Switchboard earth bars shall be connected to the earth grid.

7.6 Fabrication drawings of all panels shall be approved by the Employer's representative before fabrication

7.6.1 The Electrical Panels shall be installed in the locations as approved by the Engineer. Electrical Panels shall be secured, plumbed and levelled and in true alignment with related adjoining work,

7.6.2 The rigid galvanized U-channels to ensure effective fixing of the Electrical Panels on the uneven floor shall be provided.

7.6.3 Anchor bolts and anchorage items shall be provided where required and field checked to ensure proper alignment and location. Templates, layout drawings, and supervision on Site shall be provided to ensure correct placing of anchorage items in concrete.

7.6.4 Supporting members, fastenings, framing hangers, bracing, brackets, straps, bolts, angles, shall be installed as required to set and rigidly connect the work.

7.6.5 Temporary bracing, gauge, or other devices shall be provided as required to accomplish erection and to provide safety and stability until the ELECTRICAL PANELS is in its final and approved position.

7.6.6 Erection tolerance requirements shall be controlled so as not to impair the strength, safety, serviceability, or appearance as Approved.

7.6.7 After installations are complete, all places where the shop applied coating is abraided, all bare steel, including bolts, nuts, washers, and welds shall be thoroughly cleaned. Each item shall be painted with the same paint as used for shop coating in the corresponding location.
8. **OTHER PROVISIONS**

8.1 The Electrical Panels shall be provided with all necessary cable lugs etc., fixed in positions on mounting plates and straps, to suit the types and directions of entry of the cables as shown on the Drawings or as specified.

8.2 Cable conductors for all circuits within the Electrical Panels shall be arranged in a tidy manner and mechanically secured at regular intervals such that any movement occurring to the conductors, either under normal operation conditions (e.g. thermal expansion, vibration, etc.) or due to short circuit in any one of the circuits, shall not cause any damage or short circuit to any healthy bare live parts in the Electrical Panels.

8.3 Each Electrical Panels shall be supplied complete with all operating handles jigs, etc. required for the normal charging, closing, opening, racking in and out operations of all circuit breakers of the Electrical Panels and shall be properly fixed in a neat manner on a board with brass hooks inside the switch room/plant room where the Electrical Panels is installed.

8.4 Each Electrical Panels shall be provided with two rubber mats of ribbed surface, complying to BS 921 or equivalent Indian standards, laid in front of and at the rear of the switch board. The rubber mats shall be continuous sheets of minimum thickness of 10 mm, each of same length as the switchboard and minimum width of not less than 1000 mm or the width of the space between the fronts or back of the switchboard to the adjacent wall.

8.5 Hydraulic operated handling truck suitable for handling all sizes of air circuit breakers for the Electrical Panels shall be provided as indicated in the BOQ.

9. **SPECIAL CONDITION:**

9.1 The Switchboard shall be complete with all components and accessories, which are necessary or usual for their efficient performance and satisfactory maintenance under the various operating and atmospheric conditions. Such parts shall be deemed to be included within the scope of supply whether specifically included or not in the specifications or in the tender schedules. The contractor shall not be eligible for any extra charges for such accessories etc.
10. RELIABILITY, MAINTENANCE, SPARES AND LIFE

10.1 The electrical panel shall be designed for reliable and safe working. It shall be designed for a maintenance free secure service life of switchboards, sub-assemblies and components for at least 30 years.

10.2 The manufacturer shall submit the list of spares which are required to be replaced as a must change item along with interval.

11. MATERIAL AND MANUFACTURING:

11.1 All similar items of the Electrical Panels and their component interchangeable. Spare parts shall be manufactured originals and shall fit all similar items of the Electrical Panels. Where machining may be needed before fitting renewable parts, the machining fits and the associated tolerances shall be shown on the drawings accompanying the instruction manuals.

11.2 All parts which are susceptible to wear or contaminated by dust shall enclosed in dust-proof housings.

11.3 The style and finish of the workmanship shall be consistent throughout the Works. Unless otherwise specified, Engineer shall decide the final colours for all paint work and other finishes to be applied to the Electrical Panels.

12. TESTING

12.1 The firm shall submit valid type test not more than 5 years old of the equipment conducted at accredited/authorised/reputed/nominated by DMRC laboratory. The type test shall be as per the governing specification.

12.2 DMRC will carry out Routine and factory acceptance tests as prescribed in the specification with following additional test

12.3 In case of Distribution Boards type test is not essential, however test of short circuit capacity must be submitted.

12.4 The manufacturer shall not change the Bill of Material used in the manufacturing of samples used for Type testing. In case the bill of material is changed then Engineer-in-charge may ask for the repetition of those type test which he considers relevant.
13. **TRAINING**

The contractor shall provide the following details:

- Every marshalling box and PLC compartment of the Electrical Panels shall be provided with a wiring diagram suitably treated to prevent deterioration from dirt or age. The diagrams shall be drawn as if viewed from the point of access to the enclosure, and shall be securely fastened to the inside of the access door of that compartment.
- Bound booklet consisting of the details of the equipment
- Operating manual
- Warranty/DLP
- Purchase specification of maintenance spares
- List of staff trained
- Details of service centre

14. **INDICATIVE LIST OF ITEMS TO BE INCLUDED IN FAT PLAN FOR ELECTRICAL PANELS**

(This list is an indicative List for the inspectors to be conducted during FAT of Power Panels. However, the detailed FAT plan needs to be developed for the specific Panel based on approved GADs and Contract Specifications and as per the tests defined in Clause – 11 of IEC 61439-1 (Routine Verification)/as per the relevant Standards as applicable.)

<table>
<thead>
<tr>
<th>S. No</th>
<th>Description</th>
<th>Type of Check</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>All items/components (switchgears, cables, wires, meters, relays etc.) used are as per the Approved Makes, Vendors and ratings.</td>
<td>Visual Check &amp; Certification before Call letter</td>
<td>Obtain confirmation from Panel Manufacturer for each Panel duly verified by the Main Contractor.</td>
</tr>
<tr>
<td>B</td>
<td>Obtain the Factory Test reports of Incoming/Raw Material</td>
<td>Verify</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Obtain the Internal Test reports/Manufacturer Test Report of Internal Quality Tests done on Panel offered for Inspection as per ISO 9001.</td>
<td>Review</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>Confirmation from Panel Manufacturer that Panel has been manufactured strictly as per approved GADs.</td>
<td>For record</td>
<td></td>
</tr>
</tbody>
</table>
**E** List of tools required for Inspection and copy of their Calibration Certificates from independent Labs/Authorities.  

**Note:** All the above are to be made part of this FAT report  

Panel must be of Modular construction as per PS. The Inspection team shall carry the approved GAD, approved Bill of materials, Contract Specification, relevant standards, copy of Approvals and approved FAT Plan from the office before proceeding for the FAT inspection to the factory promises.

### Physical/Dimensional Checks (as per approved GADs)

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Check the Length, Breadth and Height of the complete Panel.</td>
<td>Measurement</td>
</tr>
<tr>
<td>2</td>
<td>Check dimensions of each Sections and Cubicles.</td>
<td>Measurement</td>
</tr>
<tr>
<td>3</td>
<td>Check Number and dimensions of Space for future additions as per Specifications &amp; Bod.</td>
<td>Measurement</td>
</tr>
<tr>
<td>4</td>
<td>Check dimensions of the Doors/back Panels, etc. (Note: Back Panel sections should not be too bulky to handle by one individual. May be taken care during GAD and checked during FAT).</td>
<td>Measurement</td>
</tr>
<tr>
<td>5</td>
<td>Check height/dimensions of all front Mounting Accessories (such as indicators. Measuring instruments, knobs, etc.)</td>
<td>Measurement</td>
</tr>
<tr>
<td>5.1</td>
<td>EPB (Emergency Push Button) at 1300 mm where applicable.</td>
<td>Measurement</td>
</tr>
<tr>
<td>5.2</td>
<td>All Relays &amp; indicating instruments between 300 to 1800 mm</td>
<td>Measurement</td>
</tr>
<tr>
<td>5.3</td>
<td>Max. Operating Height should not be more than 1800 mm</td>
<td>Measurement</td>
</tr>
<tr>
<td>5.4</td>
<td>Blank Space between the Floor of Switch board and bottom unit (Min. 200 mm or as per PS)</td>
<td>Measurement</td>
</tr>
<tr>
<td>6</td>
<td>Check size/height of Base Frame (may be min. 100 mm. or as per PS).</td>
<td>Measurement</td>
</tr>
<tr>
<td>6.1</td>
<td>The make of the manufacturer of bought out items is clearly displayed on the items where possible.</td>
<td>Measurement</td>
</tr>
<tr>
<td>Specifications</td>
<td>Details</td>
<td></td>
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<tr>
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</tr>
<tr>
<td>6.2</td>
<td>Check that all materials used in the manufacturing of the electrical panel are fire retardant, low smoke &amp; zero halogen.</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Verify Material and Thickness of Load bearing and Non-Load Bearing Member of Panel Enclosure: Certificate/Measurement</td>
<td></td>
</tr>
<tr>
<td>7.1</td>
<td>Panel Structure</td>
<td></td>
</tr>
<tr>
<td>7.2</td>
<td>Bus bar Section</td>
<td></td>
</tr>
<tr>
<td>7.3</td>
<td>Cable Alley</td>
<td></td>
</tr>
<tr>
<td>7.4</td>
<td>Switchgear/feeder sections</td>
<td></td>
</tr>
<tr>
<td>7.5</td>
<td>Doors</td>
<td></td>
</tr>
<tr>
<td>7.6</td>
<td>Gland Plate</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Check Quality of Sheet Metal Painting and Color used. It should be as per the Specification/Approved drawings. Visual/Measurement</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Check for the Quality of Sheet Metal Workmanship. There shall not be any sharp edges, burrs, dents, etc. on the panel. Visual</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Check Number and Quality of the Door Hinges. Ensure that doors is strongly supported and should not have any unwanted deflection/shakiness. When door is closed, it is latched at adequate places with adequate crushing of gasket on metal frame. Visual</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Check Quality of the Door handles, Locks etc. Visual</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Check interlocking of Doors, Switchgears, incomers, outgoings and couplers as per the design logic and drawing Verify and Visual Check</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Check and compare the sealing arrangements all around the panel to ensure intended ingress Protection is achieved and compare with the Type test reports. Verify and Visual Check</td>
<td></td>
</tr>
<tr>
<td>13.1</td>
<td>Simple Paper insertion test for IP54. Insert a paper in the gasket and metal frame, close the door and pull the paper. It should not pull out.</td>
<td></td>
</tr>
<tr>
<td>13.2</td>
<td>Check Quality of Gaskets/sealing rubber, etc. for the Doors. The arrangement shall be such that it is replaceable during maintenance.</td>
<td></td>
</tr>
<tr>
<td>13.3</td>
<td>Check Quality of Gaskets/sealing rubber, etc., around the cut-outs for Measuring &amp;</td>
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<tr>
<td><strong>SPECIFICATIONS FOR LOW VOLTAGE ELECTRICAL PANELS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.4</td>
<td>Proper sealing of knock-outs/cut-outs/gaps for control cabling bus bar, etc., between different feeders/sections within the Panels.</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Check the Lifting arrangements (Hooks etc.) are provided.</td>
<td>Visual</td>
</tr>
<tr>
<td>14.1</td>
<td>Adequate Number of Lifting points/Hooks</td>
<td></td>
</tr>
<tr>
<td>14.2</td>
<td>Adequate Strength of Lifting Points/Hooks</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Check proper identification markings, numbering labeling, tags have been provided.</td>
<td>Visual</td>
</tr>
<tr>
<td>15.1</td>
<td>For the Panel</td>
<td></td>
</tr>
<tr>
<td>15.2</td>
<td>For each incoming and Outgoing Feeders</td>
<td></td>
</tr>
<tr>
<td>15.3</td>
<td>For Measuring and indicating instruments</td>
<td></td>
</tr>
<tr>
<td>15.4</td>
<td>Danger Plates/Signages</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Check for rust, any sign of initiation of corrosion, oxidation, etc., on the support members/nut bolts/bus bars/terminal points, etc. Initiation is an indication of use of defective material.</td>
<td>Visual</td>
</tr>
<tr>
<td><strong>CABLE ALLEYS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Check for Cable Entry Arrangement (top entry/Bottom entry) as per GADs.</td>
<td>Visual</td>
</tr>
<tr>
<td>18</td>
<td>Check for Maintenance/Working space in Cable Alleys, etc.</td>
<td>Visual/Measurement</td>
</tr>
<tr>
<td>19</td>
<td>Check for adequate Space for accommodating Cable Loops, etc.</td>
<td>Visual/Measurement</td>
</tr>
<tr>
<td>20</td>
<td>Provision for securing/clamping cables in Cable alley for proper dressing of cables.</td>
<td>Visual</td>
</tr>
<tr>
<td>21</td>
<td>Check for Knock outs for Glanding of different smaller sizes of Cables in Marshalling box (to be used for BMS cables).</td>
<td>Visual</td>
</tr>
<tr>
<td>22</td>
<td>Thickness of Glanding Plates should be minimum 5.0 mm &amp; strong enough to take the simultaneous load/forces of cables ganged on to it. The Cables shall be well supported and not exert any force on the glanding plate</td>
<td>Measurement</td>
</tr>
<tr>
<td>23</td>
<td>Proper dressing/harnessing of internal control cables and wiring within the Panel.</td>
<td>Visual</td>
</tr>
<tr>
<td>No.</td>
<td>Description</td>
<td>Method</td>
</tr>
<tr>
<td>-----</td>
<td>--------------------------------------------------------------------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>24</td>
<td>Provision of identification tags/ferrules on the internal control cables and wiring within the Panel.</td>
<td>Visual</td>
</tr>
<tr>
<td>25</td>
<td>Check that Material of Earth Bus provided in Panel is as per PS.</td>
<td>Visual</td>
</tr>
<tr>
<td>26</td>
<td>Check the Size of continuous Earth Bus provided in the Panel as per IEC.</td>
<td>Measurement</td>
</tr>
<tr>
<td>27</td>
<td>Check if the Earth Bus is properly supported and connected to the outside terminals.</td>
<td>Visual</td>
</tr>
<tr>
<td>28</td>
<td>Check that proper earthing has been provided through out the Panel and all non-current carrying parts are properly earthed.</td>
<td>Visual</td>
</tr>
<tr>
<td>29</td>
<td>All the Gland plates have been earthed properly.</td>
<td>Visual</td>
</tr>
<tr>
<td>30</td>
<td>All Doors and openable sections must be earthed through flexible wires/jumpers (dual if required as per Specs)</td>
<td>Visual</td>
</tr>
<tr>
<td>31</td>
<td>Cases of all instruments and apparatus shall be earthed by a conductor of suitable size (but not less than 2.5 sq. mm)</td>
<td>Visual</td>
</tr>
<tr>
<td>32</td>
<td>Check that the Frame of Switchgear is earthed, when racked in to the Cubicie.</td>
<td>Visual</td>
</tr>
<tr>
<td>33</td>
<td>Check Bus bar dimensions as per Approved GAD (Only rectangular Busbar is permitted)</td>
<td>Measurement</td>
</tr>
<tr>
<td>34</td>
<td>Neutral bus shall be of full size</td>
<td>Measurement</td>
</tr>
<tr>
<td>35</td>
<td>Material of the busbar shall be as per approved specification</td>
<td>Visual/Certificate</td>
</tr>
<tr>
<td>36</td>
<td>Quality (Conductivity) of the Material of the busbar (Copper/Almunium) shall be as per approved specification</td>
<td>Certificate/Measurement</td>
</tr>
<tr>
<td>37</td>
<td>Check the quality of conducting material used for Bus bar and the Quality of Tinning on the Copper Bus bar.</td>
<td>Certificate/Measurement/Visual</td>
</tr>
<tr>
<td>37.1</td>
<td>Factory tinned Bus bars to be used. Obtain the Factory Test certificate and attach the report.</td>
<td></td>
</tr>
<tr>
<td>37.2</td>
<td>Tinning of Bus Bar edges after cutting/sizing also to be checked.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>Verification Method</td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------------------------------------------------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>38</td>
<td>Check that the Bending of Bus Bars should be on Rollers of adequate diameter to avoid undue bending stresses</td>
<td>Confirmation &amp; Cross-Check</td>
</tr>
<tr>
<td>39</td>
<td>Check the fixing/mounting arrangements of Main bus bar to ensure that there are no undue stresses due to misalignment of fixing arrangements. (Focus on the location where Panel is divided into different sections to ensure that the Bus Bar sections match properly).</td>
<td>Visual</td>
</tr>
<tr>
<td>39.1</td>
<td>Check the proven design of bus bar connections of OEM &amp; its compliance in the manufactured product</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>Bus bar must be color coded for Phase identification</td>
<td>Visual</td>
</tr>
<tr>
<td></td>
<td>Note: In case, sleeve is to be provided over the Bus bar for color coding as per PS, then the material of the sleeve must be as per the relevant clauses of PS.</td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>Check the distance between Bus bar supports and compare with Type tested assemblies/Approved GADs.</td>
<td>Measurement</td>
</tr>
<tr>
<td>42</td>
<td>Bus Bar Supports should be of approved material.</td>
<td>Confirmation</td>
</tr>
<tr>
<td>43</td>
<td>Measure minimum Electrical clearances between the bus bars for different Phases, Neutral and Earth. (Main Bus as well as Tap off Bus bars) (Minimum clearance will be between Live parts and Earth)</td>
<td>Measurement</td>
</tr>
<tr>
<td>44</td>
<td>Check the interconnecting / Tap-off links between Main Bus and bus sections for proper tightness etc. (connection with the double split cast brass clamp is permitted)</td>
<td>Measurement</td>
</tr>
<tr>
<td>45</td>
<td>Interconnection between Bus Bar and Switchgear - must be high conductivity Copper Bar and must be insulated and Colour coded</td>
<td>Visual</td>
</tr>
<tr>
<td>46</td>
<td>Proper compartmentation at locations where connecting Links enter the Switchgear section, bus bar sections and Cable Alley must be ensured.</td>
<td>Visual</td>
</tr>
</tbody>
</table>
### SPECIFICATIONS FOR LOW VOLTAGE ELECTRICAL PANELS

<p>| | | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>(Form - 4 b, Type - 5 to be ensured, for Underground section) For elevated, separate compartments for incoming and Outgoing cable terminations, to be ensured.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>47</strong></td>
<td>Proper Shrouding of Bus bar joints / tap off points to be ensured. Material to be as per PS of the Contract.</td>
<td>Visual</td>
</tr>
<tr>
<td><strong>48</strong></td>
<td>Proper clearances and segregation must be maintained between Terminals / Tap - offs of different feeders from Main Bus Bars.</td>
<td>Measurement</td>
</tr>
</tbody>
</table>

#### INTERNAL WIRING, TERMINAL BLOCK

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<table>
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<tbody>
<tr>
<td><strong>49</strong></td>
<td>Check if the Wiring for all power and Control circuit is being provided as per Approved GAD / Specifications.</td>
<td>Verify Material Test Certificate</td>
</tr>
<tr>
<td></td>
<td>Note:- Internal Wiring in LT panels to be LSZH / FS as per Specs for Underground stations. For elevated stations, internal wiring may be ensured as per PS.</td>
<td></td>
</tr>
<tr>
<td><strong>50</strong></td>
<td>Termination arrangements</td>
<td></td>
</tr>
<tr>
<td><strong>50.1</strong></td>
<td>Terminal blocks should be of Non-Hygroscopic of Melamine</td>
<td>Verify Material</td>
</tr>
<tr>
<td><strong>50.2</strong></td>
<td>At terminal points - Plain and Spring Washers with electro - tinning to be used</td>
<td>Visual</td>
</tr>
<tr>
<td><strong>50.3</strong></td>
<td>Check the tightness of wiring termination</td>
<td>Visual</td>
</tr>
<tr>
<td><strong>50.4</strong></td>
<td>Terminal should have test probe facility</td>
<td>Visual</td>
</tr>
<tr>
<td><strong>50.5</strong></td>
<td>All Live parts of Terminal blocks must be fully shrouded</td>
<td>Visual</td>
</tr>
<tr>
<td><strong>50.6</strong></td>
<td>Spare Capacity of Terminals</td>
<td>Visual</td>
</tr>
<tr>
<td><strong>50.7</strong></td>
<td>Cable terminations should be with lugs of adequate size and with proper crimping</td>
<td>Visual</td>
</tr>
<tr>
<td><strong>50.8</strong></td>
<td>No more than two wire to be connected to the Terminal</td>
<td>Visual</td>
</tr>
<tr>
<td><strong>50.9</strong></td>
<td>Terminals should have identification Labels.</td>
<td>Visual</td>
</tr>
<tr>
<td><strong>50.11</strong></td>
<td>Check if the adequate size of the cables / wires is being used for the control wiring</td>
<td>Measurement</td>
</tr>
<tr>
<td><strong>50.12</strong></td>
<td>Check Provision of Protection for Control wiring as approved</td>
<td>Visual</td>
</tr>
<tr>
<td><strong>50.11</strong></td>
<td>All the internal wiring shall be properly dressed and randomly check the traceability of the wires from the wiring diagram</td>
<td>Visual</td>
</tr>
<tr>
<td>MARSHALLING BOX for BMS (if applicable)</td>
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<td>--------------------------------------</td>
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<tr>
<td>51.1 Marshalling Box / Separate chamber for the BMS connection is provided as per the Approved GAD</td>
<td>Visual</td>
<td></td>
</tr>
<tr>
<td>51.2 Check the BMS points have been provided as per the approved I/O schedule</td>
<td>Visual</td>
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<tr>
<td>51.3 Provision of Softlinks points for the control shall be checked</td>
<td>Visual</td>
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<tr>
<td>51.4 All the terminals for the BMS shall be properly secured and identification mark along with the voltage level shall be provided</td>
<td>Visual</td>
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<tr>
<td>51.5 Randomly check voltage level at the BMS points for any leakage voltage etc (at Potential free contacts)</td>
<td>Measurement</td>
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<tr>
<td>51.6 No power wiring / cable should pass through marshelling box</td>
<td>Visual</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>SWITCHGEARS, PROTECTIONS, INDICATIONS, ANNUNICATIONS AND MEASURING INSTRUMENTS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>52 Detailed Check list for these items of the Panel may be prepared based on the GADs / Contract Specifications</td>
<td>Factory Test Certificates and Test during FAT</td>
</tr>
<tr>
<td>53 Test Certificates / Calibration Certificates for Measuring instruments to be ensured</td>
<td>Factory Test Certificates</td>
</tr>
<tr>
<td>54 Check Surge Arresters (if applicable) have been provided</td>
<td>Visual &amp; Manufacturer's Test Reports</td>
</tr>
<tr>
<td>55 Separate CTs for Measurement and Protection of relevant Class and Burden as per PS to be ensured</td>
<td>Visual &amp; Manufacturer's Test Reports</td>
</tr>
<tr>
<td>56 Check Control Logics, Interlocks and Protections Schemes in detail as per the approved plan / arrangement.</td>
<td>Visual, Simulation, Primary &amp; Secondary Injection etc</td>
</tr>
<tr>
<td>57 Check the working of ALTS &amp; Controls provided for safe operation.</td>
<td>Visual, Simulation, Primary &amp; Secondary Injection etc</td>
</tr>
</tbody>
</table>

| MISCELLANEOUS |  |
### Specifications for Low Voltage Electrical Panels

<table>
<thead>
<tr>
<th></th>
<th>Check the lights, sockets, anti condensation heaters and air circulation means provided in the Panels as per GADs.</th>
<th>Visual</th>
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</thead>
<tbody>
<tr>
<td>59</td>
<td>All the Control and power wiring must per properly segregated.</td>
<td>Visual</td>
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<tr>
<td>60</td>
<td>Padlocks and interlock provision and Functions to be checked for the safety for each.</td>
<td>Visual</td>
</tr>
<tr>
<td>61</td>
<td>Check for extendability of the Panels (including Bus Bars) on either side.</td>
<td>Visual</td>
</tr>
<tr>
<td>62</td>
<td>Check provision of entry for Fire Trace Tube and internally with in the various cubicles and adequate sealing arrangements.</td>
<td>Visual</td>
</tr>
<tr>
<td>63</td>
<td>Ensure that there are No Joints in the cables used</td>
<td></td>
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<tr>
<td>64</td>
<td>The tests defined in Clause - 11 of IEC 61439 - 1 (Routine Verification)/as per the relevant Standards as applicable are also to be performed for which separate Test sheet may be prepared.</td>
<td></td>
</tr>
<tr>
<td>65</td>
<td>The make of the manufacturers of bought out items is clearly displayed on the items where possible.</td>
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<tr>
<td>66</td>
<td>Check that all materials used in the manufacturing of the electrical panel are fire retardant, low smoke &amp; zero halogen.</td>
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</tbody>
</table>

### APFC Panel

<table>
<thead>
<tr>
<th></th>
<th>Ensure that material/equipment of only one make is used in the entire Electrical Panel assembly.</th>
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</thead>
<tbody>
<tr>
<td>68</td>
<td>Check the make, rating and specification of capacitors used.</td>
<td></td>
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<td>69</td>
<td>Check the functioning of APFEC relay as defined in the operating manual of the relay.</td>
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<td>70</td>
<td>Check the installation of capacitor &amp; inductor as per the form &amp; specification.</td>
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<tr>
<td>71</td>
<td>Check the working of cooling fans only when temperature goes above set value and atleast one capacitor in service.</td>
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<tr>
<td>72</td>
<td>Check the sizing of the filter used to ascertain the cleaning frequency for continuous working of cooling fan.</td>
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<tr>
<td>S. No.</td>
<td>Description</td>
<td>Unit</td>
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<td>19</td>
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</table>
**Length marking:** *Length shall be marked with number at one meter intervals on the sheath.*

*Bidder to furnish the data*