SECTION- B2.7

LOW VOLTAGE SWITCHGEARS/SWITCH BOARDS

2.7.1 PREAMBLE

A. This section of specification defines the technical requirements for Low Voltage Switchgear & switch boards up to 1000V as specified in accordance with the requirements of the Contract Documents and codes.

B. Scope of work includes Design, Manufacture, Assembly, Inspection, Testing at Manufacturer's Works, Delivery to Site, Installation and Commissioning of the Low voltage Switchgear, complete as specified in the schedule of requirement meeting the intents of the Tender. This specification shall be used in conjunction with all drawings, Schedule of requirement and BOQ attached. Scope of work includes erection, testing and commissioning services with necessary termination cabling / bus work required for satisfactory operation of the whole system

C. Following terminology shall describe the LV switch boards.
   a. Feeder Panels
   b. MDB (Main distribution boards)
   c. CO panel (Changeover panel)
   d. SDB (Sub distribution boards),
   e. FDB (Final distribution boards)
   f. MCC (Motor control centre)
   g. Starter panels
   h. ATS (Automatic transfer switch)
   i. Meter boards
   j. And as mentioned on the single line diagram

D. LV distribution is supplied at 415V, 3 Phase, 4 Wire, 50 Hz. LV distributions from the switchboards will be via cabling or bus bar. These switchboards will be fitted with Air Circuit Breakers (ACB) and Molded Case Circuit Breakers (MCCB) type circuit breakers to serve but not limited to the following equipment/plant:
   1. Tenant Apartment
   2. Shell & Core Tenant areas in the podium
   3. Motor Control Centers (MCCs)
   4. Dedicated mechanical/hydraulic plant
   5. Elevator Motor Rooms
   6. Vertical & horizontal Busbars
   7. Local Distribution boards
   8. Fire Pumps
   9. Fire Suppression System
   10. Fire Alarm System
   11. Stair Pressurization
   12. Building Management System
   13. Dedicated Security/Telecommunication equipment

E. The Low Voltage distribution system shall commence after the substations located at level, within the building. Low Voltage shall comprise of sub distribution cables and rising bus bar. Low Voltage sub-distribution and rising bus bars shall be installed in vertical electrical risers within the building.

F. The transformers will serve associated LV switch rooms located in MEP plant rooms. The LV switch rooms will contain switchboards that supply power to normal, emergency and life safety loads. Each LV switch room will serve specific areas in order to provide a manageable size of switchgear.

G. Wherever indicated the LT isolators and enclosures will be fitted with electromechanical interlocks for interlocking purposes to prevent the parallel operation of systems.

H. All outgoing sub main from main Low Voltage switchboards will generally be carried out using multicore cables FR/FS PH120 or Bus-duct. Low Voltage sub-distribution will use vertical rising bus bar systems within the tower core. All the floors within the building are served from substation located at respective floor level.

I. The LV switchboards will be floor mounted, front operated, and fully compartmentalized cubical type, extendable on both sides and be fully Type tested/ASTA Certified (IP21 for indoor installations and IP54 for outdoor installations – where a rating lower than IP65 is proposed externally the panel shall be enclosed within an IP65 enclosure). Meters will be fitted within the LV switchboard to monitor the incoming supply as well as certain outgoing circuits common areas. An equipotential earthing system shall be provided to the site. Main earth bars shall be provided in all HV and LV electrical switch rooms as shown on the earthing schematics/ layout

drawings. Each main earth bar shall be provided with 2No connections for earthing. The LV panels shall be configured to suit a TN-S earthing with neutralizing links provided within each panel. Ensure all equipment and systems are to provide electro-magnetic compatibility within the systems and with any other systems installed in the same location.

J. The Contractor shall install systems strictly in line with manufacturers recommendations and shall ensure all works are in line with recommended EMC mitigation measures in IEC 61000-5 (Installation and mitigation guidelines).Where the busbar/ bus duct shall commence from the primary LV panels to End feed unit, the flexible connection detail for the same shall be defined properly.

K. Equipment meeting the requirements of IEC/ANSI or any other internationally recognized standard which ensure a quality equal to or better than as per the standards indicated below shall also be acceptable. When the equipment conforms to any other standards, salient points of difference between the standards adopted and those prescribed in this specification shall be clearly brought out in the tender and a copy of the applicable standards(s) in English language shall also be enclosed by the supplier with the tender.

L. An equipotential earthing system shall be provided to the site. Main earth bars shall be provided in all HV and LV electrical switch rooms as shown on the earthing schematics/ layout drawings. Each main earth bar shall be provided with 2No connections to the building vertical earthing grip cap by approved test links. The LV panels shall be configured to suit a TN-S earthing with neutralizing links provided within each panel.

M. Ensure all equipment and systems are to provide electromagnetic compatibility within the systems and with any other systems installed in the same location.

N. The Contractor shall install systems strictly in line with manufacturers recommendations and shall ensure all works are in line with recommended EMC mitigation measures in IEC 61000-5 (Installation and mitigation guidelines).

O. Tenant Low Voltage distribution shall be provided via rising mains to supply the on floor power requirements. Each Tenant will be provided with a dedicated electrical utility meter if applicable.

P. Where the busbar/ bus duct shall commence from the primary LV panels the flexible connection detail for the same shall be defined properly.

2.7.2 SUMMARY

A. The equipment shall comply with the technical specification and guaranteed technical particulars specified herein. Any deviations to the specification shall be indicated clearly clause by clause

B. The complete system shall comply to requirements.

C. Codes and Standards: The Low Voltage Switchgear shall be designed, manufactured and tested in accordance with the latest applicable sections of the IEC codes. IEC codes shall have precedence over IS code. Conflicts between referenced documents shall be identified to the **Lodha Representative** in writing for resolution.

IEC 60044	Instrument transformers.
IEC 60051	Direct acting indicating analogue electrical measuring instruments and their accessories.
IEC 60073	Basic and safety principles for man-machine interface, marking and identification - Coding principles for indicators and actuators
IEC 60189	PVC insulated cables for switchgear and control wiring.
IEC 60255	Electrical relays.
IEC 60258	Direct acting recording electrical measuring instruments and their accessories.
IEC 60269	Low-voltage fuses.
IEC 60417 DB	Graphical symbols for use on equipment.
IEC 61439	Low voltage switchgear and control gear assemblies.
IEC 60445	Basic and safety principles for man-machine interface marking and identification. Identification of equipment terminals and of termination's of certain designated conductors. Including general rules for an alphanumeric system.
IEC 62052	Class 0.5, 1 and 2 alternating current watt-hour meters.
IEC 60529	Degrees of protection provided by enclosures. (IP Code)
IEC 60617 DB	Graphical symbols for diagrams.

IEC 60715	Dimensions of low voltage switchgear and control gear. Standardised mounting on rails for mechanical support of electrical devices in switchgear and control gear installations.
IEC60947	Low Voltage switchgear and control gear
IEC TR 61641	Enclosed LV Switchgear and Control gear assemblies – guide for testing under conditions of arcing due to internal fault.
IEC 60831-1 & 2	Power Factor Correction Capacitors
BSEN61439-2:2011	Low Voltage Switchboard
IEC 60831	Capacitor switching contactors
IEC 60289	Detuned reactors

IS 5082	Material for data for aluminium bus bars
IS 13703	Low voltage fuses.
IS 2705	Current transformers.
IS 3156	Voltage transformers.
IS 1248	Electrical indicating instruments.
IS 13010	AC Watthour Meters, Class 0.5, 1 and 2
IS 3231	Electrical relays for power system protection.
IS 13947 : Part 5 : Sec 2	Part 5 : Control Circuit Devices and Switching Elements - Section 2 : Proximity Switches
IS 694	PVC insulated cables for working voltages upto and including 1100V.
IS 11353	Guide for uniform system of marking and identification of conductors and apparatus terminals.
IS 5578	Guide for marking of insulated conductors.
IS 3618	Phosphate treatment of Iron and steel for protection against corrosion.
IS 6005	Code of practice of phosphating of Iron and steel.
IS 5	Colours for ready mixed paints and enamels.
IS/IEC 60947 : Part 1	Degree of protection provided by enclosures for switchgear and Control.

In general the order of precedence is: -

- Drawing(s)
- This specification
- Reference standards
- BOQ

2.7.3 SUBMITTALS

A. Product Data: For each type of switchgear and related equipment, include the following: Rated capacities, operating characteristics, furnished specialties, and accessories for individual [**interrupter switches**] [**circuit breakers**]. Time-current characteristic curves for over current protective devices, **tripping coordination charts, cascading charts,** including [**circuit-breaker relay trip**] [**fusible**] devices & weight of the sections.

B. Product Data for Power Factor Correction Capacitors: For each type of product specified, include data on features, components, ratings, and performance. Include dimensioned plan and elevation views of enclosures and details of control panels. Show access and workspace requirements.

C. Danger/Warning labels shall have white lettering on a red background and shall be in English, Hindi. All other labels shall have black lettering on a white background. All labels shall be fixed by screws or rivets.

D. Shop Drawings: General Arrangement drawings with Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment BOM. Show method of field assembly and location and size of each field connection. Include the following:

1. Tabulation of installed devices with features and ratings.
2. Outline and general arrangement drawing showing dimensions, shipping sections, and weights of each assembled section.

3. Drawing of cable termination compartments showing preferred locations for conduits and indicating space available for cable terminations.
4. Floor plan drawing showing locations for anchor bolts [**and leveling channels**].
5. Current ratings of buses.
6. Short-time and short-circuit ratings of switchgear assembly.
7. Nameplate legends.
8. Mimic-bus diagram.
9. Utility company's metering provisions with indication of approval by utility company.
10. Wiring Diagrams: For each type of switchgear and related equipment, include the following:
    1. Power, signal, and control wiring.
    2. Three-line diagrams of current and future secondary circuits showing device terminal numbers and internal diagrams.
    3. Schematic control diagrams.
    4. Diagrams showing connections of component devices and equipment.
    5. Schematic diagrams showing connections to remote devices.

11. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer.
    a. Design Calculations: Calculate requirements for selecting seismic restraints.
    b. Detail fabrication, including anchorages and attachments to structure and to supported equipment.
12. Documents shall comprise but not limited to the following :

A : Indicates that the document to be submitted as per the Lodhas approved material submission schedule.
B : Indicates that the document to be submitted after successful testing and commissioning of the integrated system before handing over of the system.

Sr. No.	Engineering Data	Reqd With Bid	Required after Purchase Order			
			For approval		As built	
			Qty	Schedule Days	Qty	Schedule Days
1	Outline dimension drawing	yes	7	A	6	B
2	Heat dissipation calculations	yes	7	A	6	B
4	Cross sections with part description & Foundation dwg.	yes	7	A	6	B
4	Completed Data Sheets	yes	7	A	6	B
5	Bill of Materials for scope of Supply	yes	7	A	6	B
6	Installation Drawings, Operation / Maintenance Manual	yes	7	A	4	With dispatch
7	Priced Spare List for 2 years service	yes				
8	Terminal point schedule / drawing		7	A	6	B
9	Control Schematic Diagram		7	A	6	B
10	Type test certificate for short circuit breaking current of circuit breaker		7	A	6	At the time of inspection
11	Type test certificate for short circuit withstand.		7	A	6	At the time of inspection
12	Inspection Test Reports				6	At the time of inspection
13	Test Certificates for bought out items				6	
14	Quality Test Plan		7	A	6	

E. Manufacturer Seismic Qualification Certification: Submit certification that Low voltage Switchgear, accessories, and components will withstand seismic forces. " Include the following:
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
      b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
   2. Dimensioned Outline Drawings of Equipment Unit: Identify centre of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

2.7.4 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with applicable requirements of the laws, codes, ordinances, and regulations of Country, State, and Municipal authorities having jurisdiction & applicable Standards.

B. Standards: The Low voltage Switchgear and Accessories shall confirm to the requirement of latest revision of all relevant Indian Standards and also IEC Standards.

C. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing in **accordance with IEC/IS/and BS codes and is** acceptable to authorities having jurisdiction.

D. Electrical Components, Devices, and Accessories: Listed and labeled as per **INDIAN** NEC 2011 and IS 732 1989 (reaffirmed 2005), by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

2.7.5 INSPECTION AND TESTING AT MANUFACTURER PREMISES

A. The **Contractor** shall provide test certificates with **as per the approved material submission schedule** each design and rating of switchgear for Type and Routine tests carried out on the switchgear. Tests shall be those listed in the relevant standards. The **routine** tests shall be for the precise cubicle configuration proposed, including any adapter units between switchgear and control gear.

B. The **Contractor** shall provide type test certificates for all ratings of Current transformers, Voltage transformers, relays, meters and other auxiliary equipment used in the switchgear.

C. The **Lodha Representative** reserves the right to witness the following tests:-
   1. **Factory acceptance tests including** Routine tests on all switchgear/components as specified in the relevant standards.
   2. Operational (electrical and mechanical) tests on all components.
   3. Protection operation by secondary injection of current and voltage as required.
   4. Protection operation by primary injection of current as applicable.
   5. Interchange ability test.

D. Type tests, viz
Vendor shall furnish type test certificates for similar capacitor banks, In the absence of the same, Vendor shall perform the type tests without any cost implication to the Purchaser.

E. Routine test
The following tests for the power capacitors shall be carried out in accordance with IEC 70:-
   - Capacitance
   - Capacitor Losses
   - A HV test between terminals
   - AC voltage test between terminals and container dry test.
   - Tests between terminals and earth for capacitor banks

F. The **Contractor** shall give two weeks' notice of tests prior to commencement.

G. The **Lodha Representative** reserves the right to inspect switchgear at the Manufacturer's works at any time prior to despatch to prove compliance with this specification.

H. The **Lodha Representative** shall also have the right to carry out intermediate inspection at Seller's works during manufacturing stage.

I. All the travelling & accommodation expenses towards the Inspection or witnessing the testing of equipment by the **Lodha Representative** will be in **Contractors** scope.

2.7.6 MANUFACTURERS

A. Approved Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to those listed in Section G.

B. All switchgear shall be sourced from the same manufacture (i.e. ACBs/MCCBs/MCBs etc, mixing of switchgear manufacture shall not be permitted. To allow grading of the switchgear the selected manufacturer shall have full product range available have their own software for grading and network analysis. Contractor they shall provide full training to the Engineer and Lodha for using the software and shall provide a named person working directly for the original manufacturer whose job will be to carry out network and grading analysis for review by the Lodha Representative.

2.7.7 LV PANEL CONSTRUCTION

2.7.7.1 DESIGN

A. The electrical arrangement of the switchgear, protection, metering, control, interlocking, inter-tripping, auxiliary power supply etc. shall be as shown on the one-line diagram(s).

B. The control scheme shall provide for automatic load transfer if the normal incoming supply to a bus is lost, and also permit manual switching to remove second incoming line from service or to return an incoming line to service after a transfer, with no break in the power supply.

C. All components of the switchboard shall be rated for the electrical system characteristics shown on the one-line diagram(s). The rating of equipment/component shall take full account of all heat sources and other de-rating factors, non-linear loads within the enclosures. Special reference is made in respect of enhanced circuit making requirements and the DC component of fault current at breaking.

D. The switchgear shall be suitable for operation with system voltage and frequency variations as stated on the one-line diagram(s).

E. Wherever possible rated voltages and lightning impulse withstand voltages shall be selected from the respective IS / IEC standards as specified

F. All switchgear shall be sourced from the same manufacture (i.e. ACBs/MCCBs/MCBs etc, mixing of switchgear manufacture shall not be permitted on this project. To allow grading of the switchgear the selected manufacturer shall have their own software for grading and network analysis. Where coordination study is proposed by the Contractor they shall provide for full training to the Engineer and Lodha in using the software and shall provide a named person working directly for the original manufacturer whose job will be to carry out network and grading analysis for review by the Lodha Representative.

G. A discrimination study shall be provided for the complete LV distribution system from the incoming protective device downstream to the final circuit protective device by consultant. The study shall be provided in paper and electronic format for approval by the Lodha Representative. If discrimination is not achieved between any 2No protective devices this shall be identified to the Lodha Representative and if this is not carried out it shall be deemed that full discrimination has been achieved. Contractor to verify the design and calculations and in case of any discrepancy contractor to provide solution wherein total discrimination is achieved without any cost to Lodha.

H. Unless otherwise stated only electronic releases (LSI) will be used on MCCBs and ACBs. These releases shall be integral to the protective device

1. Ratings: Nominal System Voltage: 415 V, 3Phaes 4 wire, 50 Hz.
2. The electrical arrangement of the switchgear, protection, metering, control, interlocking, inter-tripping, auxiliary power supply etc. shall be as shown on the one-line diagram(s).
3. The control scheme shall provide for automatic load transfer if the normal incoming supply to a bus is lost, and also permit manual switching to remove second incoming line from service or to return an incoming line to service after a transfer, with no break in the power supply.

4. All components of the switchboard shall be rated for the electrical system characteristics shown on the one-line diagram(s). The rating of equipment/component shall take full account of all heat sources and other derating factors, non-linear loads within the enclosures. Special reference is made in respect of enhanced circuit making requirements and the DC component of fault current at breaking.
5. The switchgear shall be suitable for operation with system voltage and frequency variations as stated on the one-line diagram(s).
6. Wherever possible rated voltages and lightning impulse withstand voltages shall be selected from the IS / IEC standards.
7. A discrimination study shall be provided for the complete LV distribution system from the incoming protective device downstream to the final circuit protective device. The study shall be provided in paper and electronic format for approval by the Lodha Representative. If discrimination is not achieved between any 2No protective devices this shall be identified to the Lodha Representative and if this is not carried out it shall be deemed that full discrimination has been achieved.
8. Unless otherwise stated only electronic releases (LSI) will be used on MCCBs and ACBs.
9. For all LV switchboards, the main incoming and interconnection circuit breakers shall consist of Draw out type Air Circuit Breakers (ACBs) suitably sized for the connected load. The outgoing circuits from the LV switchboards shall consist of Moulded Case Circuit Breakers (MCCBs) for current ratings up to 800 Amps. For outgoing circuits of 800 Amps or above, Air Circuit Breakers (ACBs) shall be used. Full electronic releases (LSI)/Microprocessor based release shall be supplied on all ACBs and MCCBs. Electronic releases (LSIG) shall be provided for ACBs and MCCBs as specified in Electrical schematic and it should be an integrated single unit. Use of Extended ELR with CBCT is not acceptable in place of LSIG releases for Switchgears.
10. Each main LV switchboard shall be provided with a battery backed up power supply from the LV distribution systems for all control, automatic tripping functions and motor driven switching functions. Motor mechanisms shall be fitted to outgoing breakers serving essential and non essential loads. (Note: Control supply will be 220VAC.).
11. Switchgear shall have the following optional components, features, and accessories & as mentioned on SLD:
    a) Provision for Communication modules.-
    b) Analogue / Digital instruments.
    c) Relays.
    d) Surge arresters.
    e) Provisions for future devices.
    f) Fungus proofing (space heaters).
    g) Extended terminals for monitoring and controls.

2.7.7.2 OPERATION REQUIREMENT

A. The LV Switchboards that serve life safety and Essential/ Emergency loads as shown on the schematics drawings shall have in built electromechanical interlocks, to enable the switchboard to be served by the standby generator system in the event of mains failure.

B. Switchgear shall be provided to allow mains to generator supply changeover operation to take place. A mains failure shall be the auto mains failure (AMF) panels which shall initiate a signal to the respective generator to start. The life safety generator startup procedure will be achieved by the generator control panel. The generator supply, incoming circuit breaker from the main LT switchboard will prevent through electromechanical interlocking the paralleling of DG and utility power supply.

C. The system response time and time required to starting of DG & reaching rated voltage to be described. Electrical contractor to provide supply phase failure sensing at terminals for generator supply to extend. All necessary route drilling for cutting to be provided by Electrical contractor to Generator vendor.

D. Apartment Low Voltage distribution shall be provided via rising mains to supply the on floor power requirements. Each apartment holder will be provided with a dedicated electrical utility meter at respective floor level.

2.7.7.3 CONSTRUCTION REQUIREMENTS FOR SWITCH BOARDS

A. The LV switchboards shall be sheet steel metal enclosed, free standing floor mounted, front operated, totally enclosed dead front and fully compartmentalized cubical type, extendable on both sides and be fully Type tested ASTA/KEMA Certified (IP42 for indoor installations and IP54 for outdoor installations – where a rating lower that IP65 is proposed externally the panel shall be enclosed within an IP65 enclosure). Meters will be fitted within the LV switchboard to monitor the incoming supply as well as certain outgoing circuits to tenant and lettable areas.

B. Switch boards shall conform to Form 4 Type 6 or Form 3 b for MLTPs and Emergency panels. (Refer to SLD for specific requirements).

C. Enclosed Switches and Circuit Breakers cubicles shall be metal enclosed, floor mounted / Wall mounted.

D. All CRCA sheet steel used for the construction of the panels shall be 2mm thick and shall be folded and braced as necessary to provide a rigid support for all components. Sheet steel shrouds and partitions shall be of minimum 1.6 mm thickness. Joints of any kind in sheet steel shall be seam welded, all welding slag grounded off and welding pits wiped smooth with plumber metal. Wherever required, stiffeners shall be provided to increase stiffness of large size doors and covers.

E. The panels shall be totally enclosed, completely dust and vermin proof. Gaskets between all adjacent units and beneath all covers shall be provided to render the joints dust proof. All doors and covers shall be fully gasketed with foam rubber and/or rubber strips and shall be lockable. Doors shall have concealed hinges.

F. All panels and covers shall be properly fitted and secured with the frame, and holes in the panel correctly positioned. Fixing screws shall enter into holes tapped into an adequate thickness of metal or provided with bolt and nuts. Self-threading screws shall not be used in the construction of the panels.

G. A base channel of 75mm x 40mm x 5mm thick shall be provided at the bottom. A clearance of 300mm between the floor of the panels and the bottom of the lower most units shall be provided.

H. Knockout holes of appropriate size and number shall be provided in the panels in conformity with the number, and size of incoming and outgoing conduits/cables.

I. The panels shall be provided with removable un-drilled sheet steel gland plates (3mm thick) at top to drill holes for cable/ conduit entry at site. The panels shall be designed to facilitate easy inspection, maintenance and repair.

J. The panels shall be sufficiently rigid to support the equipment without distortion under normal and short circuit condition. They shall be suitably braced for short circuit duty. Provision shall be made for permanently earthing the frames and other non-current carrying parts of the switchgear by two independent earth connections

K. The height of the panels shall not exceed 2100 mm from finish floor level. The maximum operating levels of the top most cubicles shall not be more than 1800 mm finish floor level. The operating level of the lower most cubicles shall not be less than 200 mm from finish floor level.

L. Every cabinet shall be trifoliate or engraved metal name plates. All panel shall be provided with circuit diagram engraved on FR PVC sheet.

M. The Switchgear shall be provided with integral base frame for each vertical panel which shall be suitable for directly bolting or tack welding to the Buyer's base frame. The structure, including doors and panels, shall be suitable of withstanding the stresses due to seismic conditions as specified in aforementioned site conditions.

N. Switchgear and Busbars shall be arranged to permit future extension at both ends. End of busbar shall be suitably drilled and relevant fishplates shall be provided for main LT panels for this purpose. Panels at extreme ends shall have opening which shall be covered by using screwed plates with neoprene gaskets for moisture egress prevention. Details of drilled holes in bus-bar and opening shall be clearly indicated in the suppliers drawing.

O. The panels shall be of adequate size with a provision of 20% spare space to accommodate possible future additional switch gear. The panel shall be designed such that the internal space is sufficient for hot air movement, and the electrical component do not attain temperature more than 40 degree Celsius. Canopy for busduct riser should be in coordination with busduct detail.

P. Structures, including doors and panels, shall be capable of withstanding the internal pressure created by faults within the structure (equal to the maximum fault-current rating for a specified duration) without danger to the operating personnel. The minimum standard required is detailed in IEC/IS. Type test certificate(s) shall be provided with the quotation.

Q. Structures shall be capable of bearing all mechanical loads viz., cubicle module rack in, rack out and in no case the frame/base plate shall deform during the normal specified operation.

R. The structure, including doors shall be suitable of withstanding the stresses due to seismic conditions as specified in aforementioned site conditions.

S. Structures shall be provided with barriers to prevent the transfer of ionised gases between adjacent compartments except busbar chambers

T. Switchgear shall generally be self-ventilating.

U. Interlocks, busbar shutters, covers, etc. shall be provided to prevent incorrect or unsafe operation, and to prevent access to live parts. Interlocks shall be provided to prevent opening of the front doors of cubicles whilst the circuit breaker / switch is in the closed position.

V. Key interlocking shall be provided on incoming, outgoing and sectionalised units as required by material requisition and one line diagram(s).

W. Provision of remote tripping of main LT board as per Contract documents.

X. All circuit breaker / switch shall have provision for padlocking. Padlocking facility for multiple locks shall be provided in the Off / Test / Isolated position.

Y. Switchgear shall be designed and constructed to facilitate inspection, cleaning, repair and maintenance and to ensure absolute safety during operation, inspection and maintenance. It shall be possible to work safely within individual compartments whilst the remainder of the switchgear is energized.

Z. Similar parts and components shall be interchangeable.

AA. Unless otherwise stated on the one-line diagram, switchgear intended for indoor installation shall have minimum protection of IP 21 and outdoor installation shall have minimum protection of IP 65 in accordance with codes as stated above.

BB. All hardware shall be corrosion resistant. All joints and connections of the panel members shall be Zinc passivated or Cadmium plated, high quality steel bolts, nuts and washers secured against loosening.

CC. Incoming and bus section must be located in non-tiered separate cubicles.

DD. All the feeders shall be withdraw-able type. Plug in arrangement is preferred over Slide in contacts for external control cable connection to the module.

EE. Each compartment shall have the following features:

FF. Space heater operating at one-half or less of rated voltage, sized to prevent condensation.

GG. Louvers equipped with insect and rodent screen and filter, and arranged to permit air circulation while excluding rodents and exterior dust.

HH. Hinged front door with locking provisions.

II. Interior light with switch.

JJ. Duplex receptacle.

KK. Power for heaters, lights, and receptacles to be standard 230V AC supply through static inverter.

LL. Finish: The panels shall be provided with Manufacturer's standard Siemens Grey (RAL7042) finish. The panel shall be treated with 7 –treatment tank process before painting to reduce the chances of corrosion due to surrounding atmosphere conditions.

2.7.7.4 PANEL COMPONENTS

A. MAIN BUS

1. Tin Plated copper full length of switchgear up to and including Main Incomer size of 63A and Aluminium for Main Incomer size above 63A Main Incomer. The busbars shall be of 3 phase, 4 wire system with separate neutral & earthing busbar.
2. Busbars and connections shall be supported on unbreakable, non-flammable, hard drawn tinned mounted on non-hygroscopic fire retardant epoxy ceramic or resin cast insulators at sufficiently close intervals to prevent busbar sag and shall effectively withstand without damage electromagnetic stresses in the event of short circuit. Bus-bars shall withstand short-circuit capacity as mentioned in BOQ and SLD.
3. The neutral as well as earth bar shall also be capable of withstanding the fault level. Temperature rise in bus-bars shall not exceed 40 deg. above ambient.
4. Busbars including branch connections shall be fully insulated except in cable/bus duct compartment(s). FRP shrouds shall be provided at joints and tap offs. Busbars exposed to air shall be tin plated.
5. Main busbar shall be of the same cross sectional area throughout the length of the switchgear. And Shall be Made up conducting material and breaking capacity as shown on SLD.
6. The current rating of the neutral busbar shall be 100% of the phase busbars.
7. Maximum current density for the busbars shall be 0.8 A/sq.mm for aluminium and 1.2 A/sq.mm for copper busbars
8. Busbars shall be insulated with fire retardant heat-shrink sleeves of applicable grade as approved by the Employer's representative and marked to indicate the phase colouring. Colour coding shall be as per NEC Necessary derating due to insulation shall be considered for sizing the busbars and relevant calculations shall be produced with submittal for final approval by the Lodha Representative.
9. Busbars, at bus section switches, shall be arranged to permit safe work with one bus-section de-energised. In addition it shall not be possible for arcs to transfer across a section or coupler.
10. Branch connections shall be sized as per the circuit breaker / switch rating. The busbars shall be housed in a separate compartment.
11. The busbar shall be isolated with 3mm thick FRP sheets or Acrylic Sheet or Metal sheet to avoid any accidental contact. All busbars connections shall be done by drilling holes in busbars and connecting by chromium plated brass bolts and nuts. Additional cross section of bus bars shall be provided in all Panels/ Distribution boards to cover up the holes drilled in the busbars. Spring and flat washers shall be used for tightening the bolts.
12. Minimum clearance between phase & earth shall be 20mm and phase to phase shall be 25mm.
13. An earthing busbar sized for the full rating of the phase shall be provided along the full length of the switchgear structure with provision for earth cable / bar connections at each end. It shall be possible to disconnect the earth cable / bar connection to facilitate meggering, when required. Where frame leakage protection is specified a separate insulated bus bar is required in addition.
14. Busbars and connections shall be adequately sized, braced and supported to withstand the mechanical forces and thermal effects resulting from the switchgear rated short circuit current and carry certification from a recognised testing authority.
15. Each circuit breaker shall be housed in separate compartments and shall be enclosed on all sides. Sheet steel hinged lockable door shall be duly interlocked with the breaker units in "ON" and "OFF" positions. Safety interlocks shall be provided for circuit breaker to prevent the breaker from being drawn-out when the breaker is in "ON" position.

16. The door shall not form an integral part of the draw out position of the circuit breaker. All instruments and indicating lamp shall be mounted on the compartment door. Sheet steel barrier shall be provided between the tiers in a vertical section.
17. Removable sheet steel gland plates shall be provided for fixing the cable glands. The space in cable alleys between gland plates and terminals for connecting the lugs must be adequate for the specified size of cables. Manufacturer shall show these clearances on the general arrangement drawings and the same shall be increased if so instructed by the Consultants, without extra price. The Tenderers may submit such drawings with their tenders, if approval is required before finalising the order. Supports for clamping cable cores and module identifying numbers shall be provided in cable alleys.
18. Labelling of panels for feeders shall be as per SLD/actual installed
19. Copper surfaces at aluminium to copper joints shall be silver / tin plated.
20. Engraved PVC labels shall be provided on all incoming and outgoing feeders. Single line circuit diagram showing the arrangements of circuit inside the Panels shall be pasted on inside of the panel door and covered with transparent laminated plastic sheet

B. AIR CIRCUIT BREAKERS:

1. The ACB shall conform to the requirements of all the codes as listed above and shall be type tested & certified for compliance to standards from– accredited international lab. The circuit breaker shall be suitable for 415 V, 50 Hz supply system. Air Circuit Breakers shall be with moulded housing flush front, draw out type and shall be provided with a trip free manual operating mechanism or as indicated in drawings and bill of quantities with mechanical "ON" "OFF" "TRIP" indications. ACBs shall be compact type.
2. The ACB shall be 3/ 4 pole with modular construction, draw out, manually or electrically operated version as specified. The circuit breakers shall be for continuous rating and service short Circuit Breaking capacity (Ics) shall be as specified on the single line diagram and should be equal to the Ultimate breaking capacity(Icu) and short circuit withstand values(Icw) for 1 sec.
3. Circuit breakers shall be designed to 'close' and `trip' without opening the circuit breaker compartment door. The operating handle and the mechanical trip push button shall be at the front of the breakers panel. Inspection of main contacts should be possible without using any tools. The ACB shall be provided with a door interlock. i.e. door should not be open when circuit breaker is closed and breaker should not be closed when door is open. ACB's shall be with safety shutter , Anti pumping and Rating error preventor. Electrical/ Mechanical life of ACB's shall be minimum 15000 cycles upto 2500A & 5000 cycles above 3200A.
4. All current carrying parts shall be silver plated and suitable arcing contacts with proper arc chutes shall be provided to protect the main contacts. The ACB shall have double insulation (Class-II) with moving and fixed contacts totally enclosed for enhanced safety and in accessibility to live parts. All electrical closing breaker shall be with electrical motor wound stored energy spring closing mechanism with mechanical indicator to provide ON/OFF status of the ACB. Breaker shall be capable of being racked out into testing, isolation, maintenance positions and kept locked in any position.
5. Rated insulation voltage shall be 1000 volts AC.

B.(i). Cradle:

1. The cradle shall be so designed and constructed as to permit smooth withdrawal and insertion of the breaker into it. The movements shall be free from jerks, easy to operate and shall be on steel balls/rollers and not on flat surfaces.
2. There shall be 3 distinct and separate position of the circuit breaker on the cradle.
3. Racking Interlock in Connected/Test/Disconnected Position.

Service Position	:	Main Isolating contacts and control contacts of the breaker are engaged.
Test Position	:	Main Isolating contacts are isolated but control contacts are still engaged.
Isolated Position	:	Both main isolating and control contacts are isolated.

Maintenance Position: Completely rack out for maintenance.

4. There shall be provision for locking the breaker in any or all of the first three positions.

   The following safety features shall be incorporated:

   1. Withdrawal or engagement of Circuit breaker shall not be possible unless it is in open condition.
   2. Operation of Circuit breaker shall not be possible unless it is fully in service, test or drawn out position.
   3. All modules shall be provided with safety shutters operated automatically by movement of the carriage to cover exposed live parts when the module is withdrawn.
   4. All Switchgear module front covers shall have provision for locking.
   5. Switchgear operating handles shall be provided with arrangement for locking in 'OFF' position.

5. Air Circuit breakers shall be:

   1. Withdraw-able type or as mentioned in the drawings and BOQ
   2. Of air break design
   3. Have the number of poles specified on the system Single-Line-Diagram
   4. Suitable for uninterrupted duty and utilisation category B to IEC or equivalent standard
   5. Circuit breakers of identical rating shall be interchangeable. Circuit breakers shall be electrically operated with provision for manual (mechanical) operation. Tripping, closing, control and indication supplies for circuit breakers shall be as shown on the one-line diagram(s). Circuit breaker operating mechanisms shall be motor wound spring. The closing spring shall be automatically recharged after discharge and be ready for next closing command. The closing spring condition - "charged" or "discharged" shall be shown via a positively driven indicator. Test facilities shall be provided to permit operation of the circuit breaker whilst in the test position.
   6. Circuit breakers shall be provided with trip circuit supervision to monitor trip circuit continuity and trip circuit supply. Alarm and indication facilities shall be provided for each circuit breaker and a volt free group contact provided via internal bus wiring for remote common alarm. Circuit breakers shall be provided with four normally open and four normally closed spare, auxiliary contacts wired out to terminals.

      In addition auxiliary contacts shall be provided for:-

      1. Circuit breaker in service position.
      2. Circuit breaker in test position
      3. Volt free contact for integration to BMS system/ Fire Alarm system
      4. DG integration with AMF panel.
      5. In any event no less than 4No. NO and 4No. NC auxiliary contacts shall be provided.

      Auxiliary contacts shall be suitable for inductive circuit switching. Auxiliary contacts multiplication shall be by latch type relays to prevent inadvertent change of contact position on loss of auxiliary supply.

   7. Withdraw able circuit breakers and their Cubicles shall:

      a) Be interlocked to prevent

      1. The breaker being inserted into the service position unless it is open.
      2. The breaker being withdrawn from the service position unless it is open.
      3. The breaker being closed unless it is fully in the service, withdrawn/test or earthing position.
      4. Remote operation whilst in the withdrawn/test position.

      b) Be fitted with busbar and cable circuit shutters

      1. With padlocking facilities.

2. Coloured red for busbar and yellow for circuit. For bus-section and coupler applications the shutters shall be labelled with the busbar number
3. Of metal construction and effectively earthed to the main housing.
4. Of the positively driven type, gravity drop shutters are not acceptable.
5. Capable of being individually operated by hand.

Each circuit breaker shall have provision for padlocking in the test and isolated positions and have indications for these positions. Each circuit breaker shall be provided with an anti pumping facility in the circuit breaker closing circuit.

B.(II). Protections

The breaker should be equipped with micro-controller based , communicable type release with RS 485 port for communication to offer accurate and versatile protection with complete flexibility and shall offer complete over current protection to the electrical system by provision of full microelectronic releases incorporating:

1. Long time protection (L): Long-time current and long-time delay to be adjustable.
2. Short time protection (S) Short-time current and short-time delay to be adjustable along with mode ($t=k$ and $t=k/i^2$).Instantaneous protection (I): Instantaneous current and long-time delay to be adjustable..
3. Ground fault protecti^{o}n (G) : Earth Fault Pick-up current and Earth fault time delay to be adjustable.
4. The LSIG feature shall be used at incomer of Main LT Panel & Main DG set Panel. The LSI feature shall be used for all the panels except Main LT Panel & main Dg set Panel. The protection release shall have following features and settings:
   a) True RMS Sensing

      The release shall sample the current at the rate of 16 times per cycle to monitor the actual load current waveform flowing in the system and shall monitor the true RMS value of the load current. It shall take into account the effect of harmonics also.

   b) Thermal Memory

      When the breaker shall reclose after tripping on overload, then the thermal stresses caused by the overload if not dissipated completely, shall get stored in the memory of the release and this thermal memory shall ensure reduced tripping time in case of subsequent overloads. Realistic Hot/Cold curves shall take into account the integrated heating effects to offer closer protection to the system.

   c) Defined time-current characteristics :

      A variety of pick-up and time delay settings shall be available to define the current thresholds and the delays to be set independently for different protection zones thereby achieving a close-to-ideal protection curve.

   d) Trip Indication

      Individual fault indication for each type of fault should be provided by LEDs for faster fault diagnosis.

   e) Self powered

      The release shall draw its power from the main breaker CTs and shall require no external power supply for its operation.
5. All incomer ACBs for LT panel shall have following additional protections other than mentioned above.
   a) Under and over voltage
   b) Under and over frequency

6. The release should provide local indication of actual percentage loading at any instant. The release should be able to communicate on MODBUS RTU protocol using inbuilt RS485 port and shall be integral part of supply with trip unit. Parameters of the Protection Release should be changeable from Release as well as through communication network. Release should have graphical LCD for display of power parameters. The release of incoming breakers should provide comprehensive metering with the following parameters

    a) Phase currents (running, avg & max) – All parameters in single window.

    b) Release should be able to capture short circuit current on which ACB has tripped. The last ten trips and alarms shall be stored in memory with the date & time stamping along with type of fault and alarm. The sensing CT Should be Rogowsky type with measurement precision of 1%.

    c) Release should be self powered .

    d) Release should have facility to select different type of IDMTL protection (DT,SIT,VIT,EIT,HVF) for better co-ordination with HT Breaker/Fuse.

    e) Phase voltages (running, avg & max)

    f) Energy & power parameters (active, reactive and apparent)

    g) PF

    h) Frequency

    i) Maximum Demand (KVA & KW)

    j) Total Harmonics distortion (From fundamental to 50^{th} harmonic)

B.(iii). Safety Features

1. The safety shutter shall prevent inadvertent contact with isolating contacts when breaker is withdrawn from the Cradle.
2. It shall not be possible to interchange two circuit breakers of two different thermal ratings. For Draw-out breakers, an arrangement shall be provided to prevent rating mismatch between breaker and cradle.
3. There shall be provision of positive earth connection between fixed and moving portion of the ACB either through connector plug or sliding solid earth mechanism. Earthing bolts shall be provided on the cradle or body of fixed ACB.
4. The incoming panel accommodating ACB shall be provided with indicating lamps for ON-OFF positions, digital voltmeter and ammeter of size not less than 96 mm x 96 mm, selector switches, MCB for protection circuit and measuring instrument circuits.
5. It shall be possible to bolt the draw out frame not only in connected position but also in TEST and DISCONNECTED position to prevent dislocation due to vibration and shocks.
6. Draw out breakers should not close unless in distinct Service/Test/Isolated positions.
7. The insulation material used shall conform to Glow wire test as per IEC60695.
8. The ACB shall provide in built electrical and mechanical anti-pumping.
9. All EDO ACB`s Shall have Ready to Close Contact to ensure that the ACB gets a command only when it is ready to close for applications of Remote Control, AMF, Synchronization and Auto Source Change Over Systems.

C. MCCBs

1. The Contract shall include for moulded case circuit breakers (MCCB) to be in accordance with respective codes as specified above and used in the locations as indicated on the attached drawings.
2. MCCB shall comply with the requirements of the relevant standards and should have test certificates for breaking capacities from independent test authority i.e. accredited international lab.

3. MCCB shall comprise of Quick Make -break switching mechanism, arc extinguishing device and the tripping unit shall be contained in a compact, high strength, heat resistant, flame retardant, insulating moulded case with high withstand capability against thermal and mechanical stresses
4. The breaking capacity of MCCB shall be as specified in the one-Line-Diagram. The rated service breaking capacity (Ics) should be equal to rated ultimate breaking capacities (Icu). MCCBs for motor application should be selected in line with Type-2 Co-ordination as per relevant codes as stated above. The breaker as supplied with ROM should meet IP54 degree of protection. All breakers shall be withstand for 2.5 kV voltage level between phase and earth for 1 second.
5. The MCCB shall employ maintenance free minimum let-through energies and capable of achieving discrimination up to the full short circuit capacity of the downstream MCCB. The manufacturer shall provide both the discrimination tables and let-through energy curves for their switchgears.
6. Each unit shall be manufactured from high grade non-track mouldings and be complete with clearly visible enclosed contact areas and de-ionisation chambers ON, OFF and TRIP switch positions, quick make and break switch actions and lockable switch handle or associated control.
7. Adjustable type electronic trips shall be incorporated in each unit as specified to provide satisfactory overload and short circuit protection together with short circuit indicators, under-voltage trips, shunt trips, short circuit delay trips, motor operated drives and auxiliary contacts as indicated on the attached drawings and/or Specification Sections/or Schedules.
8. Each circuit breaker shall be capable of being manually reset only after tripping against overload or short circuit conditions. Short circuit delay trips shall be of the stepless, adjustable type within the range of 0-200 m.s.
9. Each circuit shunt trip shall be capable of operating satisfactorily when the coil voltage is between 70% and 120% of its rated voltage. Under voltage relay shall be capable of operating on a slowly failing voltage between 70% and 45% of the rated operating voltage. Self-resetting under voltage relays shall be reset at not less than 85% of the rated operating voltage. The under frequency Relay shall operate when the frequency fall below 47.5 Hz or increases above 52.5 Hz i.e +/-5% of the Rated voltage..
10. The power operation of MCCB and MCCBI (isolator) units shall be effected by means of an approved universal type motor complete with electro-magnetic clutch and emergency hand operating handle. The motor operated units shall be capable of operating satisfactorily when the motor terminal voltage is between 85% and 105% of rated voltage.
11. The minimum size of MCCB or MCCBI units indicated on the attached drawings and/or Specification Sections shall be that which has resulted from the application of any temperature, enclosure or similar de-rating factor.
12. The operation of an MCCB or MCCBI unit shall be such that it shall not endanger the operator or show signs of undue wear. In all cases the design of the switch drives shall be arranged to open all poles of the supply positively and simultaneously. The speed at which the switch contacts open or close shall be independent of the speed at which the associated handle is actuated.
13. Where moulded case circuit breakers are used as isolators (MCCBI) they shall be identical to the basic MCCB units described above but without the addition of any form of electronic trips or relays, under-voltage relays, shunt trips, unless otherwise stated.
14. All MCCBs shall include the facility for a remote shunt trip device to be incorporated via a simple on site addition.
15. All MCCBs shall include the facility for an earth leakage trip and/or indication device to be incorporated via a simple on site addition.
16. The fault rating of MCCB employed shall be at lease equal to that expected at the point installed in the network.
17. Ensure discrimination on overload and short circuit applications is achieved using the proposed switchgear components. Under no operating conditions shall the supply to a whole distribution board be lost due to a fault on a downstream circuit.

18. Protection Functions:

    The breaker should be equipped with micro-controller based , communicable type release with RS 485 port for communication to offer accurate and versatile protection with complete flexibility and shall offer complete over current protection to the electrical system by provision of full microelectronic releases incorporating:

1. Long time protection (L): Long-time current and long-time delay to be adjustable.
2. Short time protection (S) Short-time current and short-time delay to be adjustable along with mode (t=k and t=k/i2).
3. Instantaneous protection (I): Instantaneous current and long-time delay to be adjustable..
4. The LSIG feature shall be used at incomer of Main LT Panel & Main DG set Panel.
5. The LSI feature shall be used for all the panels except Main LT Panel & main Dg set Panel.
6. Microprocessor trip units shall be adjustable and it shall be possible to fit lead seals to prevent unauthorised access to the settings
7. Microprocessor trip units shall comply with standard (measurement of rms current values, electromagnetic compatibility, etc.)
8. Protection settings shall apply to all poles of circuit breaker.
9. All Microprocessor components shall withstand temperatures up to 125 ℃

19. Testing:

10. Original test certificate of the MCCB shall be furnished.
11. Pre-commissioning tests on the switch board panel incorporating the MCCB shall be done as per standard specifications.
12. Sequence of operation for ultimate short circuit breaking capacity and verification of overload release shall be a part of the testing.
13. Interlocking:

    Moulded, case circuit breakers shall be provided with the following interlocking devices for interlocking the door of a switch board.

1. Handle interlock to prevent unnecessary manipulations of the breaker.
2. Door interlock to prevent the door being opened when the breaker is in ON position.
3. Defeat-interlocking device to open the door even if the breaker is in ON position.
4. The MCCB shall be current limiting type and comprise of quick make – Break switching mechanism. MCCBs shall be capable of defined variable overload adjustment. All MCCBs rated 100 Amps and above shall have adjustable over load & short circuit pick-up both in Thermal magnetic and Microprocessor Trip Units.
5. All MCCB with microprocessor based release unit, the protection shall be adjustable Overload, Short circuit and instantaneous earth fault protection with time delay(Provide only where noted on SLD).
6. The trip command shall override all other commands

D. Motor Protection Circuit Breaker (MPCB)

1. The devices shall be in utilization category A and AC4. MPCB shall have a rated operational and insulation voltage of 690V AC (50 Hz) and MPCB shall be suitable for isolation and shall have a rated impulse withstand voltage (Uimp) of 6 kV.
2. The motor circuit breakers shall be designed to be mounted vertically or horizontally without derating. Power supply shall be from the top or from the bottom. In order to ensure maximum safety, the contacts shall be isolated from other functions such as the operating mechanism, casing, releases, auxiliaries, etc, by high performance thermoplastic chambers. 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 shall close, open, and trip simultaneously.

3. The motor circuit breakers shall accept a padlocking device in the “isolated” position.
4. The insulation coordination within the Low Voltage.
5. The motor circuit breakers shall be equipped with a “PUSH TO TRIP” device on the front enabling the correct operation of the mechanism and poles opening to be checked. The auxiliary contacts shall be front or side mounting, and both arrangements shall be possible. The front-mounting attachments shall not change the breaker surface area. Depending on its mounting direction the single pole contact block could be NO or NC.
6. All the electrical auxiliaries and accessories shall be equipped with terminal blocks and shall be plug-in type.
7. The motor circuit breakers shall have coordination with the downstream contactor enabling the provision of a perfectly co-ordinated motor-starter. This combination shall enable type 1 or type 2 co-ordinations of the protective devices. Type 2 co-ordination shall be guaranteed by tables tested and certified by an official laboratory: LOVAG (or other official laboratory).
8. The motor circuit breakers, depending on the type, could be equipped with a door-mounted operator which shall allow the device setting.
9. The motor circuit breakers shall be equipped with releases comprising a thermal element assuring overload protection and a magnetic element for short-circuit protection. In order to ensure safety and avoid unwanted tripping, the magnetic trip threshold (fixed) shall be factory set to an average value of 12 Ir.
10. All the elements of the motor circuit breakers shall be designated to enable operation at an ambient temperature of 40°C without derating. The thermal trips shall be adjustable on the front by a rotary selector. The adjustment of the protection shall be simultaneous for all poles. Phase unbalance and phase loss detection shall be available. Temperature compensation (-20°C to +60°C)

E. SWITCH FUSE UNITS (SFU)

All SFUs shall comply with codes as listed above.

1. All Fuses shall comply with codes. Test certificates from independent testing authorities should be submitted.
2. All SFUs from 32A to 800A should be rated for AC-23A utilization category
3. SFUs shall have pad lock / key lock facility in OFF position with optional door interlock facility
4. Power loss of HRC fuses should be lower than the power loss limit.
5. All fuses should be provided with facility of local/remote indication in the event of fuse operation
6. SFUs should have adequate terminal width to ensure proper contact surface area when terminated with appropriate aluminium cables with lugs
7. Rated fused short circuit capacity of SFUs should be equal to rated breaking capacity of associated HRC fuse.
8. SFUs should be fitted with enhanced safety features like fuse barriers , terminal shrouds at incoming & outgoing, phase barriers
9. It should be possible to inspect and replace contacts in installed condition (without removing the cables)
10. It should have large/adequate ground clearance from terminals to facilitate connection of multiple cables.
11. It should be possible to fit Castle lock, aux. contact block, Fuse operation indicators, and Fuse monitors in the SFUs.
12. All insulating material of SFUs should meet requirements of glow wire test.
13. It should be possible to achieve same quadrant of operation for SFUs irrespective of orientation of terminals (mounting of SFUs) with the same handle.
14. SFUs shall have door interlock feature with defeat facility.

15. SFUs shall have telescopic shaft with step less adjustment.
16. SFUs shall have positive ON – OFF indication
17. Mechanism shall be front operated, quick make - quick break type.
18. Mechanism to be of quad break type.
19. Ingress protection should be of minimum IP20 for an open execution type
20. SFU should be front operated
21. SFU should have pad lock, door interlock and defeat feature facility

F. ISOLATOR

1. All isolating switches shall be hand operated, single pole and neutral, double pole, triple pole and neutral, or four pole as specified and be ASTA certified.
2. The neutral contact shall be arranged to be switched or linked as specified and in the switched neutral units the neutral contact shall make before, and break later, than the phase contacts.
3. Units exceeding 100A rating shall have a removable bolted link. Each unit shall be of the 415 volt (a.c. between phase) rating and be complete with a sheet metal case manufactured from not less than 1.7mm thick metal. Each unit shall incorporate a hinged cover provided with adequate lugs to enable padlocks to be fitted if required.
4. Suitable phase identification shall be fitted to all units. Each switch shall have a quick make and break switch action with spring assisted mechanism ensuring positive ON/OFF movement and identification. Operating handles shall be retractable and arranged to close the switch with an upward movement.
5. Adequate wiring space shall be provided in each unit to facilitate wiring and connection and, if possible, removable side and top panels shall be provided. Each complete unit shall be fitted with all necessary terminals, shrouds, earthing connections etc., and be stove enameled finished to an approved colour. Submit details of the proposed manufacturer to the Lodha Representative for review.
6. Isolator Units shall
   a) Be of the fixed, double air break type.
   b) Be of the rating and number of poles as stated on the One-Line Diagram.
   c) Be provided with facilities for padlocking in the ‘off ’ position
   d) Be of the fault-make, load-break type, unless specified otherwise
   e) Be interlocked to prevent the compartment door being opened unless the isolator is in the open position.

G. EARTHING

1. All metallic non-current carrying parts of the switchgear shall be bonded together and connected to the switchgear earth busbar.
2. All doors shall be bonded to the main structure by means of a flexible copper connection arranged so that it cannot be trapped as the door is opened or closed.
3. Withdraw able parts (e.g. circuit breakers) shall be effectively earthed until they are completely withdrawn with all power and control connections disconnected.
4. Provision shall be made, for earthing cable screen and armouring to the earth busbar, near the gland.
5. All control, instrument and communication cables, if any, shall be earthed suitably to prevent any electromagnetic interference and ensure electromagnetic compatibility.
6. Each earthing point shall be marked with an E.
7. Provision shall be made for an instrument clean earth.

8. 50% additional bar is required if not able to provide body as CPC.

H. CURRENT TRANSFORMERS

1. Burden and accuracy class suitable for connected relays, meters, and instruments.
2. The current transformers shall be manufactured in accordance with IEC/EN/ IS as listed above. The current transformers shall be of ring type construction. The case of the current transformer shall be of glass filled polycarbonate, flame retardant grade classified. The CTs shall be varnished, air cooled type,
3. The CT shall be suitable for metering purpose having 1.0 class of accuracy.
4. The Current transformer shall have marking & nameplate as per IS2705 in addition to class of insulation complying to the requirement of IEC relevant codes. The marking shall be indelible.
5. The Current Transformer shall have following:
6. Insulation Class : E Class
7. Operating Frequency ; 50 Hz
8. Rated Primary Current: 1A to 7500A
9. Rated Secondary Current: 5A
10. Rated Burden: 15VA
11. Ambient Temperature: -20ºC to +45ºC
12. Test Voltage: 3KV, 50Hz for 1 minute.
13. The following tests shall be applied to the current transformer.
    i. Type Test: The type test shall be carried out as per IS2705 Part I&II including short time current & temperature rise tests in NABL accredited laboratory shall be submitted & got approved before commencement of supply.
    ii. Routine Test: The supplier shall conduct all the routine tests such as Ratio test, phase angle error test for 1.0 accuracy class as per IS 2705 Part I&II.
    iii. Commissioning Test: In accordance with IS 2075, power frequency test on primary winding shall be carried out at manufacturers works.
    iv. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems, with the following features:
        1. Inputs from 5-A current-transformer secondary's, and potential terminals rated to 600 V.
        2. Switch-selectable digital display with the following features:
        3. Phase Currents, Each Phase: Plus or minus 1%.
        4. Phase-to-Phase Voltages, Three Phase: Plus or minus 1%.
        5. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1%.
        6. Three-Phase Real Power: Plus or minus 2%.
        7. Three-Phase Reactive Power: Plus or minus 2%.
        8. Power Factor: Plus or minus 2%.
        9. Frequency: Plus or minus 0.5%.
        10. Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2%.
        11. Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

    Communications module suitable for remote monitoring of meter quantities and functions.

I. AUXILIARY SUPPLIES

1. Auxiliary supplies (closing, tripping, control, indication, heaters, etc.) shall be in accordance with the one-line diagram(s).
2. Where motor charging spring operating mechanism is specified for circuit breaker, it shall be rated for the rated auxiliary control supply operation.
3. Circuit breaker closing, tripping, control and indication power shall be supplied from suitably rated 230 Volt AC supply units backed up by inverter/ DG supply. Where dc supply units are not in the Contractor scope, then he shall specify his standing load, peak load and permissible voltage variation for the respective circuit in the quotation.
4. All auxiliary supplies shall be individually protected within each circuit breaker housing. Individual protection shall be by suitably rated fuses.
5. For shunt trip circuits the protection shall be rated at least 400% of the load.
6. Anti-condensation heater supplies shall be derived internally from each busbar section.
7. Incoming Auxiliary Supplies shall be protected by suitably rated fuses at the point of entry to the switchboard. The Contractor shall ensure discrimination with individual circuit fuses. Volt free group contact shall be provided via internal bus wiring for remote common alarm.

J. SECONDARY WIRING (CONTROL WIRING):

1. Secondary wiring shall be fire retardant for LT panels and shall be fire rated as per requirements for all life safety panels; 600V/1000V grade insulated stranded copper conductors. Minimum size shall be 1.5sqmm except for electronic wiring.
2. Secondary wiring within the switchgear shall be securely held in position (either loomed or run in fire retardant trunking). Where wiring enters or passes through compartments it shall be suitably protected mechanically. Secondary wiring layout shall permit alterations to individual circuits without requiring shutdown of the complete switchboard.
3. Bus wires for closing, tripping, control, indication, heaters etc. shall be provided and run within the switchgear shall be suitably sized and individually protected. Bus wires for Serial communication shall be run in a separate tray with metallic enclosure.
4. Secondary wiring for CTs, AC auxiliary supply and inter panel wiring shall be by different colours as specified in the LT & Control cables section.
5. Wiring identification shall be by numbered and/or lettered sleeves, of insulating material adjacent to the terminals. They shall be indelibly marked and removal without disconnecting the wire from its terminal shall not be possible.
6. Flexible cables shall be used for connections on door mounted equipment. Wiring shall be loomed, wrapped in flexible FR PVC conduit and be firmly clamped at both ends to prevent movement at terminations.
7. All flexible control wires of similar types shall be installed in twisted form to reduce EMC propagation.
8. All wiring for external connections shall be brought out to individual terminals on a readily accessible terminal block.
9. Generally no more than two wires shall be connected to a terminal.

K. CABLE TERMINATION

1. Cable terminating facilities and terminals shall be suitable for the specified cable type and conductor size. Consideration and provision shall be taken by the Contractor on the equipment design for the use of cables with aluminium / copper conductors as mentioned on Single Line Diagram / Switchgear schedule.
2. The cable terminals and neutral link shall be brought out to a cable alley suitably located and accessible from the panel front. The current transformers for instruments metering shall be mounted on the terminal blocks. No direct connection of incoming or outgoing cables to internal components of the Panels/Distribution board is permitted.

3. Terminal blocks shall be arranged and positioned to afford ready access for carrying out external cable termination, testing, inspection and maintenance. There shall be ample clear space allowed between the terminals and the gland-plate for the spreading and termination of external conductors.
4. Terminal blocks shall be mounted in a single deck arrangement. Terminal blocks for the connection of external control wiring shall be of the clamp type with a facility to connect two wires on each side of the terminal. A minimum of 20% spare terminals shall be provided.
5. All external wiring shall be on one side of the terminal block only.
6. All terminal blocks shall be shrouded or provided with transparent covers. Pinch screw type terminals are not acceptable.
7. Terminals for different voltages shall be separated by partitions.
8. Terminal boxes (where specified) shall be suitable for dry type terminations unless otherwise specified.
9. A terminal box or chamber with undrilled gland plate or entry panel of sufficient dimensions to terminate the specified cables shall be provided. Direction of cable entry shall be Top / Bottom as per site Conditions & Prior Approval to be taken from Lodha Representative
10. Positioning of cable terminations shall avoid obstruction of other cable terminations, removable covers, etc. and provide for easy access for terminating cables.
11. There shall be sufficient clear space allowed between the terminal block and the cable entry for the spreading and termination of external conductors. Should this not be possible using the standard design in relation to specified cable size then the seller shall incorporate an extended cable glanding box within its design.
12. Termination of single core cables shall be through a non-magnetic gland plate and provision made for bonding and earthing any armour and/or concentric ground conductors.
13. Separate cable facilities shall be provided for each cubicle and for power and control cables.
14. Adequate support arrangement shall be provided for each cable to avoid undue strain on the cable terminations.
15. Cable sleeves shall be of the shrink type, applied cold by a mechanical device or by the use of heat. They shall provide a sufficient thickness of insulation to suit the particular application. Insulation tapes used in joints and terminations shall be compatible with, and have a temperature rating and insulating property not less than the cable insulation. When cables are to be connected to bus bar, breakers etc., the insulation and/or sheath shall be removed for a distance of 150 mm from the connection and replaced by suitable heat resisting insulation for all normal and fire rated cables.
16. The terminal blocks shall be mounted so as to not restrict the movement of withdrawable circuit breakers.
17. Where bus duct is specified, adequate provision shall be made for supporting and fastening of the bus duct at the switchgear. The terminals shall be provided with a sufficient pre-drilled contact area for accepting flexible connectors, and proper access shall be provided for making off (or disconnections of), the connections while the bus duct remains in place.
18. Inter panel wiring within each shipping section shall be the Contractors responsibility. For wiring between shipping sections, the Contractor shall provide terminal blocks on adjoining shipping sections and supply suitable connecting (jumping) wires.

L. METERING, PROTECTION, CONTROL AND INDICATION

1. Meters will be multifunction type units suitable for three- or four-wire systems, capable of recording current, voltage per phase, frequency, KVA, kW and power factor. The display and control unit that is flush or semi flush mounted in instrument compartment door.
2. Where specified, an “intelligent” control, protection and monitoring system shall be provided. Protective relays shall be of the electronic or microprocessor based type. Meters shall be of the microprocessor based type with serial communication facility.
3. Metering, protection and control shall be provided as shown on the single-line diagram(s).

4. Meters and relays shall be capable of withstanding without damage the secondary currents associated with the switchgear rated fault current flowing in the primary of current transformers.
5. External zero adjustment / calibration shall be possible on all indicating instruments to facilitate adjustment without dismantling the instrument.
6. Protective relays shall, wherever possible, be of the draw out type with hand reset operation indicator. Lockout relays shall be of the hand-reset type.
7. Voltage free alarm contacts shall be provided for alarms as shown on the Single-line diagram(s) and as per the requirements of the BMS.
8. Status indication illuminators (green-open, red-closed, amber-tripped) and positive drive mechanical position indicators shall be provided for each circuit breaker. Contacts for remote indication shall be provided.
9. Control of circuit breakers shall be carried out at either:-
   a) Control Switch at Cubicle Door
   b) Remote control desk / panel / DCS (Remote selector switch position indication shall be provided)
   c) It shall be possible to both mechanically and electrically trip circuit breakers at the switchgear.

M. MISCELLANEOUS

1. Anti-condensation heaters with disconnect switch and pilot lamp are to be provided in switchboard, controlled by hygrostat.
2. Schematic and wiring diagram certified and stamped by the manufacturer to be provided suitably located within each switchboard.
3. Indicating lamps shall be of LED type. All indicating lamps shall be of high intensity colored LED type, with guaranteed life of 10 years minimum.
4. All relays shall be certified for 100,000 operations.
5. The voltmeters shall be 144mm x 144mm size, moving iron type, with commutator, range 0-415 V.Voltmeter burden shall not be more than 4.5 VA and enclosure shall be suitable for a RH of 95 percent non-condensing.
6. The ammeters shall be 144mm x 144mm size with expanded scale in the operating region and with MDI indicators on all feeders with necessary current transformers. Ammeter shall be of 600V insulation class and shall have overload scales for motor start duty. Ammeter burden shall not be more than 0.5 VA and enclosure shall be suitable for a RH of 95 percent non-condensing. Ammeters shall carry “dead rider” indicator needles to indicate maximum values recorded. These are to be of the re-settable type.
7. Current transformers provided in the MDB shall be certified to conform to IEC 185, class H insulation, 0.2 accuracy class as per I.E.C and secondary 5A, of suitable VA rating. The Current transformers shall have type test certification from an accredited testing laboratory and shall be subject to 100 percent routine tests as per the IEC.
8. Switchboard shall contain filters as necessary to prevent any harmonics produced “down stream” from traveling “upstream”. To within the I.E.C. recommendations for “point-of-common-coupling”.
9. Switchboard shall contain surge diverters on the incomer feeders.
   a. The surge diverters shall be certified rated for location category C as per BS6651-1999 Annex-C.
   b. The surge diverters shall be individual per phase and shall be Metal Oxide Varistor (MOV) or Gas Discharge Tube (GDT) type.
   c. The surge diverter shall be provided with local visible fault condition indicator and relay contacts wired to provide remote indication of protection status on the BMS.

2.7.7.5 FDB (FINAL DISTRIBUTION BOARDS)

A. All terminals shall be readily accessible from the front of the distribution board.

B. Include for each distribution board to be of the size and type as detailed in the Specification sections, Particular requirements for consumer units shall be as specified in IS 8623 part III.

C. Each unit shall be of the 500 volt pattern as a minimum requirement and be complete with a pressed or fabricated steel case manufactured from sheet steel having a minimum thickness of 16 SWG double door configuration, painted with primer of 2 coats of low VOC paint of approved colour.

D. Hinged doors shall be provided and shall be complete with All DB's front door should be self - lockable.

E. All live terminals or parts shall be shrouded by insulating material to ensure that it is impossible for any live metal to be touched whilst withdrawing or replacing the MCB units or fuses.

F. The Isolator or miniature circuit breakers (MCB) and/or residual current device (RCD) shall be arranged in banks which shall be easily removable to facilitate wiring and connection. Adequate non-ferrous bus-bars shall be fitted to the banks and shall be complete with suitable cast brass terminal for the termination of the cables. The diameter of each terminal pinching screw shall be not less than 75% of the diameter of the cable entry hole.

G. Each distribution board shall be complete with an internal RCD and MCB circuit chart clearly detailing the circuit numbers, area served and the respective circuit breaker sizes. The charts shall be type-written, glued to stiff cardboard, covered with clear Perspex and fixed to the inside face of the door by means of screws and nuts. In addition to the above the Contractor shall hand over a master copy of all such schedules in a ring binder.

H. In addition, each circuit chart shall contain full details of the size and type of cable feeding the distribution board, grouping factors, length of the cable etc., together with the size, type and location of the main or sub-main distribution board or rising busbar serving the board.

I. Circuit and phase colour identification bands shall be fitted to all phase, neutral, earth and control circuit cables. Distribution boards shall be supplied complete with all outgoing MCBs, RCDs etc. as specified in the schedule and also be supplied with blank ways as necessary.

J. Each distribution board shall be new and complete with all necessary shrouds, carriers, Isolator, RCD and MCB units etc., with metal case stove enamelled finished to an approved colour.

K. Where distribution boards are surface mounted, and the installation is concealed within the walls, the conduits shall be terminated in a suitable flush adaptable box measuring not less than 400mm x 400mm. The distribution board shall be mounted over the box and attached to the box with four brass machine screws into threaded holes at the corner of the box and in addition shall be securely fixed to the wall with raw bolts or raw plugs and screws.

L. Final connections between the adaptable box and the distribution board shall be made via a large square or rectangular hole in the back of the distribution board. The edges of the hole shall be finished with a suitable insulating material to ensure that the cables are not pulled over rough or sharp edges.

M. The insulating material shall be securely fixed to the distribution board and the adaptable box shall be adequately bonded to the distribution board by means of a short length of flexible copper tape, bolts, nuts and shake proof washers.

N. Each neutral bar incorporated in distribution boards shall have the same number of connections as there are phase connections within the boards. Each neutral wire connection shall be made in the same order as the phase wires are connected to the protection units.

O. The neutral bar shall be of the same cross sectional area as the respective phase bus-bars.

P. Earth bars shall be provided having the same number of connections as for the phases and the conductors terminated in a like manner.

Q. Where the schematic diagrams indicate a single feed serving two separate distribution boards (for example lighting and power boards) include for manufacturing a composite unit with a solid shrouded copper link between the live side of the board isolators and the incoming feeder cable.

R. For all DB's upto 12 way TPN & SPN no pad locks are required. Distribution Boards (DBs) shall be suitable for operation on 3 Phase/single phase, 415/240 volts, 50 cycles, neutral grounded at transformer. The DB shall be minimum di-electric strength of 2.5 KV / Sec. All Distribution Boards shall be manufactured by a manufacturer listed in List of approved makes

DB's shall comply with the latest Relevant Indian Standards and Electricity Rules and Regulations.

S. All removable/ hinged doors and covers shall be grounded by 4.0 sqm tinned stranded copper connectors. DBs shall be suitable for the climatic conditions. Joints of any kind in sheet metal shall be seam welded, all welding, slag shall be rounded off and welding pits wiped smooth with plumber metal. The general construction shall confirm to IS-8623 for factory built assembled switchgear & control gear for voltage up to and including 1100 V AC.

T. Knockout holes of appropriate size and number shall be provided in the DB's in conformity with the location of cable/conduit connections. Detachable sheet steel gland plates shall be provided at the top / bottom to make holes for additional cable entry at site if required.

U. DBs shall comprises of the following:

1. Installation accessories shall be part of the DB for fixing conductor and rails for mounting MCB's and ELCB's(RCD's) etc.. neutral bus bars & earthing bus bars required in the circuit. All busbars in the DBs shall be insulated type.
2. Service cable /interconnection shall be part of the Distribution Boards.
3. The board shall be installed at a height such that the operating is within reach of the normal human height i.e. 1.8 meters from finish floor level.
4. Degree of protection shall be IP-42 for indoor application and IP-65 for outdoor application.
5. All three phase distribution boards shall have 4 rows and single phase distribution boards shall have single rows for housing of MCB's and RCCB's unless noted otherwise.
6. Phase segregation to be maintained in all three phase distribution boards.
7. Earthing shall be provided in each DB's.
8. 3 Phase DB shall have phase to phase isolation (PPI). It shall have one main neutral and 4 separate sub neutral links, one for each phase of adequate capacity as per number of outgoings per phase.
9. All the DB shall ne minimum 10kA rating.

V. Residential DB shall be of following type

a. Single phase

b. Three Phase or As per SLD/DB schedule.

W. Basement & podium DB shall be with following:

a. Timer control for controlling the lights as per timing i.e.

i. 6p.m. to 9p.m. -100% lighting,

ii. 9p.m. to 11p.m. -70% lighting,

iii. 11p.m. to 6a.m. -20% lighting,

iv. 6a.m. to 7p.m. -0% lighting,

X. Settings shall be altered /decided as specific to the project needs in consultation with FM at the time of handover.

Y. RCD/RCBO for Jacuzzi & bath tub shall be 10mA & to be installed near equipment in an enclosure.

2.7.7.6 COMPONENT

A. MCB's

1. Miniature air break circuit breakers shall be provided in accordance with the following Specification Sections, and shall fully comply with IS 60898, respective codes as specified above. Breakers shall be used for the following types of installation:
   i. Type B MCB - Trips between 4 and 5 times of full load current.
   ii. Type C MCB - Trips between 5 and 10 times of full load current.
   ii. Type D MCB - Trips between 10 and 20 times of full load current
2. Distribution boards incorporating MCB's shall be arranged such that sub-circuits cannot be made alive by unauthorised persons. MCB's shall be of the plug-in type or supplied capable of being locked in the OFF position.
3. All sizes of MCB's shall be checked with the Engineer before any orders are placed. Each MCB, unless otherwise stated, shall be of the hermetically sealed, thermal magnetic type having a rated short circuit capacity Icn of a minimum of 10kA (unless otherwise noted) at 415volts a.c.
4. MCB's used for the final means of protection and isolation to items of fixed or removable equipment shall be complete with flush GI box and with front plate arranged as overlapping for flush mounted units.
5. Assemblies shall be arranged for flush or surface mounting as indicated in the detail sections of this Specification, schedules or drawings, and the associated front plates shall be finished to match the general lighting switches.
6. MCB's shall be provided with positive means for preventing any one pole of a multi-pole MCB being operated or tripped independently of the other poles.
7. Coordination shall be achieved for all load conditions, i.e. a fault on a downstream circuit shall not cause supply to a distribution board to trip. Miniature Circuit Breaker shall comply with IS-8828-1996/IEC60 898-1995. Miniature circuit breakers shall be quick make and break type for 230/415 VAC 50 Hz application with magnetic thermal release for over current and short circuit protection.
8. The MCB shall be suitable for manual closing, opening and automatic tripping under overload and short circuit. The MCB shall also be trip free type.
9. Single pole / three pole versions shall be furnished as required and all MCB's shall be DIN rail mounted with double locking tightening screws.
10. MCB shall ensure complete electrical isolation of downstream circuit or equipment when the MCB is switched OFF.
11. The MCB's shall be housed in the panel boards and shall have suitable connections at the outgoing terminal for termination via tinned cable lugs and for bus-bars connection on the incoming side
12. The housing shall be heat resistant and having a high impact strength. The terminals shall be protected against finger contact to IP20 Degree of protection. All DP, TP, TPN and 4 Pole miniature circuit breakers shall have a common trip bar independent to the external operating handle.
13. The terminal of the MCB's and their open and close conditions shall be clearly / indelibly marked.
14. The MCB's shall be rated for 10 KA fault level. or as per the rating listed on the drawings/ load schedule/ approved drawings/ or elsewhere to comply with the discrimination and tripping philosophy.
15. The MCB's shall be suitable for housing in the lighting boards and is suitable for connection at the outgoing side by tinned cable lugs and for bus-bars connection on the incoming side.

B. RCCBs, RCBOs, RCDs

1. All Residual Current Device (RCD) shall comply with the respective codes as specified RCDs shall be provided within every distribution board to comply with the requirements of the local supply authority.
2. The RCDs shall be suitable for minimum 20,000 operations.

3. A test device shall be incorporated to check the integrity of the earth leakage detection system and the tripping mechanism. When the unit is connected to service, pressing the test knob shall trip the RCD and the operating handle shall move to the "OFF" position
4. The enclosure of the RCD shall be moulded from high quality insulating material. The material shall be fire retardant, anti tracking, non-hygroscopic, impact resistant and shall with stand high temperature.
5. All parts of switching mechanism shall be non-greasing, self lubricating material so as to provide consistent and trouble free operation.
6. RCD shall be 2/4 pole 415 volts 50Hz, 30-300mA sensitivity. The rating of the RCD shall be as required.
7. These shall be suitable for manual closing and opening and for automatic tripping under earth fault circuit of 30-300 mA where the tripping shall be current/voltage tripping.
8. Operation of RCD shall be independent of mounting position and trip free type. RCDs shall be provided within every distribution board to comply with the requirements of the local supply authority. The sensitivity of the RCDs shall be as follows:-

Circuit/Equipment/Apparatus	Rated Operating Current (mA)
6/16A switched socket outlets	30
Water heater/coolers	30
Refrigerator/washing machine and similar apparatus	30
Domestic water pumps	30
Under water lighting	10
16A switched socket outlets (general purpose)	30
General lighting	30
Flood lighting	100/300
VRV/Split type air conditioner	100
Fan coil/air handling units/VAV	100
Package type A/C unit	100/300
Chiller	100-500-1000
Irrigation pump	100
Electric cooker	100
Industrial machine	100/300
Elevators/Escalators	300/500
Neon sign/Cold Cathode/Facade lighting	300

C. TIME SWITCHES

1. Time switches shall be self-contained unit suitable for mains operation. All units shall have self-starting synchronous motor with single-pole fuse in the motor circuit, 3-way terminal block and thirty-six (36) hours spring reserve complete with an automatic solar dial/ solid state switch with timing control. Rating shall be selected 10% excess of the circuit it is feeding.
2. The solar dial shall be capable of switching ON The lighting at sunset and OFF at sunrise throughout the year by control of a secondary calendar dial with month and day settings. The automatic switching time shall be adjustable.
3. Time switches shall be encased in dust-tight metal casing having hinged front cover with clear Perspex window. The casing shall be effectively earthed.
4. A manual bypass switch shall be incorporated with the time switch to facilitate maintenance of the latter.

2.7.7.7 AUTOMATIC TRANSFER SWITCHES (Through Electromechanical interlocks)

A. Mechanically Held Transfer Switch

1. The transfer switch shall be electrically operated and mechanically held. The electrical operator shall be a momentarily energized, single-solenoid or linear motor mechanism (upto 1000A). Main operators which include over current disconnect devices shall not be acceptable.

2. The switch shall be mechanically interlocked to ensure only two possible positions under normal operation and only one position at a time, normal or emergency.
3. The switch shall be positively locked and unaffected by momentary outages, so that contact pressure is maintained at a constant value and contact temperature rise is minimized for maximum reliability and operating life.
4. All main contacts shall be silver composition. Switches rated 160 amperes and above shall have segmented, blow-on construction for high withstand and close-on capability and be protected by separate arcing contacts.
5. Inspection of all contacts shall be possible from the front of the switch without disconnection of power conductors. Switches rated 600 amps and higher shall have front removable and replaceable contacts. All stationary and moveable contacts shall be replaceable without removing power conductors and/or bus bars.
6. Designs utilizing components of moulded-case circuit breakers, contactors, or parts thereof, which are not intended for continuous duty, repetitive switching or transfer between two active power sources, are not acceptable.
7. Where neutral conductors must be switched as shown on the plans, the ATS shall be provided with fully rated simultaneous switching or overlapping neutral transfer contacts. In case of overlapping neutral, the neutrals of the normal and emergency power sources shall be connected together only during the transfer and retransfer operation and remain connected together until power source contacts close on the source to which the transfer is being made. The overlapping neutral contacts when provided shall not overlap for a period greater than 100 milliseconds.
8. Where neutral conductors are to be solidly connected as shown on the plans, a neutral conductor plate with fully rated AL-CU pressure connectors shall be provided.

B. Mechanically Held Transfer Switch:

1. Voltage and frequency on both the normal and emergency sources (as noted below) shall be continuously monitored, with the following pickup, dropout, and trip setting capabilities (values shown as % of nominal unless otherwise specified):

Parameter	Sources	Dropout / Trip	Pickup / Reset
Undervoltage	TPN&E	70 to 98%	85 to 100%
Overvoltage	TPN&E	102 to 115%	2% below trip
Underfrequency	N&E	85 to 98%	90 to 100%
Overfrequency	N&E	102 to 110%	2% below trip
Voltage unbalance	N&E	5 to 20%	1% below dropout

Repetitive accuracy of all settings shall be within minimum ± 1% over an operating temperature range of -20°C to 60°C.

2. Voltage and frequency settings shall be field adjustable in 1% increments either locally with the display and keypad or remotely via serial communications port access.
3. Source status screens shall be provided for both normal & emergency to pro-vide digital readout of voltage on all 3 phases, frequency and phase rotation.

C. Time Delays:

The following adjustable time delays shall be provided:

1. 0 to 6 seconds to override momentary normal source outages and delay all transfer and engine starting signals.
2. 0 to minimum of 120 sec on transfer to emergency for controlled timing of transfer of loads to emergency.
3. 0 to 60 minutes for actual normal power failures and for the test mode function. Time delay shall be automatically bypassed if the emergency source fails and the normal source is acceptable.
4. 0 to minimum of 40 minutes on shut down of engine generator for cool down.
5. 0 to minimum of 1 minute to drive an external relay(s) for selective load disconnect control. The controller shall have the ability to activate an adjustable time delay.

D. External AC Power Supply:

1. Provision shall be for static inverter backed 230V AC power supply to allow the LCD and the door mounted control indicators to remain functional when both power sources are dead. The supply shall include 2 hour battery backup and to be charged via mains supply.

E. Withstand and Closing Ratings:

1. The ATS shall be rated to close on and withstand the available RMS symmetrical short circuit current at the ATS terminals with the type of over current protection shown on the plans.
2. The ATS shall be labelled in accordance with 1½ and 3 cycle, long-time ratings. ATSs which are not tested and labelled with 1½ and 3 cycle (any breaker) ratings and have series, or specific breaker ratings only, shall not acceptable.

F. Proprietary ATS

1. Below are technical requirements for proprietary ATS units to be incorporated as per item A to E listed above and as per below schedule:

Sl No	Item Description	Proprietary ATS Compliance Required
1	ElectroMagnetic Compatibility (EMC)	EN 61000 (all part compliance required)
	Conducted Radiated Emissions	EN55022
	Voltage Dips & Interruptions Immunity	EN61000-4-11 (1994)
2	ATS manufacturing and testing Standards	The ATS is fully complaint to UL 1008 or IEC 60947-6-1 and IEC 60947-3 .
3	ATS operation Ratings	1) Rate short time withstand current for 1 second Icw (Ka effective) as per SLD 2) Short circuit making capacity(KA peak) as per the system kA 3) Prospective short circuit(kA rms)as per the system kA 4) Shall be operated with ACB/MCCB/SFU
4	Electrical endurance test	ATS should be tested for mixed load AC-33A duty cycle however AC-31A & B,AC-32A & B,AC 33-B, AC -31B is acceptable with due de-rating applied wrt to temperature and duty cycle.
5	Neutral Position	Overlapping Neutral or Open Transition Transfer Switch with neutral rating with same current and withstand capacity as that of power poles moreover syncronized with them in term of switching. The time difference between poles and neutral switching is in the range of 50 µs-500 µs which negligible for any switching surge to come up. The same is negligible for neutral to float in the absence of phases.
6	Self power ATS	ATS should be self powered from the source whichever available.
7	Operation mechanism	Double throw switch with single solenoid operation or two switches on common shaft ensuring better mechanical interlocking with single controller
8	Product offered	63A-160A: ATyS M 125A- 3200A ATyS e
9	Speed of operation	As specified in the SLD's
10	In phase monitor for phase angle	In phase monitoring is required or the status transition should take place @ zero position wherein all phase and neutral current are zero together with delay in change in position such that there shall not be any in rush currents. Above conditions are achieve through inbuilt controllers comprising of monitoring and control modules.
11	ATS Construction and Performance Test Agency	ASTA/KEMA/KEMA KEUR/UL

G. Tests & Certification:

1. The complete ATS shall be factory tested to ensure proper operation of the individual components and correct overall sequence of operation and to ensure that the operating transfer time, voltage, frequency and time delay settings are in compliance with the specification requirements.
2. Upon request, the manufacturer shall provide a notarized letter certifying compliance with all of the requirements of this specification including compliance with the above codes and standards, and withstand and closing ratings. The certification shall identify, by serial number(s), the equipment involved. No exceptions to the specifications, other than those stipulated at the time of the submittal, shall be included in the certification.
3. The ATS manufacturer shall be certified to ISO 9001 International Quality Standard and the manufacturer shall have third party certification verifying quality assurance in design/development, production, installation as per item F-11 and servicing in accordance with ISO 9001.

H. Service Representation:

1. The service center's personnel must be factory trained and must be on call 24 hours a day, 365 days a year.
2. The manufacturer shall maintain records of each switch, by serial number, for a minimum of 20 years.

2.7.7.8 CAPACITORS

A. Unless specified otherwise Capacitor Banks shall conform in design, material, construction and performance to the latest editions of the International recommendations (IEC standards). In addition to the above listed standards, the local authority regulations shall also be adhered to.

B. Construction: Multiple capacitor cells or elements, factory wired in 3 phase groups and mounted in metal enclosures.

C. Capacitors: The capacitors shall be automatic type, of modular design and suitable for vertical or horizontal mounting. The capacitors shall be of dry-type low loss units and shall not require any gas or liquid impregnation. Use of poly chlorinated biphenols (PCB) and oil as capacitor impregnation will not be permitted.

D. Capacitor Bank circuit breakers: Current-limiting, non-expulsion type, factory installed in each phase and located within the equipment enclosure. Features include the following:

E. Circuit breakers ratings and characteristics: As recommended by capacitor manufacturer to prevent capacitor bank rupture.

F. Viewing Window: On each capacitor section door to allow for visual inspection of the individual capacitor circuit breakers.

G. Enclosure: Capacitor bank enclosure shall be from approved manufacturer. Wherever the capacitor bank is part of the main distribution board and interconnected internally with busbars, the enclosure shall be of same construction as the approved main distribution board. Enclosure types are as follows:

Indoor Enclosures: IP52 as per IEC 60529 or as indicated.
Outdoor Enclosures: IP56 as per IEC 60529 equipped with watertight conduit connections.

2.7.7.9 FIXED CAPACITORS

A. Description: Integrally fused, unless otherwise indicated, with quantities, ratings, mounting provisions, and electrical connections as indicated.

B. The capacitors shall have a rated operational voltage of 300/415V AC, 50Hz, 3-phase and rated insulation level of 6KV for 1minute at 50Hz. The capacitors shall be suitable for withstanding a current overload of at least 30% and a voltage overloads of at least 10% as standard. The tolerance on capacitance values shall be in the range of 0 to +10%. The current consumption of the capacitor unit shall not exceed 2.2A/Kvar.

C. Discharge Resistors: Each capacitor element shall have a built-in discharge resistor to fully discharge the capacitor before energizing and re-charging the capacitor to minimize the voltage transients. Resistors may be omitted if permitted by IEC standards.

D. Internal Wiring: Factory wired, ready for field connection to external circuits at a single set of pressure terminals.

2.7.7.10 AUTOMATIC POWER-FACTOR-CORRECTION UNITS

A. Description: Factory installed in its own enclosure and connected to power circuits as indicated. Units include a separately mounted current transformer to sense current in the power circuit and to provide input to the unit controls.

B. Configuration: System includes integrally mounted, factory-wired major components including the following:

1. Incoming line section including main disconnect switch.
2. In-rush reactor section.
3. Multiple-fused capacitor banks.
4. Multiple vacuum load interrupter switches.
5. Control cabinet.
6. Power-factor meter.

C. Performance Requirements: Controls permit operator to select a target power factor adjustable to any value between 0.95 and 0.80 lagging. Regulator shall be of user programmable type microprocessor based or electronic controller. Regulator shall be suitable for 6-step switching or 12-step switching with various switching programming option. The regulator shall have soft touch keys integral to program the unit. The regulator unit in addition to switching the capacitor for automatic compensation shall provide the alarms for over compensation. There shall be alarm for over voltage also. The unit shall have a 7 segment LED display unit which shall display the parameters for programming and status. The regulator shall be suitable for flush mount and shall be mounted on the front door of the capacitor bank. The regulator accuracy class shall be at least 1.5%. Controls continuously sense the power factor on the circuit being corrected and, when the power factor differs from the target setting for more than 10 seconds, operate a vacuum load interrupter to switch a capacitor bank into or out of the circuit. Interrupters are opened or closed as required to bring the corrected circuit power factor closer to the target setting. Switch only 1 capacitor bank at a time.

D. Solid-state, microprocessor-based controls include an under voltage relay that interrupts capacitor switching for power supply interruptions longer than 15 ms. "Advance" and "Retard" push buttons on the control panel permit manual sequencing of capacitor switching.

E. 3-Pole, Load Interrupter Switch: Rated for the repetitive high-inrush-switching duty presented by the capacitor loading.

F. Fuses for Protection of Capacitor Banks: Rated to protect interrupter, interconnecting wiring, and capacitors.

G. In-rush Limiting Reactor: Installed in capacitor circuits where required to limit switching surges to within interrupter ratings. Reactors are mechanically braced to withstand the maximum fault current to which they may be exposed.

- Indicating lights designate energized capacitor banks.
- Plated copper, braced to withstand the maximum fault current to which it may be exposed.

H. Enclosure Access: Hinged door with hand-operated catch. Door is interlocked with cor ols or main circuit breaker to de-energize capacitors when door is opened.

I. Current Transformer: Type and configuration to suit sensing and mounting conditions.

J. Power-Factor Meter: Switchboard type, mounted in the enclosure door, with 0.5 lagging to 0.5 leading scale and accuracy of plus or minus 1 percent.

K. Main Disconnect Switch: Operable from outside the enclosure to disconnect the unit with an operating handle that can be padlocked.

L. Contactors: provided for capacitor switching (capacitor without detuning reactors) shall be of pecial contactor designed for switching capacitors. Special capacitor switching contactors shall b fitted with a block of early make poles and damping resistors, limiting the value of the current on closing to 60In max. The current limitation at switch-on shall increase the life of all the components in the installation, in particular that of the fuses and the capacitor. Contactors shall be at least suitable for 100 operating cycles / hour. Contactor shall withstand the prospective peak current of 200In at

switch on. Contactor for switching capacitor with detuning reactors shall be as per manufacturer recommendations.

M. Detuned reactors: shall be provided where high harmonic pollution (Gh > Ssc/70) is present. Detuned reactors shall be designed to protect the capacitors by preventing amplification of the harmonic present on the network. Detuned reactors shall be connected in series with the capacitors. The capacitor voltage rating shall be increased by 10% when used with the detuned reactors.

N. Detuned reactors shall be three phase iron core with copper winding. Detuned reactors shall be natural air cooled, dry type with aluminum foil windings insulated between layers which are impregnated under vacuum.

O. Detuned reactor shall atleast meet the following technical characteristics:

1. Tolerance: +/- 5%
2. Tolerance between phase: Lmax / Lmin <1.07
3. Turning order: 4.3 (relative impedance: 5.4%)
4. Harmonic current spectrum for turning order 4.3:
   a) I 3 = 2 % I1
   b) I 5 = 69% I1
   c) I 7 = 19 % I1
   d) I 11 = 6 % I1
5. Permissible over load fundamental current: 1.1 times the nominal current (I1)
6. Insulation level: 1.1KV
7. Test voltage (coil to core): 3KV 1minute

2.7.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver in sections of lengths that can be moved past obstructions in delivery path. Deliver MDBs and components properly packaged and mounted on pallets, or skids to facilitate handling of heavy items. Utilize factory-fabricated type containers or wrappings for MDBs and components to protect equipment from damage. Inspect equipment to ensure that no damage has occurred during shipment.

B. Store indoors in clean, dry space with uniform temperature to prevent condensation. Protect from exposure to dirt, fumes, water, corrosive substances, and physical damage.

C. Handle MDBs carefully to prevent physical damage to equipment and components. Remove packaging, including the opening of crates and containers, avoiding the use of excessive hammering and jarring which would damage the electrical equipment contained therein. Do not install damaged equipment; remove from site and replace damaged equipment with new.

2.7.9 COORDINATION

A. Coordinate layout and installation of main distribution boards and components with other construction and electrical work, including conduit, piping, equipment, adjacent surfaces, raceways, electrical boxes and fittings, and cabling/wiring work. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Co-ordinate locations to ensure a clear safety working space of a least 1000mm all around the MDB and a clearance of at least 2000mm in the front, except specifically permitted otherwise.

C. Coordinate size and location of supporting frames / concrete bases (as applicable). Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements.

2.7.10 EXECUTION

2.7.10.1. EXAMINATION

A. Examine elements and surfaces to receive switchgear for compliance with requirements for installation tolerances, required clearances, and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.

2.7.10.2. INSTALLATION

A. Install main distribution boards as indicated, in accordance with manufacturer's written instructions, and with recognized industry practices; complying with applicable requirements of applicable standards or codes approved.

B. Install Main Distribution Board only after the room has been fully completed, including all painting and made dust tight and vacuum cleaned.

C. Installation to be certified by manufacturer/authorized representative.

D. Equipment Bases: Ensure that concrete bases and foundations provided for installation of equipment are constructed in accordance with the approved Shop and Construction Drawings and equipment manufacturers' drawings and that holes for fixing bolts and provisions for passage of cables etc. are provided as required.

E. Alternatively, Switchboards can be anchored to steel-channel sills 100 mm high (min and as necessary), arranged and sized according to manufacturer's written instructions. Attach by tack welding or bolting. Level and grout sills flush with motor control center mounting surface

F. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from main distribution board units and components.

G. Cable Trenches: Ensure that trench construction and covers where provided for installation of power and control cables are in accordance with the approved Shop and Construction Drawings.

H. Built-In Items: Ensure that equipment supports, fixings and the like, and sleeves for passage of feeders and cables which are to be built into concrete foundations, bases, cable trenches or building structure are provided as and when required and that they are properly installed.

I. Equipment: Install on concrete bases etc., and assemble completely plumb and level, before grouting in holding-down bolts. Installation to be inspected and certified as fit for "energization" by manufacturer/authorized representative.

J. Supports And Terminations: Install all incoming and outgoing cable supports, cable ends and termination fittings required for power and control cables.

K. Relays: Set in accordance with manufacturer's instructions and in accordance with an approved scheme.

L. Make Good, damage painted surfaces, clean and apply rust-inhibiting prime coat and 2 finishing coats of approved enamel upon delivery of equipment to site, or as required by the Engineer.

M. Operating Instructions: Frame and mount the printed basic operating instructions for main distribution boards, including control and key interlocking sequences and emergency procedures. Fabricate frame of metal and cover instructions with clear acrylic plastic. Mount in front of main distribution boards.

N. Install clear copy of certified and stamped "As-Built" drawings inside the Panel

O. Install panel key on stainless steel chain fixed securely alongside board.

P. Correction of errors generated during busbars installation: Ensure that these errors, such as excessive busbar drilling, do not affect the electrical properties and current carrying capacities of the busbars. The Engineer reserves the right to reject such unsatisfactory installations.

Q. An approved type 1.20m wide non-slip rubber floor mat in accordance with IEC 61111 and rated to 1.0kV shall be fitted along the full length of each main LV. switchboard supplied. This material shall suitable for heavy duty electrical safety matting and shall be fully tested and certified for electrical insulation properties to IEC 61111; 2009 and shall be continuously marked with 5kV

Proof Test, 10kV Withstand Voltage and 1000V Working. Each matt to IEC 61111 Class 0 - 6mm Thick.

R. Heavy grade bitumastic felt shall be provided between the floor and the switchboard. The switchgear shall be installed in accordance with the manufacturer's recommendations, the specification and any requirements of the local power supply authority requirements .After installation and levelling, ensure all entries into the switchboard are insect and rodent proof by means of suitable plates, grouting or screens.

2.7.10.3. CONNECTIONS

A. Tighten bus joints, electrical connectors, and terminals according to manufacturer's published torque-tightening values.

2.7.10.4. FIELD QUALITY CONTROL

A. Equipment: Inspect equipment upon delivery to Site and report any damage to the Engineer.

B. Switchgear: Inspect and check switchgear for completeness, component ratings, types, sizes, and wiring connections. Check phasing of busbars, contacts and clearances.

C. Prior to energization of circuitry, check all accessible connections to manufacturer's torque tightening specification.

D. Tests: After installation and before hand-over, carry out all visual and mechanical inspection and electrical tests required by the governing codes and any other tests the Engineer may require to check compliance of installation with the Specification, including, but not limited to, the following. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest. All testing to be witnessed/certified by manufacturer as acceptable results.

1. Insulation resistance tests for each main distribution board bus, component, connecting supply, feeder, and control circuit.
2. Continuity tests of each circuit.
3. Operational tests.

E. Test Procedure: Conform to the following:

F. Protective Device and Relay Settings: Verify that settings given on the Drawings are appropriate for final system configuration and parameters based on system study. Where discrepancies are found, recommend final settings for approval before making final adjustments.

G. Submit short circuit and coordinated relay settings with calculations based on IEC from the medium voltage incomer to the final load.

H. Load shedding program to be developed by identifying the nonessential loads for generator or turbine loading.

I. Main And Control Circuits: Using 1000 V megger (2000 Megohm range), check insulation resistance between phases, between phases and earth/enclosure and between neutral and earth.

J. Primary Injection Tests: Provide portable test equipment to test time-delay characteristics of circuit breakers by simulating an overload or fault condition. Measure and record all test results and ambient conditions and compare with manufacturer's data.

K. Instantaneous Trip Elements: Test by high current primary injection, using high-current primary injection test-sets and reports all readings.

L. Routine tests on site are to be carried out on every main distribution board in accordance with the Standard specified for FBAs assembled from standardized components outside the works of the manufacturer. Routine tests are also to be carried out on every FBA, delivered to site, if requested by the Engineer.

M. Manufacturer/authorized representative shall install and certify "equipment ready for energization"

N. All test record certificates shall be clear, having a distinctive test certificate number, signed and certified by authorized testing agency, contractor and Engineer.

O. Conduct site test with Oscilloscope after loading of the MDB to demonstrate that harmonic filters function properly as specified.

P. Inspections and Tests for Power Factor Correction Capacitors: Inspect and test component features, functions, operations, and protective devices according to manufacturer's instructions and International Electrical Testing Association.

Q. Re-test: Correct deficiencies identified by tests and observations and retest until specified requirements are met

2.7.10.5. CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

2.7.10.6. DEMONSTRATION

A. General: Manufacturer's factory-authorized service representative to train the Employer's personnel in the operation of the Unit.

B. Equipment: Check operation of each unit with Owner's personnel present and before Substantial Completion. Determine that operational systems and devices are functioning properly.

C. Instruction: Instruct the Employer's personnel in proper use, maintenance, adjustment, and repair of each system.

2.7.11 SAT FOR LV PANEL

Inspection and Testing on Main LV Switchboards

a. Visual Inspection tests

1. Name plate details as per drawings .....
2. Physical and mechanical condition satisfactory .....
3. All insulators physically inspected and are free from any damage .....
4. Installation of the CB and compartment satisfactory .....
5. No scratches or damages on the sheet metal parts .....
6. Lubricants correctly applied to movable parts .....
7. Correct lubricants applied to current carrying parts .....
8. Current transformer name plate details as per drawings .....
9. The switchgear components match with Single Line Diagrams .....
6. Tightness of accessible bolts tested with a torque wrench .....
7. Mechanical rack in / rack out operation is smooth and satisfactory .....
8. Mechanical opening and closing operation is smooth and satisfactory .....
9. Manual spring charging mechanism is tested and satisfactory .....
10. Mechanical indication for spring charging mechanism satisfactory .....
11. All the required tools available in a box as per manufacturer's recommendation.....

b. Electrical Tests

(i) Components testing

1. Confirm completion of testing on CTs .....
2. Confirm completion of testing on MCCBs .....
3. Confirm completion of testing on CBs .....
4. Confirm completion of testing on Protection relays .....
5 Confirm completion of testing on Panel Meters .....
6. Confirm completion of testing on earthing system .....
7. Confirm completion of Primary Injection testing .....

(ii) Insulation Resistance tests on the Switchboards

Apply 1000 V DC for 1 minute.

Phase	IR Value in M Ohms
R (Y& B shorted and earthed)	
R (Y& B shorted and earthed)	
R (Y& B shorted and earthed)	

(iii) High Voltage Test

Applied Voltage :1.6kV AC for 1 Min

Phase	Leakage Current (mA)	Remarks
R (Y & B Phases shorted and Earthed)		
Y (R & B Phases shorted and Earthed		
B (R & Y Phases shorted and Earthed		

(iv) IR Test (After HV)

Applied Voltage : 5kV DC for 1 Min.

Phase	IR Value in M Ohms
R (Y& B shorted and earthed)	
Y (Y& B shorted and earthed)	
B (Y& B shorted and earthed)	

(v) Contact Resistance Measurement

Current Injected :

Feeder / Section	Contact Resistance in μΩ		
	R	Y	B

(vi) *Contact Resistance Measurement for Busbars

Current Injected :

BusBar / Bus Section	***Contact Resistance in μΩ***		
	R	***Y***	***B***

(vii) Changeover scheme logic tests

a) In Service Position

Mode of Selector Switch	Manual		Auto			
Condition						
Incomer – 1						
Incomer – 2						
Bus Coupler						
Remarks						

(viii) Phase Rotation Tests

Feeder / Section	Phase Rotation

(ix) Inspection and Testing of MDB Under Voltage Relay

c. RELAY DATA

RELAY TYPE		MODEL NUMBER	
AUX VOLTS		SERIAL NUMBER	

d. GENERAL INSPECTION AND CHECKS

(1) Installation and wiring correct to relevant drawings ……
(2 Model Number and rating information correct ……
(3 Relay case connected to local earth bar ……
(4 Output contacts are operating properly ……
(5 Insulation resistance to earth ……

e. TEST RESULTS

Relay settings :

a. Under Voltage Pick up test

Phase	Under Voltage setting (V)	Pick up Voltage (V)	
		Actual	Expected
R			
Y			
B			

b. Timing Tests

Phase	Relay U/V setting	Time delay setting	Time to pick up	
			Actual	Expected
R				
Y				
B				

END OF SECTION –B 2.7