
SECTION 17 LOW VOLTAGE SWITCHBOARDS

1.0 GENERAL

1.1 WORK DESCRIPTION

The switchboard shall be built in accordance with IEC 439 “Factory Built Assemblies for Low Voltage” or BS 5486 “Factory-built Assemblies of Switchgear and Control Gear for Voltage up to and including 1000 AC and 1200V DC.

All factory built assemblies shall be capable of withstanding the electrical, mechanical and thermal stresses of the prospective fault level experience. The prospective fault levels of the various factory built assemblies shall be as indicated in the Drawings.

All equipment used in the factory built assemblies shall have been type tested. Type set certificates shall be submitted for all major equipment at the time of technical submission. Besides, a full type test report as specified under IEC 60439-1, the Low voltage switchboard shall also be tested for electromagnetic compatibility (EMC), internal arcing-fault test and seismic withstand test under the relevant standards.

All factory built assemblies, as a complete unit shall have a rating equal to or greater than the integrated equipment rating as indicated in the Drawing.

All factory built assemblies subject to rain or wet conditions or located outside electrical switch room shall be weatherproof constructed to IP 65, able to withstand high impact strength of 60 KN/m² (min), temperature resistant with consideration of Ambient temper 50°C and average switch room temperature 40°C. Flame retardant and corrosion resistant.

1.2 STANDARDS

The LV switchboards and distribution boards shall be constructed in accordance with the latest revision of the following standards:

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| 1. | BS 88 | : | Cartridge fuses for voltages up to and including 1000V AC and 1500V DC. |
| 2. | BS 89 | : | Direct acting electrical indicating analogue electrical measuring instruments and their accessories. |
| 3. | BS 142 | : | Electrical protective relays |
| 4. | BS 159 | : | Busbars and busbar connection |
| 5. | BS 1433 | : | Copper for electrical purposes. Rods and bars. |
| 6. | BS EN 60898 | : | Circuit-breakers for over current protection for household and similar installations. |
| 7. | BS 3938 | : | Current transformers |
| 8. | BS EN 60947-2 | : | Low-voltage switchgear and controlgear, Part 2 circuit-breakers. |
| 9. | BS 4794 | : | Control switches (switching devices, Part 1 including contactor relays, for control and auxiliary circuits, for voltages up to and including 1000V AC and 1200V DC). General requirements. |
| 10. | BS 5419 | : | Air-break switches, air-break disconnectors, and fuse combination units for voltages up to and including 1000V AC and 1200V DC. |
| 11. | BS 5420 | : | Degrees of protection of enclosures of switch Part I |

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| 12. | BS 5424 | : | great Part I and controlgear for voltages up to and including 1000V AC and 1200V DC. |
| 13. | BS 5486 | : | Controlgear for voltages up to and including 1000V AC and 1200V DC – Part 1 Contactors. |
| 14. | BS 5685 | : | Low-voltage switchgear and control gear Part 1 assemblies. Part I : Requirement for type tested and partially type tested assemblies. |
| 15. | BS 5992 | : | Electricity meters – Part I : Class 0.5, 1 and 2 single phase and polyphase, single-rate and multi-rate watt-hour meters. |
| 16. | BS 6004 | : | Electrical relays |
| 17. | BS 6231 | : | PVC insulated cables, (non-armoured), for electric power and lighting. |
| 18. | BS7430 | : | PVC insulated cables for switchgear and controlgear wiring. |
| 19. | IEC 60439-1 | : | Earthing |
| 20. | AS 3439-1 | : | Low-voltage switchgear and controlgear assemblies Part 1 : Type-tested and partially type-tested assemblies |
| 21. | IEC 68-3-3 | : | Low-voltage switchgear and controlgear assemblies. Part 1 : Type-tested and partially type-tested assemblies |
| | | | Environment testing Part 3 : Guidance Seismic test methods for equipments. |

BS/IEC or other National standards not mentioned above but are applicable to this installation shall also apply.

1.3 SUBMISSION

A component list and catalogues.

Detailed shop drawings of all factory built assemblies shall be submitted for approval before construction commences.

Such drawings shall show the proposed method of construction of the cubicles, method of supporting equipment and busbars, full details of busbar layout, method of support, electrical control wiring diagrams, equipment weight, colours and surface treatment.

The drawings shall also incorporate a full list of proposed materials. The construction shall not commence until the drawings are approved for construction.

Factory and site testing procedures and report formats shall also be included.

2.0 PRODUCTS

2.1 GENERAL

The factory built assemblies shall be of the totally enclosed, modular cubicle type, which are extensible and suitable for floor mounting as indicated in the drawings. The assemblies shall be manufactured in a facility that is ISO 9000 certified.

The factory built assemblies shall be compartmented and utilize sheet steel plates of thickness as detailed below. The panels shall be vermin proof and constructed to a minimum degree of

protection of IP ratings to BS 5420. The IP ratings indicated below shall be applicable unless otherwise indicated in the drawing.

Main and Sub-Switchboards

1. 2mm thick sheet steel
2. Form 4a, Type 3 for Main Board and for Emergency Board and Form 2b, Type 2 for Distribution Board unless otherwise specified to BS 5486 with separation of busbars from the functional units and separation of all functional units from one another
3. Minimum IP 44 and IP 2X after opening of doors & panels (of external covers) unless otherwise specified.
4. IP65 for location subject to rain wet conditions or located outside electrical switch room.
5. Switchboard frame shall be of modular detail and extensible.
6. The interior of each cubicle shall be dust inert and vermin resistant.

Switchboard frames shall be fabrication of 2.0mm thick electro-galvanized steel. All joints shall be neatly formed and finished flush with the adjacent surfaces by grinding and/or machining. No joints shall be located on a corner and all bare edges shall be lipped.

Structural members and bracing, where necessary, shall be welded or bolted to the frame.

2.2 DOORS AND PANELS

Full access shall be provided to service and maintain all equipment inside each cubicle by means of a suitable hinged door that shall open a minimum of 120 degrees. All hinged doors shall have an earth braid connected to the cubicle.

Doors and panels shall be constructed of 2 mm electro-galvanized sheet steel, pressed or rolled so that edges are given a neat round finish and shall reinforced with a suitable frame welded to the inside folded edge of the door. An approved stiffener shall be welded to the inside of each door and/or panel.

Doors shall hang on substantially concealed non-corrosive hinges and shall be fitted with good quality door handles to Engineer's approval which shall be lockable and operable by the same key. The door handles shall be fitted with toggles to operate rods to latch with suitable slots in both the top and bottom of the switchboards. Latching rods shall be guided by brackets. The latching rods and associated brackets shall be cadmium plated.

All front, side and top panels shall be constructed in a manner similar to that specified for doors above. They shall be fitted to the frame from the outside with captive, hand tightened screw. Panels longer than 1.2 meters shall be provided with 3 point locking system

2.3 BASEPLATE AND INSULATING PANELS

The switchboards shall be mounted on 50mm X 50mm C-channel. Wherever insulating panels are required to mount special equipment, they shall be of high quality black bakelite, polished on the front.

All edges must be cut straight and square and shall be chamfered on the front edge with a 3mm chamfer.

2.4 FINISHING OF METAL WORK

Panel work of the switchboards shall be finished with electrostatic epoxy power coating of minimum 50 microns all treat with 180°C 12 minute oven backing. All metal work shall be rust inhibited and sprayed with two coats of primer. The painting shall be of best quality oven-bake epoxy power coated, of Grey colour.

After erection on site and after all inspection and tests have been carried out, the Contractor shall thoroughly clean all painted parts, touch-up with application of an additional coat of anti-corrosive structural priming paint to any part of the originally painted surfaces that have been scratched or otherwise marked and at least one additional touch-up finishing coat of Grey colour.

2.5 BUSBARS AND CURRENT CARRYING PARTS

The manufacturing of the busbar system shall comply to the latest edition of BS 158 and BS 159. All busbars and current carrying parts shall be manufactured to carry a current density of not more than 1.55 A/mm² and shall be capable of carrying normal current continuously without the temperature rise of any part exceeding 30°C. Their location shall be such as to ensure adequate spacing between conductors and they shall be securely fastened and braced to withstand all stress set up during transportation, erection and normal operation, and under short circuit conditions. The busbars shall not be damaged in any way under a fault of short circuit experience with minimum 46 MVA for 3 seconds. Where two or more conductors are used to form a phase, it shall be separated with an air gap sufficient to allow for the ventilation of the individual conductors all round. Busbar supports shall be made of slotted first grade "Bakelite" or glass fiber reinforced polymer able to withstand minimum operating temperature of 110°C.

All connections in current carrying parts shall be made by means of bolts with lock nuts. The use of tapped holes and studs or any other alternative method of connection in current carrying parts shall not be employed without the express approval of the Engineer prior to manufacture.

Busbars shall be provided with approved shrinkable tube of adhesive stickers of appropriate phase colour to indicate phases.

All connections, tapping and clamping shall be made in an approved manner to ensure minimum contact resistance. All connections in the busbars shall be firmly bolted and clamped with even tension. Before assembly, all busbar joint surfaces shall be filed or finished to remove burrs, dents and oxides and silvered to maintain good continuity at all joints.

All intermediate conducting material shall be used when there is a possibility of electrolytic action when contacts of the copper busbars with dissimilar metals are made.

An earth bar minimum size comply with BS7671 and BS7430 with minimum 50mm x 10mm to each vertical section of the cubicle units and shall run the full length at the bottom of each switchboard. All metal parts of the switchboards and associated equipment shall be bonded and connected to this earth bar. Minimum 2 connections to main earthing system shall be provided. The protective circuit shall have a rated conditional short circuit current of 39kA at 240V and a rated peak and short-circuit withstand current of 81.9kA and 39kA for 1 sec respectively.

The neutral busbar shall be the same size of that of the phase bars and shall be provided with an adequate number of terminals including cable lugs, bolts, etc. to suit the installation.

For circuits not less than 200A, busbar drops to moulded case circuit breakers or other apparatus shall be made of circular or rectangular busbar covered with Nylex tubing of appropriate colour and terminated in adequately sized concentric lug, of lug type, cone grip cable sockets or approved equal. Cables may be used for circuits less than 200A to type test configuration.

All visible rectangular busbars shall be bare tinned type size 1.55A/mm² based on current density. Rated current of assembly shall be based on tinned busbar and must be certified by type testing.

All screws, bolts, washers used for the busbars shall be cadmium plated. All contact parts of the busbars and connections shall be sanded and coated with a thin coat of chemical inert petroleum jelly. All bolts shall be tightened with an even tension. Approved spring washers shall be used at all joints complete with cadmium plated high tensile steel bolts.

All busbars and switchgear terminals to which outgoing or incoming cables are terminated shall be manufactured for a maximum temperature of 30⁰C above ambient. Where there are two incomers to the Low voltage switchboard, the bus-coupler and the busbar works shall type tested to certify the integrity of the system.

2.6 INSULATION

The clearances and insulation shall be such as to withstand the standard 3 kV dielectric tests on the switchboard.

All insulation used shall be of the best quality and sufficiently strong to withstand all stresses which may be imposed on it in the ordinary erection and operation of the switchboards.

Where insulators are cemented or jointed to metal parts, such jointing shall be of such a nature that no dangerous stresses are set up in the insulators by the unequal expansion or contraction of the insulation and the metal through the range of temperatures stated.

2.7 CABLE OR BUSDUCT ENTRIES

Provision shall be made within the factory built assemblies for the proper support and bracing of outgoing and incoming cables or busducts.

Weatherproof cable glands and all necessary non-ferrous gland plates, etc. shall be provided for all cables entering or leaving the switchboards. Cable terminating end boxes shall be mounted from top of the switchgear in the cubicles. Cable supports shall be provided for the termination boxes.

Busduct entries to the switchboard shall be liaised with busduct vendor for the exact position and phasing.

Detail of cable or busduct in and out of the switchboard shall take into the IP rating requirement as specified for the switchboard.

2.8 PHASING

Phase rotation shall be strictly maintained throughout the project, and shall comply with the requirements of BS 258. Phase distinguishing colours shall be RED, YELLOW and BLUE.

2.9 LABELS

All factory built assemblies and equipment shall be clearly labeled in accordance with Local Authority's regulations and to indicate its functions by means of engraved 'Traffolite' labels. Plastic labels are not acceptable. Emergency Main Switch Board shall be "red-on-white" others shall be "black-on-white". Engraved lettering not less than 20mm high or as otherwise required and approved.

Labels shall be attached by means of chrome finished countersunk screws and nuts.

Prior to engraving the labels, a label schedule shall be submitted for approval. Allow for two spare sets of label blanks and of engraving as directed by the Engineer. If not so directed, the spare sets of labels are to become the property of Employer.

2.10 SPECIFICATION FOR SPARES

The switchboards shall incorporate a rack for mounting spares, moulded case circuit breakers and a minimum of 25 percent standby/space capacities shall be provided for future installation of circuit breakers.

End covers and pre-drilled holes at main busbars shall be manufactured for future extension of the switchboards at both ends.

Spare shall be provided according to those those as specified in the Switchboard schedule/Single line diagram.

2.11 BASE SUPPORTS

The base support shall be fabricated from 50mm x 50mm C-channel base sufficiently stiffened to adequately support the switchboard. The base shall be hot dip galvanized after fabrication. The base may be made as part of the switchboard.

2.12 VENTILATION

All switchboards shall be properly natural ventilated. Force ventilation to achieve the required rating of the assembly is prohibited.

Vents shall be provided with the consideration of IP rating as specified.

Detailed calculation shall be submitted to verify the total heat from the switchgear and switchboard and the amount of vents and ventilation fans size.

2.13 INDICATING INSTRUMENTS

Indicating instruments shall comply with BS 89. Meters for external panel mounting shall be of the flush pattern type with square escutcheon plate's finished matt black and polycarbonate cases.

The main low voltage switchboards shall be provided with High performance and high accuracy power meter with LCD display that capable of indicating real-time readings, demand reading, energy readings, set up and resets menus, monitoring functions as well as

high level communication via RS-485/Modbus shall be installed for the main switchboards. Power meter shall be provided for the circuits above 100A or as specified on the drawings.

The reading shall include but not limit to current (per phase, neutral and earth), voltage (L-L, L-N), real power, reactive power, apparent power, power factor, frequency, energy, power quality readings such as voltage and current THD, demand, date/time stamping, on-board memory for alarms/relay functions such as under/over conditions, phase unbalance conditions, data log, event log, etc.

The meter power shall accept inputs from standard 5A current transformers and has full-scale input of 10A. The voltage inputs shall be directly connected to 3 phase circuits of 600V and below without the need for Potential or current transformer. All reading shall be scaled to their actual values without the need for a multiplier.

The power meter set up and resets shall be password protected and easily done via the meter display or via network software.

The power meter shall be able to support RS 485 communication for interfacing with the building management system.

In addition, unless otherwise specified, following analogue indicating instrument shall be installed for sub-bard and distribution boards above 100A incoming or as specified on the drawings.

Ammeter and voltmeters shall be of moving iron coil spring controlled type with 96mm square dials, accuracy Class 1.5 with external zero adjustment screw that is accessible from the front.

Ammeters shall be selected such that full load current indications are not less than the two thirds of linear scale of the meter and have a suppressed upper scale.

Ammeters shall be capable of taking overloads of 2 times continuously and voltmeter 1.2 times continuously.

Ammeters at the main incoming feeders shall in addition to the moving iron mechanism be provided with thermal bimetal indicators with draw pointers to record maximum demands. The mechanism shall not respond to short current peaks and shall be manually resettable.

Frequency indicators shall be of the vibrating reed type. The meter shall be capable of proper operation for voltage variation of $\pm 20\%$ rated voltage.

Power factor meters shall be of the electrodynamics crossed coil mechanism suitable for balance load, three phase four-wire system. The accuracy class shall be 1.5 and range 0.5 lag to 0.5 lead.

Monitoring Kilowatt-Hour Meters and current transformers where specified shall be provided. The kilowatt-hour meter shall have a digital display reading up to 100 million Kilowatt-Hours and to the nearest 100 KW-Hr. The overall accuracy shall be better than $\pm 2.0\%$.

The KWh meters shall be of flush mounting, rear connection type, current transformer operated and suitable for three phase balanced and unbalanced loads. The meter shall be complete with the three metering elements and shall have a cyclometer register with six rollers.

Instrument dials shall be white with black markings, and scales shall be of such material that ageing, peeling or discoloration will not take place under tropical conditions.

All instruments, when mounted on the switchboard, wired and ready for service, shall be in good order and condition in every way. The measuring elements shall be completely free from any discernible stickiness either at zero or upscale, and they shall be capable of attaining the performance guaranteed by the manufacturers of the respective instruments.

All terminals shall be completely insulated and potential circuits shall be suitable fused.

2.14 SELECTOR SWITCHES

The switches shall be of the panel mounting type with totally enclosed contacts and stud connection. Ammeter selector switches shall have make before break contacts to ensure that the current transformers are never open circuited.

The ammeter selector switch shall be suitable for measuring the current in each phase independently.

The voltmeter selector switcher shall be 7-way type. Voltmeter selector switches shall have break before make contacts.

2.15 CURRENT TRANSFORMERS

Current transformers necessary for the operation of instruments and meters shall comply with BS 3938 and be of the 'straight through' epoxy-resin type. Measuring current transformer shall be of accuracy class 1 and for metering of accuracy Class 0.2 for energy metering.

They shall be adequately rated in V.A. to carry the summation of all V.A. burdens of connected loads, and shall be capable of carrying current of the corresponding circuit breakers and fuses. The output secondary current shall be 5 amperes.

They shall be capable of operation, without damage, with open circuited secondary and full load current flowing in the primary.

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

All current transformers shall be provided with an identifying label giving type, ratio, class, output and serial number.

Current transformers provided for protective gear purposes shall have overcurrent and accuracy limit factors not less than those corresponding to the short circuit level of the system. The output of each current transformer shall be not less than that specified and the capacity of the current transformers provided shall be adequate for operation of the associated protective devices and instruments. Where double ratio secondary windings are specified, a label shall be provided at the secondary terminals of the current transformer indicating clearly the connection required for either ratio. These connections and the ratio in use shall be shown on the appropriate schematic and connection diagrams. Protection current transformer shall be of a accuracy Class 5P 10 and the burden in no case shall be less than 15VA.

Magnetization curves shall be submitted at the time of shop drawing submission.

2.16 CONTACTORS

Contactors shall be fully tropicalised and robust construction and shall comply with relevant parts of BS 5424 and be rated for the following duties.

Contactors for voltages up to and including 1000 volts A.C. and 1200 volts D.C. (BS 5424 Part 1).

1. Rated duty - Uninterrupted
2. Mechanical duty - Class I
3. Making and Breaking - AC4 Category

Contactors shall be selected to suit the load such that a minimum electrical life of one million operations is ensured. The mechanical life shall be at least 5 million operations.

Contactors shall have at least 15 times making capacity and 10 times breaking capacity for contactors less than 100 amps and 10 times and 8 times respectively for contactors above 100 amps. The selection of contactors shall be coordinated with the prospective fault levels suitable at that point of installation.

Contactors shall generally be suitable for rail mounting and be of modular detail. The coil shall be suitable for +10% and -15% of nominal main voltage. Provision shall be made on the contactors for affixing of termination and contactor identification labels.

Contactors shall be provided in sheet steel enclosure of a tropical finish and vermin proof. Adequate ventilation shall be accordance with BS 5424, category IP 42 for indoor service and IP 65 for outdoor service.

The contactor shall be located within the enclosure so that upon making or opening of the contactor under normal or fault conditions, damage will not be caused to other equipment and wiring within the enclosure.

An isolating switch shall be provided for each contactor circuit except that if there is more than one contactor and they are grouped together, one incoming supply isolating switch shall be provided to isolate all contactor circuits. A mechanical interlocking device between the isolating switch and panel cover shall be provided to prevent access to live parts within the panel when the isolating switch is in the "ON" position.

Contactors equipped with both local and remote control shall have local/remote changeover switches capable of being locked by padlock in the either position.

Contactors shall be provided with spare auxiliary (2 No. + 2 NC) in addition to other required auxiliary contacts specified in the Contract.

3.0 RELAYS

3.1 CONTROL RELAYS

All control and indication relays shall be of the heavy-duty pattern fully tropicalised type.

Relays shall be grouped conveniently in dust proof cases with removable covers given access for adjustment, cleaning, etc., without dismantling the relay.

3.2 PROTECTION RELAYS

Protection relays shall be approved types complying with BS 142 or equal and shall have approved characteristics and be flush mounted in dust proof cases. Relay cases shall generally be finished in black enamel.

Relays shall be of construction detail arranged so that adjustments, testing and replacements can be effected with the minimum of time and labour. Relays of the hand reset type shall be capable of being reset without opening the case.

Relay contacts shall make firmly without bounce and the whole of the relay mechanisms shall be as far as possible unaffected by vibration or external magnetic fields.

Relays, where appropriate shall be provided with flag indicators of approved type, phase coloured where applicable. Flag indicators shall be of the hand-reset pattern and shall be capable of being reset without opening the case. Where two or more phase elements are included in one case separate indicator shall be provided for each element.

Relays with provision for manual operation from outside the case, other than resetting will not be accepted, and time delay relays shall not be of the dashpot type.

Relays shall be provided with clearly inscribed labels describing their application and rating in addition to the general-purpose labels.

Approved means shall be provided on the relay panels for the testing of protective relays and associated circuits. Withdrawable type cases and plug-in type test facilities being preferred.

Full discrimination relay curves indicate relay setting shall be co-ordinate by the Contractor and submit for approval. The submission shall cover both O/C & E/F protection up to final circuit and shall be endorsed by the Contractor's Installation Engineer.

3.3 OVERCURRENT PROTECTION

Overcurrent protection shall be of the current transformers operated direct acting type. Where instantaneous trip is specified, the relay shall incorporate an electronic timer with adjustable time delay setting.

Where IDMT characteristic is required the time/current characteristic shall comply with BS 142. IDMT type relay shall consist of an electromagnet with shading rings on the pole pieces driving an induction disc. Current setting shall be of a plug and bridging socket arrangement and time lag setting shall be by setting screw located above the time scale.

Overload phase indicator shall be provided to show the phase overload condition.

The range of current setting adjustment for phase faults shall be 50% to 200% of rated full load with tapping at 25% intervals and the time setting adjustment shall be 0 to 3 seconds at 10 times the normal operating current. The current/time characteristics of the relays shall be in accordance with the British Standard Curve and shall be provided during the technical submission.

Both electromechanical and electronic type protective relays may be considered. Submission of full technical detail and approval shall be obtained prior to installation.

3.4 EARTH LEAKAGE PROTECTION

The earth leakage relays shall be of the instantaneous type with adjustable current settings from 5% to 40% in 5% steps.

The operating coils and contacts shall be adequately rated to carry the necessary load. Operating indicator and reset facilities shall be provided.

The relays shall house in dust proof sheet metal casings, provided with viewing glass.

Both electromechanical and electronic type protective relays may be considered. Submission of full technical detail and approval shall be obtained prior to installation

4.0 CONTROL CIRCUIT WIRING AND AUXILLARY

4.1 CONTROL CIRCUIT WIRING

All wiring shall be arranged in a regular manner with bends set at 90 degree and securely held in position with suitable clips and where convenient shall be installed in the uprights and/or back-stays insulating bushes being used where necessary.

Control wiring of the switchboard shall be carried out in PVC insulated switchboard cable of size not less than 1.5mm² and those for current measurement shall be minimum 2.5mm². All meter wiring shall be of similar colours to those of the respective busbars, etc., to which connections are made. The cable termination shall be made with cable lugs.

No wires/cables shall be tee-off or jointed between terminal points.

Wiring shall be carried out in such a manner as to make circuits and connections easily traceable. Cable marking ferrules or similar shall be used at each termination. Terminals shall be designated in an approved manner.

All terminals shall be fitted with brass washers and securely fixed with lock nuts.

Displacement Insulation push-in type termination for cable up to 2.5mm², tunnel type terminals shall be provided for cables up to and below 6mm². Cables larger than 6mm² shall be terminated with compression cable lugs or proprietary makes of termination approved by the Engineer.

4.2 ANTI-CONDENSATION HEATERS

Anti-condensation heaters shall be fitted in each cubicle together with an ON/OFF isolating switch and adjustable thermostat suitable for electrical operation at 230 volts A.C. 50 Hz single phase of sufficient capacity to raise the internal ambient temperature by 5°C. The electrical apparatus so protected shall be detailed so that the maximum permitted rise in temperature is not exceeded if the heaters are energized while the switchboard is in operation.

As a general rule, the heaters shall be placed at the bottom of the cubicle.

4.3 TERMINAL BOARDS

All terminal boards shall be mounted in accessible positions and, when in enclosed cubicles shall be inclined downwards towards the door. Spacing of adjacent terminal boards shall not be less than 100 mm and the bottom of each board shall not be less than 200 mm above the incoming cable gland plate. Separate studs shall be provided on each terminal strip for the cores of incoming and outgoing cables including all spare cores.

Brass bolts and studs shall be of not less than 6 mm diameter size but stainless steel and bronze down to 4.5 mm diameter may be used provided that the current carrying capacity is adequate. All studs shall be provided with nuts, washers and lock nuts or lock washers. Where pinch type terminations shall be provided. They shall have adequate current carrying capacity and shall be provided with locking devices. Insulated barriers shall be fitted between adjacent terminals.

415/230 volt and higher voltage circuit terminals shall be segregated from other terminals and shall be fitted with non-flammable transparent plastic covers to prevent contact with any live parts. They shall have warning labels with red lettering, mounted thereof in a conspicuous position.

All connections shall be made at the front of the terminal boards and no live metal shall be exposed at the back.

4.4 FUSES AND DISCONNECTING LINKS

All fuse link and disconnecting link assemblies associated with electrical installation, instrument, protection and control circuits shall be of approved type and grouped as far as possible according to their functions. They shall be clearly labelled, both on the panels and the associated wiring diagrams.

Fuse link and disconnecting link assemblies associated with tripping circuits shall preferably be mounted on the outside of controlling compartment. All others shall be mounted internally.

Carriers and base for flush links shall be black. Disconnecting link carriers and bases shall be white.

All fuse links shall be High Rupturing Capacity (HRC) cartridge type and all fuse switches and distribution boards and the like shall be suitable for the accommodation of these fuses.

Each cartridge shall incorporate a fuse element of appropriate current rating and fusing factor in order that adequate protection and discrimination is provided to the circuit.

The high rupturing capacity (HRC) cartridge fuses of rating shown shall conform to BS 88 Part 2 Class Q1 with minimum breaking capacity of 80 KA. When fuses are used for motor protection they shall have Class R rating. Fuse bases and carriers shall be made of high-grade phenolic moulding.

4.5 PUSH BUTTON

All the push buttons shall be made of non-hygroscopic material, non-swelling and fitted to avoid any possibility of sticking. Unless otherwise specified, they shall be of the non-retaining type. All push buttons shall have minimum IP54 ingress protection rating.

The contacts of all push buttons shall be of adequate strength and have a positive wiping action when in operation.

4.6 INDICATING LAMPS AND FITTINGS

Indicating lamps fitted to the fascias of switch and instrument cubicles or panels shall be adequately ventilated.

Lamps shall be easily removed and replaced from the front of the panel by manual means not requiring the use of extractors.

The bezel of metal holding the lamp glass shall be easily removable from the body of the fitting so as to permit access to the lamp and lamp glass.

The lamps shall be clear and shall fit into an accepted standard form of lamp holder. The rated lamp voltage shall be 4% in excess of the auxiliary supply voltage AC230V and DC 48V.

The lamp glasses/lens shall be in the standard colours, red, yellow, blue and amber. The colour shall be in the glass/lens and not an applied coating and the different colored glasses/lens shall be interchangeable.

Neon indicating lamps shall not be used with coloured lens.

Unless otherwise indicated or agreed with the Engineer, all lamp colours shall conform to the following practice:

1. Red - red phase;
2. Yellow - yellow phase;
3. Blue - blue phase;
4. White - supply available.

4.7 RADIO INTERFERENCE SUPPRESSION

All Plant and apparatus, including such items as contactors, starters, relays and the like where the normal operation is such that interruption of low frequency or direct current occur, shall be fitted with means of suppressing all interference frequencies caused.

The standard of interference suppression shall be in accordance with the current edition of BS 800 incorporating all amendments but extended to include the frequency ranges 300 to 360 MHz and 1.000 to 3,400 MHz.

Details of the equipment and methods to be used in quantitative assessment of the level of radio interference shall be as specified in BS 727.

For guidance in the installation of electrical equipment to meet the foregoing standards, reference shall be made to BS Code of Practice CP:1006 "General Aspects of Radio Interference Suppression: which deals with interference caused by electrical apparatus and installations.

4.8 SURGE PROTECTION DEVICES

Surge Protection devices shall be provided whichever cable route from external or to external of the building.

5.0 EXECUTION

5.1 TESTING AND COMMISSIONING

All switchboards shall be tested and certified by the installation Engineer that it is safe before supply is energized, and that all the equipment comply with the requirements of the Specification.

Generally such tests in the factory and repeated at site are as follows:

1. Insulation resistance tests;
2. Earth continuity tests;
3. Dielectric test – 3 kV DC for 1 minute;
4. Check of clearance and creepage distances;
5. Tests to prove correct operation of controls, interlocks, tripping and closing circuits, indications, etc.;
6. Phasing tests;
7. Operation of all protective gear circuits by primary injection and system fault tests to check sensitivity and stability;
8. Test of accuracy of all measuring instruments;
9. Test operation of alarm devices;
10. Interfacing test with BMS
11. Checking of all internal cabling and function operation;
12. Above tests are minimum requirement and shall include all other tests required by the Engineer to verify compliance with the Specification.

Triplicate sets of all principal test records and test certificates are to be supplied for all the tests carried out in accordance with the Specification to the Engineer for approval before dispatch from the switchboard factory.

All costs, materials, equipment, labour, etc. necessary for the execution of the testing shall be included in this portion of work.

The Contractor shall include the cost for the requirement for allowing the Engineer or his representative to witness the factory tests.

5.2 TRANSPORTATION

Switchboards are not allowed to be delivered to site until the electrical room or switchroom is in a clean and acceptable condition with lockable doors.

Switchboards transported to site shall be fully covered with weatherproof covers and transportation eye bolts shall be provided for handling at site.

Switchboards which are poorly packed and result in signs of corrosion will be rejected.

All necessary measures to cover and protect the switchboards at site shall be provided. Such measures shall include a complete PVC blanket over the whole switchboard or distribution board.

5.3 REJECTION OF SWITCHBOARD

If any of the above tests fail to comply with the requirements of this Specification in any respect whatsoever at any stage of manufacture, test, erection or on completion at site, the Engineer may reject the item or defective component thereof, whichever is considered necessary, and after adjustment or modification as directed by the Engineer, the Contractor shall submit that item for further inspection and/or test. In the event of the defective item being of such nature that the requirements of this Specification cannot be fulfilled by adjustment or modification, such item is to be replaced by the Contractor at his own expense, to the entire satisfaction of the Engineer.

5.4 EARTHING

Suitable earthing terminals or studs shall be provided on the frame for the connection of 25 mm x 3 mm copper strip to the main earthing bar in the switchroom.

A main earthing bar of HDHC copper with cross-sectional area in compliance with BS7671 and BS7430 50 mm x 6 mm shall be provided in the switchroom and to which all earthing connections shall be made. This earthing bar shall run along the wall adjacent to the full length of the main switchboard. Two connections to main earthing system shall be provided.

5.5 PROVISION OF ELECTRICAL SERVICES AND EQUIPMENT TO MEET LOCAL AUTHORITIES' REQUIREMENT

All other requirements by Local Authority that are imposed in the course of execution of the work, particularly those listed below shall be provided.

1. Danger signs;
2. Rubber floor mat of 6m thickness and 1 meter width provided for the full length of the switchboard;
3. A dry chemical type fire extinguisher of 9 kg capacity with approved label;
4. Framed single line diagram with minimum A1 size endorsed by Contractor's Qualified personnel;
5. 'First-Aid' Demonstration sign;
6. Sand for cable trenches after completion of all cable installation work, if applicable.

SECTION 20 PANEL BOARDS

1.0 GENERAL

1.1 WORK DESCRIPTION

The Panelboards included, distribution boards and control panels shall be built in accordance with IEC 439 "Factory Built Assemblies for Low Voltage" or BS 5486 "Factory-built Assemblies of Switchgear and Control Gear for Voltage up to and including 1000 AC and 1200V DC.

All factory built assemblies subject to rain or wet conditions or located outside electrical switch room shall be weatherproof constructed to IP 65, able to withstand high impact strength of 60 KN/m² (min), temperature resistant, flame retardant and corrosion resistant.

1.2 STANDARDS

The Panelboards shall be engineered and constructed in accordance with the latest revision of the following standards:

1. BS 88 : Cartridge fuses for voltages up to and including 1000V AC and 1500V DC.
2. BS 89 : Direct acting electrical indicating analogue electrical measuring instruments and their accessories.
3. BS 142 : Electrical protective relays
4. BS 159 : Busbars and busbar connection
5. BS 1433 : Copper for electrical purposes. Rods and bars.
6. BS EN 60898 : Circuit-breakers for over current protection for household and similar installations.
7. BS 3938 : Current transformers
8. BS EN 60947-2 : Low-voltage switchgear and controlgear, Part 2 circuit-breakers.
9. BS 4794 : Control switches (switching devices, Part 1 including contactor relays, for control and auxiliary circuits, for voltages up to and including 1000V AC and 1200V DC). General requirements.
10. BS 5419 : Air-break switches, air-break disconnectors, and fuse combination units for voltages up to and including 1000V AC and 1200V DC.
11. BS 5420 : Degrees of protection of enclosures of switch Part I great Part I and controlgear for voltages up to and including 1000V AC and 1200V DC.
12. BS 5424 : Controlgear for voltages up to and including 1000V AC and 1200V DC – Part 1 Contactors.
13. BS 5486 : Low-voltage switchgear and control gear Part 1 assemblies. Part I : Requirement for type tested and partially type tested assemblies.
14. BS 5685 : Electricity meters – Part I : Class 0.5, 1 and 2 single phase and polyphase, single-rate and multi-rate watt-hour meters.

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| 15. | BS 5992 | : | Electrical relays |
| 16. | BS 6004 | : | PVC insulated cables, (non-armoured), for electric power and lighting. |
| 17. | BS 6231 | : | PVC insulated cables for switchgear and controlgear wiring. |
| 18. | BS7430 | : | Earthing |

BS/IEC or other National standards not mentioned above but are applicable to this installation shall also apply.

1.3 SUBMISSION

A component list and catalogues.

Detailed construction drawings of all factory built assemblies shall be submitted for approval before construction commences.

Such drawings shall show the proposed method of construction of the cubicles, method of supporting equipment and busbars, full details of busbar layout, method of support, electrical control wiring diagrams, equipment weight, colours, surface treatment.

The drawings shall also incorporate a full list of proposed materials. The construction shall not commence until the drawings are approved for construction.

Factory and site testing procedures and report formats shall also be included.

2.0 PRODUCTS

2.1 GENERAL

The factory built assemblies shall be of the totally enclosed, modular cubicle type, which are extensible and suitable for floor or wall mounting as indicated in the drawings.

The factory built assemblies shall be compartmented and utilize sheet steel plates of thickness as detailed below. The panels shall be vermin proof and constructed to a minimum degree of protection of IP ratings to BS 5420. The IP ratings indicated below shall be applicable unless otherwise indicated in the drawing.

Distribution Boards and Control Panels

1. 1.6mm thick sheet steel
2. Form 2 to BS 5486 with separate compartment for busbar section, functional unit section and terminal compartment.
3. Minimum IP 42 and IP 2X after opening of doors and panels (of external covers), unless otherwise specified.
4. IP65 for location subject to rain, wet conditions or located inside mechanical plant room.

2.2 SUB-BOARD AND DISTRIBUTION BOARD DETAIL

Sub-board and distribution board details shall refer to Motor Control Panel, SB & DB Details in the Contract.

2.3 PANELBOARDS

The equipment used and construction details shall be as detailed in this specification and/or Section 17 applicable.

The distribution board shall be of the totally enclosed, sheet metal type of minimum thickness 1.6 mm and suitable for wall mounting unless specified.

The sheet metal box shall be sprayed with one coat of anti-rust primer and two finishing coats of grey paint. The cover for the box shall have a handle lock complete with keys. Screw on type will not be accepted. The hinges for the covers should as far as possible be concealed. Knock-outs shall be provided for cable entry.

Phases shall be separated by phase barriers made of bakelite. Circuit breaker shall be mounted on a metal strip of sufficient thickness and tightly fixed. Sufficient length of busbars and metal strip space shall be provided to accommodate future circuit breakers. Sufficient terminal sand clamps shall be provided for the neutral bars and earth bars to accommodate neutral wires and earth wires. The distribution board wires shall be colour coded for easy identification and prevention of wrong phase connection. Coloured adhesive tape on distribution wires shall not be acceptable as colour code.

All circuits and breaker sizes shall be clearly labeled and mounted on an approved holder fixed on to the back of cover of the distribution board.

All distribution boards shall include a main incoming isolator, circuit breaker or switch-fuse of sufficient rating.

Distribution boards in mechanical plant room areas and in areas exposed to weather shall be of a weatherproof type or enclosed in a weatherproof housing with hinged doors of IP65 rating.

Single line diagram/Distribution schedule indicating the equipment served shall be laminated and located adjacent to each distribution board.

The equipment used and construction details shall be as detailed in earlier sections of the Specifications.

Additional space shall be allowed in each distribution board for increasing the number of circuit ways by at least 20% and suitable blank plates shall be provided for the initial installation.

2.3 METERING PANEL

The equipment used and construction details shall be as detailed in earlier sections of the Specification and in compliance with Local Authority's requirements.

Where the metering panel is to be externally wall mounted as directed by the Local Authority, the panel shall be supplied and installed complete with all connections and works required thereof.

This portion of work shall also include all necessary consultation, liaison and compliance with the local Authorities in respect to all metering facilities and arrangements. The detail of

the metering panel and fixing detail shall be endorsed by the installation Engineer for submission.

3.0 EXECUTION

3.1 TESTING AND COMMISSIONING

All panelboards shall be tested and certified by the installation Engineer that it is safe before supply is energized, and that all the equipment comply with the requirements of the Specification.

Generally such tests in the factory and repeated at site are as follows:

1. Insulation resistance tests;
2. Earth continuity tests;
3. Check of clearance and creepage distances;
4. Tests to prove correct operation of controls, interlocks, tripping and closing circuits, indications, etc.;
5. Interfacing test with BMS control function
6. All other tests required by the Engineer to verify compliance with the Specification.

Triplicate sets of all principal test records and test certificates are to be supplied for all the tests carried out in accordance with the Specification to the Engineer for approval before dispatch from the factory.

All costs, materials, equipment, labour, etc. necessary for the execution of the testing shall be included in this portion of work.

3.2 TRANSPORTATION

Panel boards are not allow to be delivered to site until the electrical room or switchroom is in a clean and acceptable condition with lockable doors.

Panelboards, transported to site shall be fully covered with weatherproof covers and transportation eye bolts shall be provided for handling at site.

Panelboards, which are poorly packed and result in signs of corrosion will be rejected.

All necessary measures to cover and protect the panelboards at site shall be provided. Such measures shall include a complete PVC blanket over the whole panelboards.

3.3 REJECTION OF PANELBOARDS

If any of the above tests fail to comply with the requirements of this Specification in any respect whatsoever at any stage of manufacture, test, erection or on completion at site, the Engineer may reject the item or defective component thereof, whichever is considered necessary, and after adjustment or modification as directed by the Engineer, the Contractor shall submit that item for further inspection and/or test. In the event of the defective item being of such nature that the requirements of this Specification cannot be fulfilled by adjustment or modification, such item is to be replaced by the Contractor at his own expense, to the entire satisfaction of the Engineer. Delivery of panelboards on site without significant cable connection (Say 80%) shall not entitle progress payment certified for material delivery on site.

SECTION 21 MOTOR CONTROL CENTRE

1.0 GENERAL

1.1 WORK DESCRIPTION

The Motor Control Centre and control panels shall be built in accordance with IEC 439 “Factory Built Assemblies for Low Voltage” or BS 5486 “Factory-built Assemblies of Switchgear and Control Gear for Voltage up to and including 1000 AC and 1200V DC.

Motor Control Centre shall be of type manufacture conforming to tests conducted by ASTA or other recognized testing authority. Type test certificates obtained from the testing authority together with the construction details of the Motor Control Centre on which the approval was obtained shall be submitted at the time of technical submission.

All factory built assemblies shall be capable of withstanding the electrical, mechanical and thermal stresses of the prospective fault level experience.

All equipment used in the factory built assemblies shall have been type tested. Type test certificates shall be submitted for all major equipment at the time of technical submission.

All factory built assemblies, as a complete unit shall have a rating equal to or greater than the integrated equipment rating as indicated in the Drawing.

All factory built assemblies subject to rain or wet conditions or located outside electrical room shall be weatherproof constructed to IP 65, able to withstand high impact strength of 60 KN/m² (min), temperature resistant with consideration of Ambient temp 50°C and average switch room temperature 40°C, flame retardant and corrosion resistant.

1.2 STANDARDS

The Motor Control Centre and Control Panels shall be manufactured and constructed in accordance with the latest revision of the following standards:

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| 1. | BS 88 | : | Cartridge fuses for voltages up to and including 1000V AC and 1500V DC. |
| 2. | BS 89 | : | Direct acting electrical indicating analogue electrical measuring instruments and their accessories. |
| 3. | BS 142 | : | Electrical protective relays |
| 4. | BS 159 | : | Busbars and busbar connection |
| 5. | BS 1433 | : | Copper for electrical purposes. Rods and bars. |
| 6. | BS EN 60898 | : | Circuit-breakers for over current protection for household and similar installations. |
| 7. | BS 3938 | : | Current transformers |
| 8. | BS EN 60947-2 | : | Low-voltage switchgear and controlgear, Part 2 circuit-breakers. |
| 9. | BS 4794 | : | Control switches (switching devices, Part 1 including contactor relays, for control and auxiliary circuits, for voltages up to and including 1000V AC and 1200V DC). General requirements. |
| 10. | BS 5419 | : | Air-break switches, air-break disconnectors, and fuse combination units for voltages up to and including 1000V AC and 1200V DC. |

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| 11. | BS 5420 | : | Degrees of protection of enclosures of switch Part I great Part I and controlgear for voltages up to and including 1000V AC and 1200V DC. |
| 12. | BS 5424 | : | Controlgear for voltages up to and including 1000V AC and 1200V DC – Part 1 Contactors. |
| 13. | BS 5486 | : | Low-voltage switchgear and control gear Part 1 assemblies. Part I : Requirement for type tested and partially type tested assemblies. |
| 14. | BS 5685 | : | Electricity meters – Part I : Class 0.5, 1 and 2 single phase and polyphase, single-rate and multi-rate watt-hour meters. |
| 15. | BS 5992 | : | Electrical relays |
| 16. | BS 6004 | : | PVC insulated cables, non-armoured, for electric power and lighting. |
| 17. | BS 6231 | : | PVC insulated cables for switchgear and controlgear wiring. |
| 18. | BS7430 | : | Earthing |

BS/IEC or other National standards not mentioned above but are applicable to this installation shall also apply.

1.3 SUBMISSION

A component list and catalogues.

Detailed construction drawings of all factory built assemblies shall be submitted for approval before construction commences.

Such drawings shall show the proposed method of construction of the cubicles, method of supporting equipment and busbars, full details of busbar layout, method of support, electrical control wiring diagrams, equipment weight, colours, and surface treatment.

The drawings shall also incorporate a full list of proposed materials. The construction shall not commence until the drawings are approved for construction.

Factory and site testing procedures and report formats shall also be included.

2.0 PRODUCTS

2.1 GENERAL

The factory built assemblies shall be of the totally enclosed, modular cubicle type, which are extensible and suitable for floor mounting as indicated in the drawings.

The factory built assemblies shall be compartmented and utilize sheet steel plates of thickness as detailed below. The panels shall be vermin proof and constructed to a minimum degree of protection of IP ratings to BS 5420. The IP ratings indicated below shall be applicable unless otherwise indicated in the drawing.

Motor Control Centre

1. 2mm thick sheet steel

2. Form 3b for Motor Control Centre unless otherwise specified to BS 5486 with separation of busbars from the functional units and separation of all functional units from one another
3. Minimum IP 42 and IP 2X after opening of doors & panels (of external covers) unless otherwise specified.
4. IP65 for location subject to rain wet conditions or located outside electrical room.
5. Motor Control Centre frame shall be of modular detail and extensible.
6. The interior of each cubicle shall be dust inert and vermin resistant.

Motor Control Centre frames shall be fabrication of 2.0mm thick electro-galvanized steel. All joints shall be neatly formed and finished flush with the adjacent surfaces by grinding and/or machining. No joints shall be located on a corner and all bare edges shall be lipped.

Structural members and bracing, where necessary, shall be welded or bolted to the frame.

2.2 DOORS AND PANELS

Full access shall be provided to service and maintain all equipment inside each cubicle by means of a suitable hinged door that shall open a minimum of 120 degrees. All hinged doors shall have an earth braid connected to the cubicle.

Doors and panels shall be constructed of 2 mm electro-galvanized sheet steel, pressed or rolled so that edges are given a neat round finish and shall reinforced with a suitable frame welded to the inside folded edge of the door. An approved stiffener shall be welded to the inside of each door and/or panel.

Doors shall hang on substantially concealed non-corrosive hinges and shall be fitted with good quality door handles to Engineer's approval which shall be lockable and operable by the same key. The door handles shall be fitted with toggles to operate rods to latch with suitable slots in both the top and bottom of the Motor Control Centre. Latching rods shall be guided by brackets. The latching rods and associated brackets shall be cadmium plated.

All front, side and top panels shall be constructed in a manner similar to that specified for doors above. They shall be fitted to the frame from the outside with captive, hand tightened screw. Panels longer than 1.2 meter shall be provided with 3 point locking system

2.3 BASEPLATE AND INSULATING PANELS

The Motor Control Centre shall be mounted on 50mm X 50mm C-channel. Wherever insulating panels are required to mount special equipment, they shall be of high quality black bakelite, polished on the front.

All edges must be cut straight and square and shall be chamfered on the front edge with a 3mm chamfer.

2.4 FINISHING OF METAL WORK

Panel work of the Motor Control Centre shall be finished with electrostatic epoxy power coating of minimum 50 microns all treat with 180°C 12 minute oven baking. All metal work shall be rust inhibited and sprayed with two coats of primer. The painting shall be of best quality oven-bake epoxy power coated of Grey colour.

After erection on site and after all inspection and tests have been carried out, the Contractor shall thoroughly clean all painted parts, touch-up with application of an additional coat of anti-corrosive structural priming paint to any part of the originally painted surfaces that have been scratched or otherwise marked and at least one additional touch-up finishing coat of Grey colour.

2.5 BUSBARS AND CURRENT CARRYING PARTS

The manufacture of the busbar system shall comply to the latest edition of BS 158 and BS 159. All busbars and current carrying parts shall be manufactured to carry a current density of not more than 1.55 A/mm² and shall be capable of carrying normal current continuously without the temperature rise of any part exceeding 30°C. Their location shall be such as to ensure adequate spacing between conductors and they shall be securely fastened and braced to withstand all stress set up during transportation, erection and normal operation, and under short circuit conditions. The busbars shall not be damaged in any way under a fault of short circuit experience with minimum 35 MVA for 3 seconds. Where two or more conductors are used to form a phase, it shall be separated with an air gap sufficient to allow for the ventilation of the individual conductors all round. Busbar supports shall be made of slotted first grade "Bakelite" or glass fibre reinforced polymer able to withstand minimum operating temperature of 110°C.

All connections in current carrying parts shall be made by means of bolts with lock nuts. The use of tapped holes and studs or any other alternative method of connection in current carrying parts shall not be employed without the express approval of the Engineer prior to manufacture.

Busbars shall be provided with approved shrinkable tube of appropriate phase colour to indicate phases.

All connections, tapping and clamping shall be made in an approved manner to ensure minimum contact resistance. All connections in the busbars shall be firmly bolted and clamped with even tension. Before assembly, all busbar joint surfaces shall be filed or finished to remove burrs, dents and oxides and silvered to maintain good continuity at all joints.

All intermediate conducting material shall be used when there is a possibility of electrolytic action when contacts of the copper busbars with dissimilar metals are made.

An earth bar minimum size comply with BS7671 and BS7430 with minimum 50mm x 6mm to each vertical section of the cubicle units and shall run the full length at the bottom of each Motor Control Centre. All metal parts of the Motor Control Centre and associated equipment shall be bonded and connected to this earth bar. Minimum 2 connections to main earthing system shall be provided.

The neutral busbar shall be the same size of that of the phase bars and shall be provided with an adequate number of terminals including cable lugs, bolts, etc. to suit the installation.

For circuits not less than 200A, busbar drops to moulded case circuit breakers or other apparatus shall be made of circular or rectangular busbar covered with Nylex tubing of appropriate colour and terminated in adequately sized concentric lug, of lug type, cone grip cable sockets or approved equal. Cables may be used for circuits less than 200A to type test configuration.

All visible rectangular busbars shall be bare tinned type size 1.55A/mm² based on current density.

All screws, bolts, washers used for the busbars shall be cadmium plated. All contact parts of the busbars and connections shall be sanded and coated with a thin coat of chemical inert petroleum jelly. All bolts shall be tightened with an even tension. Approved spring washers shall be used at all joints complete with cadmium plated high tensile steel bolts.

All busbars and switchgear terminals to which outgoing or incoming cables are terminated shall be manufactured for a maximum temperature of 40°C above ambient.

2.6 INSULATION

The clearances and insulation shall be such as to withstand the standard 3 kV dielectric tests on the Motor Control Centre.

All insulation used shall be of the best quality and sufficiently strong to withstand all stresses which may be imposed on it in the ordinary erection and operation of the Motor Control Centre.

Where insulators are cemented or jointed to metal parts, such jointing shall be of such a nature that no dangerous stresses are set up in the insulators by the unequal expansion or contraction of the insulation and the metal through the range of temperatures stated in Clauses above.

2.7 CABLE OR BUSDUCT ENTRIES

Provision shall be made within the factory built assemblies for the proper support and bracing of outgoing and incoming cables or busducts.

Weatherproof cable glands and all necessary non-ferrous gland plates, etc. shall be provided for all cables entering or leaving the Motor Control Centre. Cable terminating end boxes shall be mounted from top of the switchgear in the cubicles. Cable supports shall be provided below the termination boxes.

Busduct entries to the Motor Control Centre shall be liaised with busduct vendor for the exact position and phasing.

Detail of cable or busduct in and out of the Motor Control Centre shall take into the IP rating requirement as specified for the Motor Control Centre.

2.8 PHASING

Phase rotation shall be strictly maintained throughout the project, and shall comply with the requirements of BS 258. Phase distinguishing colours shall be RED, YELLOW and BLUE.

2.9 LABELS

All factory built assemblies and equipment shall be clearly labeled in accordance with regulations and to indicate its functions by means of engraved 'Traffolite' labels. Plastic labels are not acceptable. Engraved lettering not less than 20mm high or as otherwise required and approved.

Labels shall be attached by means of chrome finished countersunk screws and nuts.

Prior to engraving the labels, a label schedule shall be submitted for approval. Cost for two sets of labels shall be included in the Contract to cater for any amendment to the label as directed by the Engineer.

2.10 SPECIFICATION FOR SPARES

The Motor Control Centre shall incorporate a rack for mounting spares, moulded case circuit breakers and a minimum of 20 percent space/standby capacities shall be provided for future installation of circuit breakers.

End covers and pre-drilled holes at main busbars shall be manufactured for future extension of the Motor Control Centre at both ends.

2.11 BASE SUPPORTS

The base support shall be fabricated from 50mm x 50mm C-channel base sufficiently stiffened to adequately support the Motor Control Centre. The base shall be hot dip galvanized after fabrication. The base may be made as part of the Motor Control Centre.

2.12 VENTILATION

All Motor Control Centre shall be properly natural ventilated.

Vents shall be provided with the consideration of IP rating as specified.

Detailed calculation shall be submitted to verify the total heat from the switchgear and Motor Control Centre and the amount of vents and ventilation fans size.

2.13 INDICATING INSTRUMENTS

Indicating instruments shall comply with BS 89. Meters for external panel mounting shall be of the flush pattern type with square escutcheon plate's finished matt black and polycarbonate cases.

The Motor Control Centers shall be provided with High performance and high accuracy power meter with LCD display that capable of indicating real-time readings, demand reading, energy readings, set up and resets menus, monitoring functions as well as high level communication via RS-485/Modbus shall be installed for the Motor Control Centre. Power meter shall be provided for the circuits above 100A or as specified on the drawings.

The reading shall include but not limit to current (per phase, neutral and earth), voltage (L-L, L-N), real power, reactive power, apparent power, power factor, frequency, energy, power quality readings such as voltage and current THD, demand, date/time stamping, on-board memory for alarms/relay functions such as under/over conditions, phase unbalance conditions, data log, event log, etc.

The meter power shall accept inputs from standard 5A current transformers and has full-scale input of 10A. The voltage inputs shall be directly connected to 3 phase circuits of 600V and below without the need for Potential or current transformer. All reading shall be scaled to their actual values without the need for a multiplier.

The power meter set up and resets shall be password protected and easily done via the meter display or via network software.

The power meter shall be able to support RS 485 communication for interfacing with the building management system.

In addition, unless otherwise specified, following analogue indicating instrument shall be installed for sub-bard and distribution boards above 100A incoming or as specified on the drawings.

Ammeter and voltmeters shall be of moving iron coil spring controlled type with 96mm square dials, accuracy Class 1.5 with external zero adjustment screw that is accessible from the front.

Ammeters shall be selected such that full load current indications are not less than the two thirds of linear scale of the meter and have a suppressed upper scale.

Ammeters shall be capable of taking overloads of 2 times continuously and voltmeter 1.2 times continuously.

Ammeters at the main incoming feeders shall in addition to the moving iron mechanism be provided with thermal bimetal indicators with draw pointers to record maximum demands. The mechanism shall not respond to short current peaks and shall be manually resettable.

Frequency indicators shall be of the vibrating reed type. The meter shall be capable of proper operation for voltage variation of $\pm 20\%$ rated voltage.

Power factor meters shall be of the electrodynamics crossed coil mechanism suitable for balance load, three phase four-wire system. The accuracy class shall be 1.5 and range 0.5 lag to 0.5 lead.

Monitoring Kilowatt-Hour Meters and current transformers where specified shall be provided. The kilowatt-hour meter shall have a digital display reading up to 100 million Kilowatt-Hours and to the nearest 100 KW-Hr. The overall accuracy shall be better than $\pm 2.0\%$.

The KWh meters shall be of flush mounting, rear connection type, current transformer operated and suitable for three phase balanced and unbalanced loads. The meter shall be complete with the three metering elements and shall have a cyclometer register with six rollers.

Instrument dials shall be white with black markings, and scales shall be of such material that ageing, peeling or discoloration will not take place under tropical conditions.

All instruments, when mounted on the Motor Control Centre, wired and ready for service, shall be in good order and condition in every way. The measuring elements shall be completely free from any discernible stickiness either at zero or upscale, and they shall be capable of attaining the performance guaranteed by the manufacturers of the respective instruments.

All terminals shall be completely insulated and potential circuits shall be suitable fused.

2.14 SELECTOR SWITCHES

The switches shall be of the panel mounting type with totally enclosed contacts and stud connection. Ammeter selector switches shall have make before break contacts to ensure that the current transformers are never open circuited.

The ammeter selector switch shall be suitable for measuring the current in each phase independently.

The voltmeter selector switcher shall be 7-way type. Voltmeter selector switches shall have break before make contacts.

2.15 CURRENT TRANSFORMERS

Current transformers necessary for the operation of instruments and meters shall comply with BS 3938 and be of the 'straight through' epoxy-resin type. Measuring current transformer shall be of accuracy class 1 and for metering of accuracy Class 0.2 for energy metering.

They shall be adequately rated in V.A. to carry the summation of all V.A. burdens of connected loads, and shall be capable of carrying current of the corresponding circuit breakers and fuses. The output secondary current shall be 5 amperes.

They shall be capable of operation, without damage, with open circuited secondary and full load current flowing in the primary.

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

All current transformers shall be provided with an identifying label giving type, ratio, class, output and serial number.

Current transformers provided for protective gear purposes shall have overcurrent and accuracy limit factors not less than those corresponding to the short circuit level of the system. The output of each current transformer shall be not less than that specified and the capacity of the current transformers provided shall be adequate for operation of the associated protective devices and instruments. Where double ratio secondary windings are specified, a label shall be provided at the secondary terminals of the current transformer indicating clearly the connection required for either ratio. These connections and the ratio in use shall be shown on the appropriate schematic and connection diagrams. Protection current transformer shall be of a accuracy Class 5P 10 and the burden in no case shall be less than 15VA.

Magnetization curves shall be submitted at the time of shop drawing submission.

2.16 CONTACTORS

Contactors shall be fully tropicalised and robust detail and shall comply with relevant parts of BS 5424 and be rated for the following duties.

Contactors for voltages up to and including 1000 volts A.C. and 1200 volts D.C. (BS 5424 Part 1).

- | | | |
|---------------------------------|---|---------------|
| 1. Rated duty | - | Uninterrupted |
| 2. Mechanical duty | - | Class I |
| 3. Making and Breaking Category | - | AC4 |

Contactors shall be selected to suit the load such that a minimum electrical life of one million operations is ensured. The mechanical life shall be at least 5 million operations.

Contactors shall have at least 15 times making capacity and 10 times breaking capacity for contactors less than 100 amps and 10 times and 8 times respectively for contactors above 100 amps. The selection of contactors shall be coordinated with the prospective fault levels suitable at that point of installation.

Contactors shall generally be suitable for rail mounting and be of modular detail. The coil shall be suitable for +10% and –15% of nominal main voltage. Provision shall be made on the contactors for affixing of termination and contactor identification labels.

Contactors shall be provided in sheet steel enclosure of a tropical finish and vermin proof. Adequate ventilation shall be accordance with BS 5424, category IP 42 for indoor service and IP 65 for outdoor service.

The contactor shall be located within the enclosure so that upon making or opening of the contactor under normal or fault conditions, damage will not be caused to other equipment and wiring within the enclosure.

An isolating switch shall be provided for each contactor circuit except that if there is more than one contactor and they are grouped together, one incoming supply isolating switch shall be provided to isolate all contactor circuits. A mechanical interlocking device between the isolating switch and panel cover shall be provided to prevent access to live parts within the panel when the isolating switch is in the “ON” position.

Contactors equipped with both local and remote control shall have local/remote changeover switches capable of being locked by padlock in the either position.

Contractor shall be provided with spares auxiliary (2NO. + 2NC) in addition to other required auxiliary contacts specified in the Contract.

3.0 RELAYS

3.1 CONTROL RELAYS

All control and indication relays shall be of the heavy-duty pattern fully tropicalised type.

Relays shall be grouped conveniently in dust proof cases with removable covers given access for adjustment, cleaning, etc., without dismantling the relay.

3.2 PROTECTION RELAYS

Protection relays shall be approved types complying with BS 142 or equal and shall have approved characteristics and be flush mounted in dust proof cases. Relay cases shall generally be finished in black enamel.

Relays shall be of construction detail arranged so that adjustments, testing and replacements can be effected with the minimum of time and labour. Relays of the hand reset type shall be capable of being reset without opening the case.

Relay contacts shall make firmly without bounce and the whole of the relay mechanisms shall be as far as possible unaffected by vibration or external magnetic fields.

Relays, where appropriate shall be provided with flag indicators of approved type, phase coloured where applicable. Flag indicators shall be of the hand-reset pattern and shall be capable of being reset without opening the case. Where two or more phase elements are included in one case separate indicator shall be provided for each element.

Relays with provision for manual operation from outside the case, other than resetting will not be accepted, and time delay relays shall not be of the dashpot type.

Relays shall be provided with clearly inscribed labels describing their application and rating in addition to the general-purpose labels.

Approved means shall be provided on the relay panels for the testing of protective relays and associated circuits. Withdrawable type cases and plug-in type test facilities being preferred.

Full discrimination relay curves indicate relay setting shall be co-ordinate by the Contractor and submit for approval. The submission shall cover both O/C & E/F protection up to final circuit.

3.3 OVERCURRENT PROTECTION

Overcurrent protection shall be of the current transformers operated direct acting type. Where instantaneous trip is specified, the relay shall incorporate an electronic timer with adjustable time delay setting.

Where IDMT characteristic is required the time/current characteristic shall comply with BS 142. IDMT type relay shall consist of an electromagnet with shading rings on the pole pieces driving an induction disc. Current setting shall be of a plug and bridging socket arrangement and time lag setting shall be by setting screw located above the time scale.

Overload phase indicator shall be provided to show the phase overload condition.

The range of current setting adjustment for phase faults shall be 50% to 200% of rated full load with tapping at 25% intervals and the time setting adjustment shall be 0 to 3 seconds at 10 times the normal operating current. The current/time characteristics of the relays shall be in accordance with the British Standard Curve and shall be provided during the technical submission.

Both electromechanical and electronic type protective relays may be considered. Submission of full technical detail and approval shall be obtained prior to installation.

3.4 EARTH LEAKAGE PROTECTION

The earth leakage relays shall be of the instantaneous type with adjustable current settings from 5% to 40% in 5% steps.

The operating coils and contacts shall be adequately rated to carry the necessary load. Operating indicator and reset facilities shall be provided.

The relays shall house in dust proof sheet metal casings, provided with viewing glass.

Both electromechanical and electronic type protective relays may be considered. Submission of full technical detail and approval shall be obtained prior to installation

4.0 CONTROL CIRCUIT WIRING AND AUXILLARY

4.1 CONTROL CIRCUIT WIRING

All wiring shall be arranged in a regular manner with bends set at 90 degree and securely held in position with suitable clips and where convenient shall be installed in the uprights and/or back-stays insulating bushes being used where necessary.

Control wiring of the Motor Control Centre shall be carried out in PVC insulated of size not less than 1.5mm² and those for current measurement shall be minimum 2.5mm². All meter wiring shall be of similar colours to those of the respective busbars, etc., to which connections are made. The cable termination shall be made with cable lugs.

No wires/cables shall be tee-off or jointed between terminal points.

Wiring shall be carried out in such a manner as to make circuits and connections easily traceable. Cable marking ferrules or similar shall be used at each termination. Terminals shall be designated in an approved manner.

All terminals shall be fitted with brass washers and securely fixed with lock nuts.

Displacement Insulation push-in type termination for cable up to 2.5mm², tunnel type terminals shall be provided for cables up to and below 6mm². Cables larger than 6mm² shall be terminated with compression cable lugs or proprietary makes of termination approved by the Engineer.

4.2 ANTI-CONDENSATION HEATERS

Anti-condensation heaters shall be fitted in each cubicle together with an ON/OFF isolating switch and adjustable thermostat suitable for electrical operation at 230 volts \pm 10% A.C. 50 Hz single phase of sufficient capacity to raise the internal ambient temperature by 5°C. The electrical apparatus so protected shall be manufactured so that the maximum permitted rise in temperature is not exceeded if the heaters are energized while the Motor Control Centre is in operation.

As a general rule, the heaters shall be placed at the bottom of the cubicle.

4.3 TERMINAL BOARDS

All terminal boards shall be mounted in accessible positions and, when in enclosed cubicles shall be inclined downwards towards the door. Spacing of adjacent terminal boards shall not be less than 100 mm and the bottom of each board shall not be less than 200 mm above the incoming cable gland plate. Separate studs shall be provided on each terminal strip for the cores of incoming and outgoing cables including all spare cores.

Brass bolts and studs shall be of not less than 6 mm diameter size but stainless steel and bronze down to 4.5 mm diameter may be used provided that the current carrying capacity is adequate. All studs shall be provided with nuts, washers and lock nuts or lock washers. Pinch type terminations shall be provided. They shall have adequate current carrying

capacity and shall be provided with locking devices. Insulated barriers shall be fitted between adjacent terminals.

400/230 volt and higher voltage circuit terminals shall be segregated from other terminals and shall be fitted with non-flammable transparent plastic covers to prevent contact with any live parts. They shall have warning labels with red lettering, mounted thereof in a conspicuous position.

All connections shall be made at the front of the terminal boards and no live metal shall be exposed at the back.

4.4 FUSES AND DISCONNECTING LINKS

All fuse link and disconnecting link assemblies associated with electrical installation, instrument, protection and control circuits shall be of approved type and grouped as far as possible according to their functions. They shall be clearly labelled, both on the panels and the associated wiring diagrams.

Fuse link and disconnecting link assemblies associated with tripping circuits shall preferably be mounted on the outside of control panels. All others shall be mounted internally.

Carriers and base for flush links shall be black. Disconnecting link carriers and bases shall be white.

All fuse links shall be High Rupturing Capacity (HRC) cartridge type and all fuse switches and the like shall be suitable for the accommodation of these fuses.

Each cartridge shall incorporate a fuse element of appropriate current rating and fusing factor in order that adequate protection and discrimination is provided to the circuit.

The high rupturing capacity (HRC) cartridge fuses of rating shown shall conform to BS 88 Part 2 Class Q1 with minimum breaking capacity of 80 KA. When fuses are used for motor protection they shall have Class R rating. Fuse bases and carriers shall be made of high-grade phenolic moulding.

4.5 PUSH BUTTON

All the push buttons shall be made of non-hygroscopic material, non-swelling and fitted to avoid any possibility of sticking. Unless otherwise specified, they shall be of the non-retaining type. All push buttons shall have minimum IP54 ingress protection rating.

The contacts of all push buttons shall be of adequate strength and have a positive wiping action when in operation.

4.6 INDICATING LAMPS AND FITTINGS

Indicating lamps fitted to the fascias of switch and instrument cubicles or panels shall be adequately ventilated.

Lamps shall be easily removed and replaced from the front of the panel by manual means not requiring the use of extractors.

The bezel of metal holding the lamp glass shall be easily removable from the body of the fitting so as to permit access to the lamp and lamp glass.

The lamps shall be clear and shall fit into an accepted standard form of lamp holder. The rated lamp voltage shall be 10% in excess of the auxiliary supply voltage, AC230V and DC48V.

The lamp glasses/lens shall be in the standard colours, red, yellow, blue and amber. The colour shall be in the glass/lens and not an applied coating and the different colored glasses/lens shall be interchangeable.

Neon indicating lamps shall not be used with coloured lens.

Unless otherwise indicated or agreed with the Engineer, all lamp colour shall conform to the following practice:

- | | | |
|-----------|---|-------------------|
| 1. Red | - | red phase; |
| 2. Yellow | - | yellow phase; |
| 3. Blue | - | blue phase; |
| 4. White | - | supply available. |
| 5. Green | - | start |

4.7 RADIO INTERFERENCE SUPPRESSION

All Plant and apparatus, including such items as contactors, starters, relays and the like where the normal operation is such that interruption of low frequency or direct current occur, shall be fitted with means of suppressing all interference frequencies caused.

The standard of interference suppression shall be in accordance with the current edition of BS 800 incorporating all amendments but extended to include the frequency ranges 300 to 360 MHz and 1.000 to 3,400 MHz.

Details of the equipment and methods to be used in quantitative assessment of the level of radio interference shall be as specified in BS 727.

For guidance in the installation of electrical equipment to meet the foregoing standards, reference shall be made to BS Code of Practice CP:1006 "General Aspects of Radio Interference Suppression: which deals with interference caused by electrical apparatus and installations.

4.8 SURGE PROTECTION DEVICES

Surge Protection devices shall be provided according to specification section 18 whichever cable route from external or to external of the building.

5.0 EXECUTION

5.1 TESTING AND COMMISSIONING

All Motor Control Centre shall be tested and certified by the Contractor that it is safe before supply is energised, and that all the equipment comply with the requirements of the Specification.

Generally such tests in the factory and repeated at site are as follows:

1. Insulation resistance tests;
2. Earth continuity tests;
3. Dielectric test – 3 kV DC for 1 minute;
4. Check of clearance and creepage distances;
5. Tests to prove correct operation of controls, interlocks, tripping and closing circuits, indications, etc.;
6. Phasing tests;
7. Operation of all protective gear circuits by primary injection and system fault tests to check sensitivity and stability;
8. Test of accuracy of all measuring instruments;
9. Test operation of alarm devices;
10. Interfacing test with BMS;
11. Checking if all internal cabling and function operation
12. Above tests are minimum requirement and shall include all other tests required by the Engineer to verify compliance with the Specification.

Triplicate sets of all principal test records and test certificates are to be supplied for all the tests carried out in accordance with the Specification to the Engineer for approval before dispatch from the Motor Control Centre factory.

All costs, materials, equipment, labour, etc. necessary for the execution of the testing shall be included in this portion of work.

5.2 TRANSPORTATION

Motor Control Centre are not allow to be delivered to site until the electrical room or Motor Control Centre room is in a clean and acceptable condition with lockable doors.

Motor Control Centre transported to site shall be fully covered with weatherproof covers and transportation eye bolts shall be provided for handling at site.

Motor Control Centre which are poorly packed and result in signs of corrosion will be rejected.

All necessary measures to cover and protect the Motor Control Centre at site shall be provided. Such measures shall include a complete PVC blanket over the whole Motor Control Centre or control panel.

5.3 REJECTION OF MOTOR CONTROL CENTRE

If any of the above tests fail to comply with the requirements of this Specification in any respect whatsoever at any stage of manufacture, test, erection or on completion at site, the Engineer may reject the item or defective component thereof, whichever is considered necessary, and after adjustment or modification as directed by the Engineer, the Contractor shall submit that item for further inspection and/or test. In the event of the defective item being of such nature that the requirements of this Specification cannot be fulfilled by adjustment or modification, such item is to be replaced by the Contractor at his own expense, to the entire satisfaction of the Engineer.

5.4 EARTHING

Suitable earthing terminals or studs shall be provided on the frame for the connection of 25 mm x 3 mm copper strip to the main earthing bar in the electrical room or Motor Control Centre Room.

A main earthing bar of HDHC copper with cross-sectional area in compliance with BS7671 and BS7430 50 mm x 6 mm shall be provided in the electrical room or Motor Control Centre room and to which all earthing connections shall be made. This earthing bar shall run along the wall adjacent to the full length of the Motor Control Centre. Two connection to main earthing system shall be provided.

5.5 PROVISION OF ELECTRICAL SERVICES AND EQUIPMENT TO MEET LOCAL AUTHORITIES' REQUIREMENT

All other requirements by Local Authority that are imposed in the course of execution of the work, particularly those listed below shall be provided.

1. Danger signs;
2. Rubber floor mat of 6m thickness and 1 meter width provided for the full length of the Motor Control Centre;
3. A dry chemical type fire extinguisher of 9 kg capacity with approved label;
4. Framed single line diagram with minimum A1 size endorsed by the Contractor.
5. 'First-Aid' Demonstration sign;
6. Sand for cable trenches after completion of all cable installation work, if applicable.

SECTION 22 AUTOMATIC TRANSFER SWITCH

1.0 GENERAL

1.1 SCOPE

Furnish and install where indicated Transfer Switches having the ratings features/accessories, enclosures, etc., indicated on the drawings or noted herein.

The Transfer Switches shall be fully rated to protect all types of loads, inductive and resistive, from loss of continuity of power, without derating, either open or enclosed.

Material and equipment shall be a standard product of a manufacturer regularly engaged in the manufacture of Transfer Switches. The experience shall include applications of equipment and materials of the same detail and/or rating as the Transfer Switches specified.

1.2 STANDARDS

The Automatic Transfer Switch shall be engineered and constructed in according with the standard specified in the respective circuit breakers section.

UL 1008 listing for Transfer Switches.

1.3 SUBMITTALS

Complete list of equipment and materials proposed, with an adequate description of each item to be furnished, shall be submitted prior to approval.

A certificate of compliance to respective circuit breaker standard compliance specified and UL 1008 must be submitted for the Transfer Switches to be supplied. The certificate is not required if the manufacturer's published data submitted and approved reflect a UL 1008 listing. Proof of UL 1008 listing does not, however, relieve the contractor of compliance with other provisions of this specification.

A typical schematic diagram with logic table shall be furnished showing normal operation of the Transfer Switch.

Final as-built drawings

As-built wiring diagrams

Certified production test reports

Installation information

1.4 QUALIFICATIONS

The manufacturer of the automatic transfer switch shall be the manufacturer of the major components within the assembly.

The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of five (5) years. When requested by the Engineer, an acceptable list of

installations with similar equipment shall be provided demonstrating compliance with this requirement.

1.5 DELIVERY STORAGE AND HANDLING

Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

1.6 MAINTENANCE MANUALS

A test report and Operations and Instructions Manual shall be included with the point-to-point wiring schematic shipped with each Transfer Switch supplied. It shall include results from factory functional testing on the identical unit and shall show each Feature/Accessory as being tested satisfactorily in accordance with the requirements of this specification. The test report shall indicate the manufacturer's Shop Order Number and Serial Number of each Transfer Switch supplied.

2.0 PRODUCTS

2.1 RATINGS

The Transfer Switches specified herein shall be 100% equipment rated for continuous duty as shown on the drawings and shall conform to the applicable requirements of respective circuit breaker standard and UL 1008 for emergency total system load. All 3 phase 4 wire Transfer Switches used with ground fault equipment shall be the true 4 pole switched neutral type with all four poles for each source being fully rated and connected to a common shaft. Overlapping neutral shall not be acceptable.

The Transfer Switch shall be rated for non-welding of contacts when used with the upstream overcurrent devices shown on the plans and with the available fault current as specified.

The withstand closing and interrupting ratings of the Transfer Switch shall be no less than those required to be compatible with the available system short circuit current and the type and rating of systems protective devices.

The voltage rating of the Transfer Switch shall be no less than the system voltage rating. The Transfer Switch contacts shall be rated for use up to 600 volts.

The continuous current rating of the Transfer Switch shall be no less than the maximum continuous current requirements of the system.

All pilot devices and relays shall be of the industrial type rated 10 amperes with self-cleaning contacts.

All switches shall be of the amp ratings shown in the attached drawings.

2.2 CONSTRUCTION

Transfer Switches specified herein shall consist of completely enclosed contact assemblies and a separate control logic panel. The contact assemblies shall be operated by a non-fused motor operator or stored energy mechanism, and be energized only momentarily during transfer providing inherently double throw switching action.

Control power for all transfer operations shall be derived from the line side of the source to which the load is being transferred.

Transfer Switches shall be capable of being operated manually under full load conditions and shall be equipped with a permanently affixed manual operator engineered to prevent injury to operating personnel in the event that the electrical operator should suddenly become energized during transfer. In addition, provisions should be provided to allow disengagement of the electrical operator during manual operation. The manual operator shall provide the same contact-to-contact transfer time as provided under normal automatic operation to prevent possible flashovers from switching the main contacts slowly.

Each Transfer Switch shall be positively interlocked mechanically and electrically to prevent simultaneous closing of both sources under either automatic or manual operation. Main contacts shall be mechanically locked in position in both Normal and Emergency positions. A neutral position shall not be possible under normal electrical operation unless a Delayed Transition accessory is required for switching highly inductive loads. Each Transfer Switch shall have a manual neutral position for load circuit maintenance. A Transfer Switch position indicator shall be visible from the front of the switch to show to which source the Transfer Switch is connected.

A logic panel shall be separately mounted from the power switching portion of the Transfer Switch. The two sections shall be connected together by control cables with plug in connectors. The control section shall be capable of being disconnected from the power section for maintenance purposes.

Each Transfer Switch shall be supplied in the appropriate enclosure. The enclosure shall be painted with the manufacturer's standard painting procedures to insure suitability for environmental conditions as referenced in the plans. Wires shall be permanently marked near the terminal at each end with the wire number shown on the approved shop drawings. Terminal facilities shall be arranged for entrance of external conductors from the top or bottom of the enclosure. Main Transfer Switch terminals shall be suitable for the termination of conductors shown on the plans.

Each transfer switch shall be seismic qualified for Uniform Building Code seismic zone 4.

2.3 TERMINATIONS

Terminal facilities shall be arranged for entrance of external conductors from the top or bottom of the enclosure. The main transfer switch terminals shall be suitable for the termination of conductors shown on the plans.

2.4 SEQUENCE OF OPERATION

Upon loss of phase-to-phase voltage of the normal source to 70% of nominal, and after a time delay, adjustable from 0.5 to 15 seconds, to override momentary dips and/or outages, a 10 ampere, 48VDC contact shall close to initiate starting of the emergency or standby source power plant. Transfer to the alternate source shall take place immediately upon attainment of 90% of rated voltage and frequency of that source. For switches not involving engine generator sets as a power source, transfer shall occur after an adjustable time delay of 1 to 60 seconds to override momentary dips and outages.

When the normal source has been restored to 90% of rated voltage, and after a time delay, adjustable from 0.5 to 32 minutes (to ensure the integrity of the normal power source), the load shall be retransferred to the normal source.

A time delay, adjustable from 0.5 to 32 minutes, shall delay shutdown of the emergency or standby power source after retransfer to allow the generator to run unloaded for cool-down, after which the generator shall be automatically shut down.

If the emergency or standby power plant should fail while carrying the load, transfer to the normal power supply shall be made instantaneously upon restoration of the normal source to satisfactory conditions.

2.5 ACCESSORIES

The logic of the transfer switch shall function through mechanical interlock. LED lights shall be included on the exterior of the switch to show:

1. Normal Source Available
2. Emergency Source Available
3. Normal Source Connected
4. Emergency Source Connected
5. Load Energized

A digital readout shall display each option as it is functioning. Readouts shall display actual line voltage, line frequency. The switch shall include the following options:

1. Provide a timer to delay transfer from the normal power source to the emergency power source (0 seconds - 30 minutes). This option does not effect the engine start circuit.
2. Provide a timer to override a momentary power outage or voltage fluctuation (0 seconds - 120 seconds).
3. Provide a timer to delay transfer from the emergency power source to the normal power source (0 seconds - 30 minutes).
4. Provide a timer to allow the generator to run unloaded after re-transfer to the normal power supply (1 second - 30 minutes).
5. Provide single phase under voltage and under frequency sensing on the emergency power source. Voltage shall be factory set at 90% pickup and 80% dropout. Frequency sensing shall be set at 48 hertz pickup and 46 hertz dropout.
6. Provide a maintenance selector switch to disconnect the motor circuit to allow testing of the logic circuit without transferring the load.
7. Provide a pilot light to indicate that the switch is in the normal position.
8. Provide a pilot light to indicate that the switch is in the emergency position.
9. Provide a pilot light to indicate that the normal power is available.
10. Provide a pilot light to indicate that the emergency power is available.

11. Provide 4NO/4NC auxiliary relay contacts that are energized when the power is available on the normal source.
12. Provide 4NO/4NC auxiliary relay contacts that are energized when the power is available on the emergency source.
13. Provide a time delay in the neutral (or both OFF) position when the load is being transferred in either direction to prevent excessive in-rush currents or out of phase transfer. An in-phase monitor is not an acceptable alternative.
14. Provide a pre-transfer signal device to open/close on a timed basis to allow the load to be de-energized up to 10 devices prior to transfer in either direction.

3.0 EXECUTION

3.1 FACTORY TESTING

Each switch shall be factory tested in accordance with circuit breaker standard and UL standards. In addition the manufacturer shall perform the following tests:

1. Insulation check to ensure the integrity of insulation and continuity of the entire system.
2. Visual inspection to ensure that the switch matches the specification requirements and to verify that the fit and finish meet quality standards.
3. Mechanical tests to confirm compatibility of the switch's logic and power sections and to verify that they are free of mechanical hindrances. Switches shall be cycled through a minimum of 50 operations by alternately removing normal and emergency power sources.
4. Electrical tests to verify the complete electrical operation of the switch and to set up the time delays and voltage sensing settings of the logic.

3.2 INSTALLATION

Installation of all switches shall be in accordance with all applicable codes, standards, and practices as well as in accordance with the recommendations of the manufacturer.

The contractor's field wiring terminating within the enclosure shall be either colour coded or wires shall be permanently marked near the terminal at each end with the wire number shown on the approved shop drawings.

The contractor shall supply grounding lugs as required to meet with the local inspection and applicable codes.

3.3 FIELD ADJUSTMENTS

The contractor shall field adjust all timing and voltage settings of the transfer switch as necessary for proper operation of the unit.

SECTION 23 LUMINAIRES AND ACCESSORIES

1.0 GENERAL

1.1 WORK DESCRIPTION

The luminaires schedule indicates the detail requirement of the luminaires selection. The exact luminaires of the installation subject to Engineer approval on the sample. The Contractor shall be responsible to ensure the selected luminaires suit the location of installation.

The Contractor shall co-ordinate the fixing detail of the luminaires, any accessories, brackets, waterproof termination box etc, required to complete the installation shall be included in the Contract

Certain types of electrical equipment or systems involving sudden changes, or low frequency or of direct electric current such as fluorescent lamps, contactors, etc. shall be fitted with radio and television interference suppression components suitable to meet the levels specified in BS 800 "Limits of Radio Interference".

1.2 STANDARDS

The manufacturing of the luminaires shall also conform to the requirements of all relevant local codes, as applicable, together with the additional requirements referred to in this Specification and Drawings, whichever is the more stringent and acceptable to the Engineer.

In the adoption of standards and requirements, the Contractor shall take the following precedence:

1. Engineer's decision;
2. Local codes of practice;
3. Drawings;
4. Specification;
5. International standards and requirements.

1.3 SUBMISSION

All technical submissions shall be approved by the Engineer prior to the respective stages of construction.

As a minimum requirement, the submission shall include the following:

1. Luminaires colour cut sheet submission with manufacturer's data, lamp date, IP rating, location of installation, quantity.
2. Sample submission;
3. Lit-up sample submission as required by Engineer.
4. Lit-up sample for all lamps with indication of location of installation and manufacturer recommended lamp life span.
5. Illumination computer print out for area as required by Engineer.
6. Shop Drawings of the fixing details showing the coordinated installation details.
7. Test reports for all emergency use luminaires.
8. Builder's works requirement.

2.0 PRODUCT

2.1 INTERNAL WIRING WITHIN LUMINAIRES

Cables interconnecting components shall be heat resisting cables and shall be neatly bundled by nylon self-locking cable ties and shall be properly routed and secured away from heat generating accessories like control gear, etc.

Cables used for internal wiring of the luminaires shall be of appropriate type and size. The insulation of the cables shall be able to withstand throughout the life of the luminaires the maximum temperature of not less than 105°C.

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

All cable terminations within the luminaires shall be suitably shrouded. At every luminaires, an earthing terminal shall be provided for connection to the circuit protective conductor.

2.2 FLUORESCENT TUBES AND PL LAMPS

Fluorescent tubes shall be energy saving type and shall comply with BS1853 and shall be as indicated on the luminaires Schedule. Fluorescent tubes shall be triphosphorus coated type having an efficacy of not less than 96 lumen per lamp watt for standard fluorescent tubes and 104 lumen per lamp watt for T5 slim fluorescent tubes, and eighty-five (85) colours rendering index.

PL lamps shall be of single-ended miniature fluorescent lamps each consisting of two narrow glass tubes welded together with a bi-pin cap and housing for starter and capacitor at one end.

Lampholders for PL lamps shall be of type G23 suitable to receive the bi-pin cap of the PL lamps. Power factor correction capacitors shall be provided to correct the power factor to better than 0.9 lagging.

2.3 FLUORESCENT FITTINGS

Except where specified or shown as being aluminium, metalware for florescent fittings, reflectors, channels, etc., shall be constructed from mild steel or zinc anneal sheet not less than 1 mm thickness. All corners and joints exposed to normal view shall be welded, ground smooth and filled where necessary before painting.

Fittings shall have closed ends unless otherwise specified or detailed. Where a diffuser is specified the diffuser shall be for the full length and width of the fitting with a surrounding flange where applicable. Diffusers shall be arranged so that they are hinged frame supported, or where specified to the contrary, hinged or removable and held by chains for maintenance.

After fabrication, metal surfaces shall be thoroughly cleaned back to the parent metal and all dust, moisture grease or oil shall be removed.

All scale and corrosion products shall be removed after which the finished article shall be cleaned with trichloroethylene.

The metalware shall be spray painted with high grade polyester powder coat on both sides and stoved. Total thickness of paint build up shall be not less than 50 micron. Finished colour shall be to approval on all surfaces.

All fittings shall be adequately ventilated to maintain the tube wall operating temperature below 65°C (50°C ambient).

All plastic diffuser shall be of non-deteriorating, colour stable material and of acrylic material.

Recessed lighting fittings shall be supported from the RC ceiling slabs using appropriate fixing accessories such as steel rod, spring clips, ceiling brackets, suspension hooks, profile brackets, etc. to ensure proper Installation of the fittings on different types of ceiling panels. Where light fittings are installed directly below large ductworks etc., the Contractor shall install suitable brackets, channels, etc. to facilitate suspension/support of the light fittings from the ceiling slabs. An adjustable resilient spring-clip shall be provided to enable the suspension length to be adjusted to fine tolerances. Suspension sets shall be adjustable proprietary make type manufactured to carry the weight of the lighting fittings and shall be of adequate lengths for installation on the false ceiling panels concerned. Suspension rods shall be of least 5mm diameter and shall fixed at positions recommended by the lighting fitting manufacturers.

At least four (4) suspension rods shall be provided for each fitting. Lighting fittings shall be supported in a manner that will ensure that the weight of each fitting is equally distributed to all supporting rods with the fitting remaining in level position. Suspension sets where exposed to sight shall be of adjustable rod type of minimum diameter 20mm with all necessary accessories.

Louvered mirror reflectors of the fluorescent lighting fittings where called for shall be manufactured for low brightness performance with double parabolic faceted, pre-anodized high purity aluminium of 88% reflectance, with minimum of glare to comply with Category 2 of CIBSE Lighting Guide LG3:1989. The louver reflectors shall have a light output ratio of at least 70%.

All diffusers shall be hinged at one side of the fitting for maintenance purposes and snap fit back into position.

All lighting fittings used as emergency lights including exit signs shall be constructed and installed In accordance with the current edition of BS5266 Code of Practice for the Installation and Maintenance of Emergency Evacuation Lighting and Power Supply Systems in Buildings. Exit signs shall be complied with Civil Defence requirements.

Identification symbol in accordance with BS5266 shall be displayed on or adjacent to each emergency lighting fitting. The symbol shall not be fixed to the diffuser of an emergency lighting fitting or to removable ceiling tiles.

2.4 CONTROL GEARS FOR FLUORESCENT LUMINAIRES

All electrical control gears shall be totally built into the fitting assembly. Separate ballast, starter and power factor correction capacitor shall be provided for individual lamp. All control gears shall be rated for 230V ± 10% AC voltage supply.

Ballasts shall be low loss type with a maximum of 6 watts loss at rated voltage and wattage comply with BS 2818.

Power factor correction capacitors complying to BS 4017 shall be provided to correct the power factor for each lamp to not less than 0.9 lagging two (2) hours after continuous operation of the lamp. All capacitors shall be fitted with suitable internal discharge resistor. Power factor capacitors shall be of a type manufactured for continuous operation in an ambient temperature of 50°C. Capacitors shall be fitted with leads in lieu of terminals so that the component is not exposed when fitting is opened.

Starters shall be complete with bases and shall of the glow type with bi-pin to comply with BS 3772. A radio interference suppression capacitor shall be fitted internally within the starter.

Control gear shall be suitably selected to suit the requirements of switching and/or dimming control as specified on the Specification Drawings.

Electronic ballasts shall be of high frequency fixed output type, low loss of less than 5 watts, suitable for T5 slim fluorescent tubes. All electronic ballasts shall comply with IEC928, IEC929 and EN55015.

2.5 TUNGSTEN LAMPES

Tungsten filament lamps shall be of the general lighting services pattern or otherwise of the coiled coil type in applicable sizes. Clear lamps shall be utilized in all fittings with the exception of open base glassware in which case lamps shall be of the silica coated type. Lamps shall be manufactured to BS 161 for general service type, and BS 1522 for projector lamps class B.1 and B.2.

All lamps shall be provided with Edison Screw (ES) holders.

Lamps of coiled coil filament type shall have a nominal life of 1000 burning hours.

2.6 High Intensity Discharge (HID) Lamps and Control Gears

High Intensity Discharge (HID) lamps where called for shall be manufactured to BS 3677 as appropriate.

Appropriate inductive ballasts for limiting the current shall be used in conjunction with the HID lamps and that the control gears installed shall be suitable for the lamps used. The control gears (ballasts, ignitors, capacity or etc.) for each lamp shall be suitable for enclosing in a weatherproof compartment where used for external areas or integrated with the luminaires. Ballasts shall be the low loss type manufactured to BS EN 60922 and rated for operation at 230V \pm 10% 50 Hz single phase AC supply. Ballasts shall be vacuum impregnated or polyester filled to ensure good heat dissipation and maximum protection from moisture and corrosion. The ballasts shall be of low noise type and shall be mounted tightly on a rigid part of the lighting fitting. No one component of the lighting fitting shall be loose and badly fastened which might become resonant. Power factor of each lamp circuit shall be maintained at better than 0.9 lagging.

2.7 EXTERNAL LIGHTING

Lighting poles for the pole lights shall be constructed using hot-dip octagonal steel columns with the base compartment housing the lamp fusegear which shall consist of a single fully shrouded single pole and neutral single entry type cut-out with HRC fuse, appropriate size MCB complete with cable sealing box, armour clamps and compression gland, where required, suitable for reception of looping PVC/SWA/PVC cables or PVC cables of the sizes as required. The finishing colour coat shall be subject to the Engineer's approval.

Wiring between lamp and cut-out shall be twin core 2.5sq mm tinned annealed circular copper conductor PVC insulated black PVC sheathed incorporating within the sheath a bare earth continuity conductor of the same cross sectional area.

Weather proof connection board shall be provided for the supply of landscape lighting as indicated on the drawings.

Lightning protection earth electrode for pole lighting higher than 6 m shall be provided by the Contractor.

2.8 EMERGENCY LIGHT FITTINGS

Emergency fluorescent light fitting shall comply to BS5266 and IEC598-2 and shall be individually equipped with battery pack to provide illumination upon sensing of power failure. The emergency fluorescent fittings are required to be type tested by approved testing laboratory to meet BS5266 and IEC598-2.

Individual control unit and battery pack shall be integrated within the light fittings

Batteries shall be sealed nickel-cadmium re-chargeable type to IEC 285 and shall be capable of continuous operation at cell wall temperature of 70°C

The batteries shall be capable to maintain the fluorescent lamp for up to two (2) hours after the main supply fails. The lumen output of the light fittings shall not be less than 50% of those under main supply condition throughout the two (2) hours of discharge period.

The charger shall be fully automatic, solid state constant voltage type, with electronic circuitry to protect the batteries against over-charge and over-discharge. The charging system shall be capable of re-charging the battery to full capacity in not more than sixteen (16) hours after a total discharge of the battery.

The control circuits shall be suitable for 230 volt \pm 10% mains operation and shall be manufactured to enable the luminaries to operate exactly like normal conventional light fittings. An unswitched live wire shall be connected to each and every luminaries with emergency pack so that the luminaries can be switched off either from the associated lighting switches, timers, contactor, etc. However, irrespective of the status of the light switch or the controlling contactor, the light fitting shall automatically illuminate or remain illuminated upon mains failure. Upon restoration of the mains supply, the lamp shall be switched back to mains supply operation and the batteries shall be re-charged again automatically.

A circuit switch shall be incorporated in the control circuit to enable testing of the circuit to be carried out. A red neon light shall be provided to show 'mains supply healthy'.

A fused terminal block fitted with cartridge fuses of appropriate rating shall be provided separately for both the charge and the maintained circuit.

All Emergency use luminaries supplied by battery or UPS shall be comply with Civil Defence code. All time and cost required to obtain subject test certificate to Civil Defence code shall be included in the Contract.

2.9 COLD CATHODE LIGHTING

The Contractor shall furnish and install the complete cold cathode lighting installation as described in the contractual details. They shall be manufactured by Cold Cathode Lighting specialist.

Lamps shall be cold cathode, 20mm mounted in a straight electrode configuration to Engineer approval. Lamps shall produce 440 lumens per 300mm (white) and shall not depreciate more than 20% after 10,000 hours of operation.

Lamps shall be made from nominal 20mm diameter lead glass halophosphor coated and baked, with heavy duty coated electrodes and shall be fabricated to the shapes and sizes required. They shall be as manufactured by a cold cathode lighting specialist. They shall be silicone-coated, and shall have adjustable snap-on lamp reflectors.

Lampholders shall be right angle, straight electrode type to Engineer approval. They shall be BSI approved, site glazed porcelain with spring bronze clip contacts to give good electrical contact and to support the lamps.

Ballasts required for the cold cathode lamps shall be the type to Engineer approval. They shall be remotely located as directed by Engineer. The ballasts shall be BSI approved, HPF, 230V, 50 Hz.

The Contractor shall install the lamp holders so that all lamps make secure electrical contact in the lamp holders.

Circuit breakers controlling the circuits feeding the cold cathode ballasts shall be capable of being locked in the open position.

The following information regarding the manufacturer shall be provided by the Contractor within sixty (60) days of signing of the Contract name of manufacturer and list of previous jobs using normal 20mm diameter lamps.

Fireman Switches for any luminaries included neon light as required by Civil Defence code shall be provided by the Contractor. The Contractor shall obtain approval from Engineer for the location of Fireman Switches.

2.10 UNDER WATER LUMINARIES

All under water luminaries shall be completed with minimum 5 m factory connected lead cable. Any termination kit required to ensure a waterproof cable termination included waterproof termination box shall be included in the Contract. IP class of under water luminaries shall be IP-68.

2.11 AIRCRAFT WARNING LIGHTS

The luminaire shall be of a maintenance free obstacle light for aviation warning with a life span of at least 100,000 hours. The lamp shall be of light emitting diode (LED) type in

accordance with local air-traffic control code requirement and complies with international Civil Aviation Organization (ICAO) standards.

Light Intensity : Vertical radiation to be at least 10cd with a coverage of 50°
: Horizontal radiation to be at least 10cd with a coverage of 360°
(lamp life of 100,000 hrs)

Luminaire housing shall be of high pressure die-cast aluminium housing to IP65 minimum requirement complete with all necessary accessories including control box, solar cell, 3-way and 4-way junction box for through wiring, mounting accessories, surge protection devices, etc.

2.12 EXIT SIGN

Exit sign shall be surface or recess mount to suit the Architectural detail.

The exit sign shall be complete with battery pack of specification refer to Emergency Light Fittings under this Section.

The exit sign shall be constructed from plastic or fiber material.

All fittings shall be adequately ventilated to maintain the tube wall operating temperature below 65°C (50°C ambient).

The Exit Sign shall manufacturer with details to Civil Defence requirement.

All light fittings used as emergency lights including exit signs shall be constructed and installed In accordance with the current edition of BS5266 Code of Practice for the Design, Installation and Maintenance of Emergency Evacuation Lighting and Power Supply Systems in Buildings.

Identification symbol in accordance with BS5266 shall be displayed on or adjacent to each emergency lighting fitting. The symbol shall not be fixed to the diffuser of an emergency lighting fitting or to removable ceiling tiles.

2.13 LAMP LIFE SPAN

The selection of luminaires shall take into account the requirements for heat dissipation, weatherproofing, insect proofing and the vibrations at the location of the installation. All luminaires installed in the Works shall have a minimum lamp operation life of not less than 80% of the average lamp life stated by the lamp manufacturer. If any lamps fail before this time, this will be treated as evidence of non-compliance of all the lamps of the same type in the installation concerned and in other installations which have the same performance criteria. The Contractor will be held responsible for the replacement cost of the affected lamps and all lamps of the same type in installations with the same performance criteria