

SECTION 3

LOW VOLTAGE POWER AND LIGHTING INSTALLATIONS

SECTION

- 16-13 Low Voltage Switchgear Assemblies
- 16-14 Circuit Breakers and Instruments
- 16-15 Main Power Distributionboards
- 16-16 Light and Power Panel Boards
- 16-17 Conduit, Trays, Trunkings, Related Fittings and Accessories
- 16-18 Wires and Cables
- 16-19 Lighting Equipment
- 16-20 Earthing System
- 16-21 Lightning Protection System
- 16-22 Motors, Starters and Controls

16-13 LOW VOLTAGE SWITCHGEAR ASSEMBLIES

16.13.1 General

This specification relates to Type Tested Assemblies (ITA) and Partially Type Tested Assemblies (PTTA) of low voltage switchgear including the design and manufacture of such assemblies.

Unless otherwise specified all terms shall be as defined in BS 4727 and BS 5486, and related documents.

The assembly type and functional content shall be as specified in this Specification.

16-13-2 Standards and Regulation

The design, manufacture, selection, installation, testing, commissioning, including consideration for future maintenance by others, of all equipment and materials described in this Specification shall comply with the requirements of BS 5486: Part 1. The Electricity at Work Regulations and the documents referenced in each of these publications.

Where more onerous requirements are specified herein, the conditions of this Specification shall take precedence.

16-13-3 Classification of Assemblies

1- General

Each assembly shall be of the enclosed type.

All functional unit handles shall be accessible via the front plates of the assemblies. Dead front assemblies will not be acceptable.

Ferrous, non-ferrous or insulated removable gland plates shall be provided forming part of the cable box, as appropriate for the type of cable to be connected.

2- Assemblies

Assemblies shall have all busbars separated from the functional units, all of which shall be separated from each other and their load terminals.

Internal separation shall be carried out using rigid barriers or partitions.

All horizontal and vertical busbars and risers including those providing final connectors between the busbars and functional units shall be air insulated and located within separate rigid compartments.

Each functional unit shall be installed in a separate compartment.

Separate compartment shall be provided as specified in the schedules and/or drawings.

A main incoming unit shall be provided in a separate compartment, which shall be arranged such that all incoming supplies, including control circuits, are isolated within the compartment.

The gaseous products of arc extinction shall not be allowed to impair the operation of switchgear devices in adjacent compartments. In addition, arcing within any compartments shall be confined to that compartment and shall not affect the operation of circuits in adjacent compartments, including faults on outgoing terminals.

Suitable terminals shall be provided for connection of outgoing cables from each functional unit. The cables shall be glanded off on gland plates within the functional unit compartment. Separate terminals shall be provided for control cables, which shall be a barrier from those for power cables.

3- Service Conditions

The assemblies described in this Specification and the associated schedules and drawing shall be suitable for use under the service conditions specified in the schedules.

4- Degree of Protection

The minimum acceptable degree of ingress protection (IP) from all directions of the installed assembly shall be as specified in the schedules.

The IP rating shall be verified by production of Test Certificates for each design of assembly.

5- Transportation

The assembly shall be suitably protected for transportation and storage in a temperature range between -25°C and $+55^{\circ}\text{C}$, and for short periods not exceeding 24 h, up to $+70^{\circ}\text{C}$.

Equipment subjected to these extreme temperatures without being operated shall not undergo any irreversible damage and shall operate normally in the specified conditions.

The assembly shall include provision to cater for moderate condensation, which may occasionally occur due to variations in temperature within the ranges specified for normal operation, transportation and storage.

16-13-4 MECHANICAL CONSTRUCTION

1- Type and Materials

All assemblies shall be of the enclosed type comprising cubicle or multiple cubicles. Cubicle sizes shall be suitable for easy access and maintenance of the functional units and associated equipment mounted in the individual cubicles. Space shall be provided to allow an overall increase of the specified functional units as specified in the schedules and drawings.

The overall height of each assembly shall not exceed 2.4 m unless shown otherwise on drawings.

Equipment for indication and/or operation shall be mounted not less than 300 mm and not more than 1800 mm above finished floor level.

2- Doors and Covers

Access to cubicles containing functional units shall be only from the front by means of hinged doors opening to not less than 85°.

All doors and covers shall have folded edges and additional bracing to eliminate whip. All doors and covers shall be sealed as appropriate to meet the specified IP rating.

All non-interlocked doors shall be fitted with suitable cylinder locks. Each cylinder lock shall be supplied with two keys. All removable covers shall be fitted with suitable zinc plated self-aligning fixing screws.

Panel construction shall be such that component manufacturer clearances are observed, and adequate ventilation shall be provided for heat dissipation. Inlet air filtration shall be provided.

Ventilation arrangements shall be detailed on the Manufacturer's and/or Fabrication Drawings.

A key cabinet shall be provided and all keys shall be clearly labeled with permanent labels.

Where it is necessary for cables and/or conduits to enter assemblies and/or pass between compartments, flexible grommets or glands shall be used.

3- Functional Units

Each functional unit shall have an integral isolating switch, the operating handle of which shall be interlock with the door, which in the open position shall isolate all incoming supplies including low control circuits.

4- Steel Enclosures

Steel enclosures of assemblies shall be constructed to BS EN 10130 Series, with a minimum thickness of 1.5mm. Enclosures shall be assembled from a modular system. The system shall provide for multi-tier sections of compatible appearance. The design shall include provision for lifting each section by means of removable lifting devices, any holes for this purpose shall be sealed adequately after removal of the lifting device.

All necessary holes and slots shall be formed prior to cleaning and fishing.

All component parts shall be cleaned to comply with the paint manufacturers recommendations, following which they shall be finished with an epoxy or polyester powder paint which is oven cured. Paint colour shall be manufacturers standard, unless otherwise specified in the schedules.

5- Installation

All assemblies shall be fixed properly and level.

6- Free Standing Assemblies

Free standing assemblies shall be securely mounted on plinths, which shall be flush with the bottom outside edge.

Plinths shall be constructed of steel, GRP or as builder's work as indicated on the drawings. Plinths shall be secured to the floor.

7- Wall Mounted Assemblies

Wall mounted assemblies shall be fixed via external lugs at the rear of the enclosure easily accessible. The enclosure and fixing shall be suitable to support the total weight of the assembly, without distortion.

8- Front Access Assemblies

Front access assemblies shall be fully maintainable and constructed from the front and arranged so that all normal operations, essential maintenance, replacement of any components and connection/ disconnection of cables can be carried out from the front of the assembly including busbar maintenance and extensions.

9- Rear Access Assemblies

Rear access assemblies shall be arranged so that all normal operations are carried out from the front of the assembly, but essential maintenance, replacement of any components and connection/disconnection of cables can be carried out from the front and/or rear of the assembly.

10- Assembly Extensions

Where extensible assemblies are specified in the schedules, it shall be possible to commence extension of an assembly in the future, by bolting on additional sections without a shut down. Connections to energized busbars and other live connections will only be carried out during a complete shutdown.

16-13-5 ELECTRICAL CONSTRUCTION

1- General

The physical condition, electrical and mechanical properties of connections and termination of all current carrying parts shall comply with recommendations of Copper Development Association.

2- Main Circuits

Main circuit wiring shall be PVC insulated to BS 6231, Type BR, and where appropriate, sized for Type 2 protection CO-ordination to IEC 947, but with a minimum size of 2.5 mm. Connections to and from functional units shall be segregated from control wiring and adequately supported to withstand the forces due to short-circuit faults. The sizes of wires shall be calculated in accordance with the IEE Wiring Regulations.

All cable connections shall be made at fixed terminal joints. Insulated conductors shall not rest against bare live parts or exposed sharp edges.

3- Auxiliary Wiring

All non-screened auxiliaries wiring, except that is required to be screened, shall be carried out in 600/1000 grade insulated, multi-stranded flexible conductors complying with BS 6231 Type BR.

The minimum conductor size shall be 1.5 mm². The colors of wires shall be as specified in the schedules.

All auxiliary wiring shall be identified at both ends with numbered and resistor color-coded ferrules. These numbers shall be shown on the control schematic-wiring diagram.

All auxiliary wiring shall be contained within cabling trunking and totally segregated from power wiring as far as practicable. Wiring of circuits at different voltage categories, e.g.LV and ELV, shall be segregated Joints will not be permitted on wiring between devices.

Cable trunking shall be of the ventilated type with clip-on covers and purpose made junctions and accessories. Cables shall not occupy more than 25% of the trunking cross-sectional area.

Wiring not contained within trunking shall be strapped in looms with removable straps and held in place by suitable cleats. Looms shall not exceed more than 25 wires. Self-adhesive straps shall not be acceptable.

All wiring connections from trunking and looms to devices shall be run in straight lined, horizontally and vertically, and be neatly dressed.

Wiring to door mounted devices shall be flexible and provided with a large enough loop to clear the edge of the opening. Protection against abrasion shall be provided by means of flexible conduit or spiral wrapping securely fixed at each end.

Where wiring passes through partitions it shall be protected against abrasion by thermoplastic grommets and spiral wrapping.

Interconnections between functional units shall be contained within a separate cabling chamber or trunking. All cables shall terminate on the functional unit terminals within the cubicle.

Functional devices which require fiber optic cables for carrying communications signals, shall be mounted so that the cables can be terminated directly on the device.

Provision shall be made for fiber optic cables to enter the assembly and relevant compartment according to the minimum bending radius. Cables shall be protected by grommets where they pass through holes.

4- Labels

All enclosures containing functional units shall be clearly labeled with a circuit, unit reference and current rating.

All labels shall be of the engraved type made from suitable multi-layer laminate and shall be fixed with zinc plated cheese head instrument screws. No other type of label will be acceptable.

Every functional unit shall be labeled separately from all others. External labels shall have letters not less than 5 mm in height and internal labels not less than 3mm. The letters shall be black in color on a white background.

All covers/doors not fitted with interlock switched disconnecters enclosing enshrouded live equipment shall be fitted with warning labels inscribed (DANGER 400V ISOLATE BEFORE OPENING)

Warning labels shall have black letters on a yellow background. Wherever possible, letters shall be not less than 30mm in height. On small covers and doors letters of 20mm or 10mm in height shall be used.

Cable boxes shall be clearly labelled both externally and internally with the circuit and functional device number.

All terminal blocks shall be labelled relative to the respective functional unit. Every control and metering device, selector switches, push-button and indicator light shall be clearly labelled to indicate its purpose.

Main identification labels shall be provided on the assembly together with a rating plate.

Fixed and withdrawal portions of equipment including fixed and plug-in devices shall be labelled with withdrawal portions cross-referenced to their fixed part. Proposed engraving details shall be submitted for comment prior to engraving.

16-13-6 Earthling

Each assembly shall be provided with a continuous copper earth bar running the whole length sized in accordance with BS 7430 for the prospective short-circuit discrete terminals shall be provided for connection to all the protective conductors Each individual section of the assembly shall be separately bonded bar.

16-13-7 Components

1- General

All components shall be installed in accordance with the instructions of their manufacturers. This requirements for type and routine testing as specified elsewhere in this Specification.

Adjusting and resetting devices shall be easily accessible.

All components shall be installed and wired such that their function is not impaired by interaction such as heat, arcs, vibration, and fields of energy present in normal operation.

Barriers for manual switching devices shall be designed such that arcs caused by switching under normal operation or the interruption or making of a fault current shall not present a danger to the operator.

All removable and withdrawal components shall be installed and designed such that they can be safely disconnected or connected to supply circuits whilst the associated conductors are alive.

All spare contacts on relays, contactors, and the like shall be wired to easily accessible terminal blocks, suitably positioned for future external wiring. Assemblies shall be provided with a spare set of fuses mounted on polyethylene coated spring clips adjacent to the fuse chart on the doors of a separate cubicle. A total of 20% of each size of fuse shall be provided with a minimum 4 of each size.

When commissioning is complete the panel shall be handed over with this complete set of spare fuses. A fully detailed fuse chart shall be provided in the same cubicle as the fuses.

Where moulded case circuit breakers are installed they shall be fitted with rotary action handles. The handles shall be lockable in the 'ON' and 'OFF' positions.

2- Selector Switches/ Push-Buttons/Indicator Lamps

The manufacturer's range shall include fully interchangeable contact blocks and lampholder blocks, which can be fitted to all actuators including switches and push-buttons.

Selector switches shall be of the rotary type, with lever or key operated actuators as specified in the schedules or shown on the drawings.

Pushbuttons shall be of the flush type. Colors shall be as specified in BS 4099. Pushbuttons used for emergency stop purpose shall be of the mushroom head type, with a twist to release action or key reset.

Contact blocks shall have double break silver plated contacts, in "NO" or "NC" configuration rated at not less than 5 A resistive at 230V 50Hz.

Indicating lamps shall be of the flush type 22mm diameter with removable colored lenses, allowing lamps to be changed from the front and shall be provided with a push to test facility. Colors shall be as specified in BS 4099.

Indicating lamps on control circuits shall be equipped with completely sealed dual wound safety isolating transformers.

Fuse failure lamps shall be of the neon type, with current limiting device.

3- Wiring Terminals

Cable termination and space for termination shall be suitable for the size of cable for in the design.

Terminal blocks shall be made of thermosetting melamine or polyamide material with a low tracking index and good flame resistance, tested to withstand a temperature rise of 90C above ambient temperature. Provision shall be made for permanent labels to be applied to each terminal for identification purpose.

All terminals shall be marked in accordance with BS 5472.

All terminals for control wiring shall have provision for plug-in test spills and in addition be fitted with isolating links. Current carrying parts shall be made of tinned brass or copper.

Completely shrouded terminals of the tunnel type shall be used for cabled up to 10 mm². The screw clamp connection shall be vibration proof, self locking and suitable for clamping two conductors.

Stranded cables up to 10 mm² shall be terminated in copper or copper alloy ferrules. The ferrules shall retain all strands of the cable.

Terminals for cables in excess of 10mm² shall be of the double connection type with bolted studs for the connection of cable lugs. The terminal and stud size shall be adequate for the current carried and the size of cable. Suitable insulating partitions and protective covers shall be provided.

All auxiliary wiring except screened cables shall be connected to incoming/ outgoing cables via insulated terminal blocks, screwscrew type, clipped onto DIN rails.

There shall be sufficient space on the DIN rail for future terminal blocks of not less than 10 % or 5 number whichever is the greater. Wires shall enter terminals singly.

Plugs and fixed sockets for the application shall be provided for the termination of screened cables.

All termination shall be mounted at least 0.2m above the base of floor mounted assemblies.

All load terminals shall be suitable for the types and sizes of cables.

4- Batteries

Batteries and chargers for closing and stripping purpose shall be provided as separate remote assemblies. These shall comply with the separate specification for batteries and charging equipment.

16-13-8 INSPECTION, TESTING AND COMMISSIONING

1- Works Tests

All assemblies shall be tested in accordance with the requirements of BS 5486: Part 1, plus requirements of associated standards.

Factory tests for the LV switchgear shall be as per the latest standard, and Test Certificates from International Laboratory shall be submitted to the Engineer.

Calculation from first principles for temperature rise and short-circuit strength will not be acceptable.

Verification of the short- circuit withstand strength is not required for assemblies having a rated PSSVC not exceeding 10KA or those protected by current limiting devices with a cut-off current not exceeding 15KA.

Verification of the short- circuit withstands strength is not required for auxiliary circuits connected to transformers whose: -

- (1) Rated power does not exceed 10 kA for a rated secondary voltage of not less than 110 V. OR

- (2) Rated power does not exceed 1.6 kVA with rated secondary voltage of less than 110 V, and whose relative short-circuit voltage is not less than 4 %.

Works tests shall include inspection of all wiring and complete electrical functioning tests.

Protection relays shall be tested by primary current injection with current equal to overload, short-circuit and earth fault conditions.

2- Site Tests

(1) Assemblies

All assemblies shall be subjected to the routine tests as defined in BS 5486 after installation on site. Test Certificates shall be provided.

(2) Functional Circuits

All functional units shall be checked for correct mechanical operation.

(3) Protection Circuits

All protection circuits in which relays are used shall be tested for correct operation by secondary injection of test currents. This shall be carried out at current equivalent to overload, short-circuit and earth fault conditions.

(4) Current Transformers

Protection circuits using current transformer (CT) operated relays shall be tested by primary injection of current to prove the transformer ratio.

3- Commissioning

Following the satisfactory conclusion of inspections and tests on completed sections of the Works, each switchgear assembly shall be duly commissioned and left in full working order. The term "Commissioning" shall be deemed to include:

- (1) The energizing of functional device circuits and equipment, which have previously been inspected, tested, found to be satisfactory and capable of being energized with complete safety.
- (2) Re starting up of all electrically powered plant and equipment, including that supplied and installed under other contracts and as specified in the schedules.
- (3) The verification of the performance of each switchgear assembly relative to all such plant and equipment by the carrying out, where required, of further tests and the making of all necessary adjustments so as to obtain optimum performance.
- (4) The proving of all interlock operations in all possible combinations and the operation of all control systems, metering and indications to meet the performance requirements specified.

16-14 CIRCUIT BREAKERS AND INSTRUMENTS

16-14-1 Air Circuit Breakers

1- General

Air break open-type circuit-breakers,(ACBS) shall comply with IEC 947 Part 1 and 2, plus any additional requirements of this Specification and shall be rated for uninterrupted duty.

2- Construction

ACBS shall be metal- clad, horizontal draw-out, cassette type with positively driven 'ON.OFF' indication.

Interchange shall be incorporated to prevent the wrong circuit breaker being racked in at any fixed position.

Security shall be provided to padlock the breaker in the service, isolated and test positions; and to close and independently padlock the shutters as specified in the schedules. It shall not be possible to withdraw or rack- in a circuit breaker when it is in the closed position. Incorrect racking-in shall be prevented.

Robust padlocks or cylinder locks shall be provided to lock each circuit breaker in one or other position during on site testing and commissioning. This shall include locking the shutters closed when a circuit breaker is racked out. Two sets of keys shall be provided for each padlock, together with a key cabinet and key schedule.

Associated Equipment, ACBS shall be fitted with the protection devices, instruments, indicators and auxiliary control functions as specified in the schedules.

3- Operating Mechanisms

ACBS shall be of the four-pole type as specified in the schedules. One pole shall be a full sized-switched neutral.

Where specified in the schedules, operating mechanisms shall be the trip-free type and shall have a latching current equal to the short-circuit prospective value.

Alternatively, the ACB shall be fitted with an instantaneous trip or making current release which operated when the ACB is closed onto a short- circuit. Anti-pumping devices shall be fitted to all operating mechanisms.

The specific method of closing shall be:

TYPE S OC: Solenoid Operated from d.c Or rectified a.c. Facilities shall be provided to remove or blank off the integral mechanical CLOSE push-button where it could be used to override protection devices, lockout relays or remote operating signals.

4- Operating Facilities

A ' number of operations' counter shall be all ACBA's. The counter shall be non-resittable.

The ACB shall have facilities for isolation, withdrawal and test position operations with the ACB isolated. Carriage position switches shall be provided for connection into appropriate control circuits to permit electrical interlocks to be defeated when the ACB is in the isolated (where applicable) test positions as specified in the schedules.

Where applicable earthing facilities shall be provided, to earth the circuit and busbars in the service, test and isolated positions.

5- Operation Clearance

Circuit breakers shall be installed with full clearances for arc-chute vents and adequate side clearances for unimpeded operation and maintenance.

6- Rating

General

The service performance characteristics shall be specified.

Rating specified are the required on-site ratings. Written confirmation shall be provided to confirm that specified rating will be obtainable under the conditions in which each circuit breaker operates. Operating conditions shall include due allowance for ambient temperature, enclosure, physical situation, position and attitude of the ACB and the proximity of other devices on full load.

A label shall be provided, in a clearly visible position on the front of each circuit breaker on which the service performance characteristics shall be displayed.

16-14-7 Protection and Tripping

Protective relay requirements shall be specified Protective relays shall be of the solid state type with selectable characteristics and comply with BS 142 and BS 5992.

All relays shall be provided with test facilities for use in commissioning and testing from the front of the switchboard.

Relays shall be of the integral or external type as applicable:

1- Tripping Characteristics

Details of tripping characteristics shall be provided for each type of ACB. The details shall include manufacturers full current discrimination tables showing over correct and short- circuit discrimination and, additionally a full set of overlay transparency discrimination curves to enable discrimination settings to be checked.

All over correct and short-circuit protective devices shall have separately adjustable time and current settings. Adjustments and settings shall be possible from the front of the ACB. The setting adjustment devices shall be behind a lockable cover plate, or similarly protected against unauthorized access.

Energy for protective devices shall be obtained from integral current transformers. Separates current transformers shall be of the accuracy class specified in the schedules and comply with BS 3938, and of suitable ratio and rating for the operating conditions. If the circuit breaker is de-rated because of high temperature

then the current transformers shall be replaced with ones suitable for the higher operating temperatures. Protection current transformers shall not be de-rated. Undervoltage, trip and closing coils shall be wired out to secondary isolating contacts in the same position on each breaker to ensure interchangeability of ACBS with the same service characteristics.

2. Commission Label

A label shall be provided, in a visible position on the front of each circuit breaker, on which the final commissioned release setting for that circuit breaker shall be displayed.

16-14-8 Auxiliary Contacts

ACB auxiliary circuits shall be arranged to provide a wiping action on contacts during withdrawal and reinstatement of the ACB, to and from its isolated position.

On completion of the switchboard installation, each ACB shall be provided with auxiliary contacts available for future use for both the ACB contact operation and the isolation operation as required. Wiring to the switching contacts shall be ferrule and brought to a terminal block.

All auxiliary contacts shall be mounted in accessible positions and away from possible electrical and mechanical danger.

16-14-9 Shutters

Where ACBS are isolated, safety shutters shall automatically cover exposed conductors.

The shutters shall be able to be padlocked in the closed position, but shall be capable of being fixed open where tests require conductor contact.

Shutter shall operate automatically by the movement of the circuit breaker, preferably without using springs.

Shutters shall be painted to BS 381C as follows:

Shutters	Color	Ref.	Lettering (white)	Additional Requirements
Incoming Circuit shutter	Signal red	537	DANGER LIVE CABLES	-
Busbar Circuit shutter	Signal red	537	BUSBARS	-
Bus-section shutter	Signal red	537	BUSBARS (on each)	With white arrows to indicate the section of switch-board with which the shuttered contacts are associated
Cuit Shutters	Lemon	355	-	-

16-14-10 Finishes

Special treatments and finishes such as tropicalisation, anti-corrosion finish and cold climate treatment shall be applied where conditions make such treatment necessary.

16-14-11 Tools

Loose equipment shall include test leads and a lifting and transportation device plus any other tools or equipment needed for routine maintenance.

16-14-12 Testing

ACBS shall be type tested by an independent approved testing authority and a complete Compliance Certificate, including short-circuit ratings, shall be provided for each type of circuit breaker.

In addition to the normal test requirements of IEC 947, ACBS shall be type tested in enclosures similar to those in which they will be installed on site. Such tests shall include temperature rises tests.

If deemed necessary, a complete set of manufacturer's on-site testing and calibration equipment shall be provided for commissioning and testing and for future fault diagnosis, testing and re-calibration of testing, trip units, control units and process controllers forming part of the installation.

16-14-13 Miniature Circuit Breakers

1- General

Miniature circuit breakers (MCBS) complying with BS 3871:Part1, IEC898 or BS EN 60898 shall be acceptable, however, all MCBS shall comply with the same standard and be from the same manufacturer's range. MCBS shall be rated for uninterrupted duty at 230/400V.

MCBS shall have Type Test Certificates from a NAMAS approved CO-ordination testing authority. Manufacturer's tripping characteristics shall be provided for each type of MCB specified.

Service and ultimate short-circuit capacities shall be specified.

The joule integral energy withstand let-through shall be specified for each MCB.

In multi-pole MCBS, including four-pole, all poles shall open, close and trip simultaneously.

Mechanisms shall be quick-make, quick-break, over-center type which are trip-free. Colored bands shall positively indicate the contact position and/or lettering to show whether the contacts are open or closed.

Security for MCBS shall be proved with effective means of locking in the "OFF" position.

2- Characteristics of Circuit Breakers

MCB current ratings instantaneous tripping characteristics shall be specified in Cable and Distribution Board Schedules.

The manufacturer's standard range shall include all MCB rating, characteristics and auxiliaries specified.

16-14-14 Molded Case Circuit Breakers

1- General

The definitions of terms and symbols used in this Specification are those used in IEC 947.

Moulded case circuit breakers, (MCCBS) shall comply with IEC 947: Part1 and 2 plus any additional requirements of this Specification.

Short-circuit capacities, impulse withstand voltages and insulation levels shall be suitable for the location of the circuit breaker in the system, i.e. at service entrance level, distribution circuit level, load level or specially level.

MCCBS shall be selected to ensure full discrimination up to and including the prospective short-circuit and earth fault currents as specified on drawings and schedules. For prospective earth fault currents the disconnection times shall not exceed 5 sec.

MCCBS shall be energy limiting type unless specified otherwise.

2- Construction

MCCBS shall be manufactured with double insulation of the front face, insulating auxiliary components from the main power poles thereby allowing as far as reasonable the fitting of auxiliary units on site without full isolation of the unit.

(1) Current Rating

Rated currents, rated service short-circuit breaking capacities and trip release settings shall be specified.

Current ratings shall be suitable for uninterrupted duty at 23/400V in the final installed location on site under full load operating conditions of the complete installation, i.e. taking account of heat produced by other devices and the ambient temperature, physical situation, enclosure, position and attitude of the MCCB. The appropriate de-rating factors shall be applied to manufacturer's standard ratings when selecting MCCBS to meet the specified ratings.

MCCBS shall be suitable for operation in both the horizontal and vertical mounting position without detrimental effect on operation or rating.

(2) Tripping Characteristics

Detail of tripping characteristics shall be provided for each type of MCCB. The details shall include manufacturer's full current discrimination tables showing overload and short-circuit discrimination and, additionally, a full set of overlay transparency discrimination curves to enable discrimination settings to be checked.

(3) Test Certificates

Complete certificates shall be provided for each type of MCCB, stating the service and ultimate short-circuit capacities.

(4) Contacts

The contact arrangement of current-limiting MCCBS shall be such that the current-limiting contacts are in series with the main contacts and remain closed in normal operation, including time delayed overcurrent tripping.

Contacts shall be arranged so that normal current is carried by low-resistance silver alloy or other non-welding material where arcing is handled by tungsten contacts.

Multi-set contact MCCBS shall be arranged using one set on contacts for thermal current and the other for arc interruption.

(5) Terminals

Terminals shall be sized to accommodate the size and type of cable for incoming and outgoing circuits as specified in the schedules or drawings. MCCBS shall be provided complete with terminal shields.

Terminals shall be arranged for direct connection to busbars, front or rear as required by the switchboard design.

All poles of multi-pole circuit breakers shall be constructed so that contacts open, close and trip simultaneously. It shall not be possible for one or more poles to be closed while another remains open and vice-versa.

(6) Operating Mechanisms

Operating mechanisms shall be over-center, quick –make, quick-break type having operating in which speed of operation of the breaker is independent of the operator.

All hand-operated circuit breakers shall be fitted with rotary action handles. The handles shall be lockable in both open and closed positions.

Where motor operated MVCCBS are specified, the motors and clutches shall also be specified. Direct action operating handles shall be provided for local operation.

Where solenoid operated MCCBS is specified, the operating voltage shall also be specified. Separate solenoids shall be provided for opening and closing operations. Built-in push buttons shall be provided for local operation.

Indication of the “ON”, “OFF” and TRIPPED conditions shall be provided not only by the position of the handle but also by means of a colored band, or line which shall be visible when the circuit breaker is on but not when it is off or tripped. The handle assuming a mid-point shall indicate the TRIPPED condition between ON and OFF. It shall not be possible to manually place the handle in the tripped position.

(7) Enclosures

Moulded case covers and non- interchangeable trip elements shall be permanently sealed at works to prevent tampering, but the trip elements may be changed/adjusted and re-sealed on site by using suitable tools.

All internal components of MCCBS shall be replaceable on site.

MCCBS shall be certified as satisfying the leakage current tests called for in IEC 947 with regards to safety isolation.

MCCBS used for motor starting shall satisfy the Type 2 CO-ordination requirements called for in IEC 947. The MCCB and the starter shall preferably be of the same manufacture, and in all cases shall be tested together and certified as satisfying the CO-ordination requirements.

All MCCBS shall be of the same manufacture and those of like kind shall be of the same type. This requirement to loose or individually mounted MCCBS as well as to those incorporated within assemblies such control panels, switchboards and distribution board.

(8) Protection Mechanisms

Each pole shall provide inverse time overcurrent protection and high set instantaneous tripping. All poles shall trip simultaneously if one defects a fault.

Trip units of ratings up to and including 32A shall be built in. Trip units above 32A shall be replaceable.

Tripping mechanisms shall be selective limiting type to obtain discrimination or by interconnection with other MCCB trip units.

All adjustable trips shall be visible and adjustable from the front with the breaker in position. Adjustments to trip settings shall be made to all poles simultaneously by means of a common adjustment mechanism.

Where thermal trips are used shall be ambient temperature compensated, taking account of the temperature inside the enclosure under continuous full load conditions. Heating of bi-metal strips shall be indirect, mains connected up to 630A rating and current transformer operated above 630A rating.

(9) Operating Facilities

Facilities shall be provided for the use of a hand-held tested for on-site testing of all operational features.

Where specified, earth leakage trips, shunts trips, under voltage trips and remote operation shall be provided. These accessories shall all be factory assembled and tested.

Current/ energy limiting MCCBS, which require replacement of the current limiters after operation, shall not be re-settable until such replacement has been made.

16-14-15 Auxiliary Contacts

Auxiliary contacts shall be provided Auxiliary contacts, shall operated simultaneously with the main breaker contacts

16-14-16 Testing

Testing shall be carried out in manner prescribed in IEC 947 plus any additional testing required on circuit breakers for use in non-standard conditions.

For MCCBS of 132A rating and above, a set of manufacturer's plug-in setting/ testing/ diagnostic equipment shall be supplied for routine testing, setting and fault diagnosis. Unless otherwise stated, only one test set is required regardless of the number of MCCBS supplied.

16-14-17 General Information

The following information shall be provided for each MCCB:

- rated current
- rated operational voltage and rated insulation voltage
- number of poles
- rated service and ultimate short-circuit capacities
- method of mounting
- method of connection
- protection against external influence
- the I2t tripping characteristics curves and the peak let-through currents at prospective fault levels
- rated short time withstand current
- rated short-circuit making capacity

16-14-18 Labeling

On the front of each MCCB a visible label shall be fitted and inscribed as follows: labeling shall be marked as follows:

Rated current and trip set (for MCCBS with multiple current ratings the maximum value shall be marked plus, without ambiguity, the value for which the MCCB has been adjusted).

- rated voltage
- manufacturer's name or trade mark
- type designation, catalogue number or serial number rated short-circuit capacity in amperes
- reference ambient temperature if deferent from 30°C

A label shall be provided, in a clearly visible position on the front of each circuit breaker, on which the final commissioned release setting for that circuit breaker shall be displayed.

16-14-19 Instruments and Metering

1- General

All electrical indicating instruments shall comply with BS 89 and shall have an Accuracy Class Index as follows:

Instrument Function Accuracy Class Index

Switchboard indicating instruments 1.0

Ammeters and voltmeters on motor 2.5

Control panels

2- Instruments

(1) General

All electrical indicating instruments shall be products of a single manufacturer.

All ammeters and voltmeters shall be of the moving iron type.

All instruments shall be flush mounted. All instruments shall be logically grouped, relative to the equipment, which they are associated.

All scale ranges of ammeters, voltmeters, wattmeters and varmeters shall be chosen so that, under normal operating conditions, each instrument will read between 60-75 % of the effective scale range.

Ammeters, voltmeters, wattmeters and vermeters shall be square patterned with scales spanning an angle of not less than 90 degrees. Meters shall have low reflectively glass.

Ammeters for use in motor control centers shall have a maximum burden of 3 VA at the upper limit of the effective range.

Instrument dials shall bear only those items of information classified as essential in BS 89, all other required information shall be marked on the exterior of the case.

Notwithstanding the requirements of BS 89, dials of power factor meters shall be marked "LEAD" and "LAG" in the appropriate quadrants.

All instruments shall be provided with external means for adjusting the zero indication.

Ammeters for use in, or in conjunction with, motor starters shall have overload scales with the maximum scale indication equal to not less than six times the upper limit of the effective range. The scale shape shall be such that the effective scale range is not less than two-thirds of the total scale length.

Ammeters for which the upper limit of the effective range does not exceed 20 amps may be direct (series) connected. For higher ranges, current transformer operated ammeters shall be used, and shall be designed for a secondary current of 50A unless otherwise specified.

The use of resistive ammeter shunts for extending the range of ammeters operating on a.c. circuits will not be acceptable.

Indicating wattmeters shall be of the air-cored dynamometer pattern, 3-phase indicating wattmeters shall be suitable for operation on a 3-phase, 4-wire system with unbalanced load, unless otherwise specified.

Varmeters shall be supplied complete with appropriate phase-shifting transformers.

All instruments shall be designed to be capable of operating continuously to the upper limit of the effective range.

(2) Ammeter and Voltmeter Switches

On 3-phase, 4-wire systems, ammeter switches shall have operating positions, marked R, Y, B and N, and an OFF position, and shall enable the single ammeter to read, in sequence, the currents in each of the three phases and the neutral wire. On 3-wire systems ammeter switches shall have three operating positions marked R, Y and B and an OFF position.

Ammeter switches shall have “ make-before-break ” contacts and shall be connected so that the associated current transformers are short-circuited when they are not connected to the ammeter.

(3) Metering Equipment

Single-phase and 3-phase integrating meters for watt-hour (and k Watt-hour and maximum demand) and for reactive volt-ampere-hours (and k VARh) shall comply with all relevant requirements of BS 5685.

Polyphase meters for registering maximum demand in kilowatts (or MW) shall comply with BS 5685: Part 3, as applicable. They shall operate on the basis of a 30-minute demand integration period.

Provision for transmission of data to an external device shall be made as follows:

- (1) kilowatt- hour consumption
- (2) kilowatt-maximum demand
- (3) time-reset pulse for maximum demand.

All meters covered by the preceding clauses shall have an Accuracy Class Designation of 2.5 or better.

All 3-phase meters shall be suitable for operation on a 4-wire system with unbalanced load.

16-14-20 Current Transformers (CTS)

1- General

All CTS shall comply with all relevant requirements of BS 3938 and shall have an Accuracy Class Designation according to the following table:

Current Transformer Function	Accuracy Class Designation
Tariff metering	0.5
Non-tariff metering	1.0
Switchboard indicating instrument	1.0
Motor starter ammeters	3.0
Protection (overcurrent,UEF)	10 P
Protection (REF)	X

Unless otherwise specified in the schedules or drawings, the CTS are required for use under service conditions not more than those set out in BS 3938.

CTS shall be designed either for measurement or for protection and shall not be used in a dual- purpose role serving both instruments and protective gear.

Unless otherwise specified, all CTS shall have 5A secondary windings.

So far it is practicable, all CTS shall be of the ring type. Wound primary CTS will only be accepted when the rated primary current is so low as to make the ring type impracticable.

One side of the secondary of each CT shall be connected to earth at one point via a bolted removable link.

For metering circuits, either, a proprietary front the panel CT test block or special "Shorting" terminals within the panel shall be provided for test purposes.

All CTS whether of the ring type or the wound primary type, for use at voltages exceeding 1000V shall be epoxy resin encapsulated.

Where dual-ratio CTS are specified, they shall be provided with two separate secondary windings capable of being connected in series or in parallel to give the required ratio.

All CTS shall be provided with a rating plate bearing the information set out in BS 3938.

CTS shall be installed in accessible places. The secondary connections shall be brought out by means of insulated leads, and made off an a suitable terminal block mounted in a readily accessible position.

Magnetization curves and/or type Test Certificates shall be provided for all CTS associated with protection devices.

Every CT shall have a rated burden at least 50 % greater than the total burden of the instruments, relays, and/or other apparatus which it is to serve.

16-14-21 Voltage Transformers

1- General

Voltage transformers shall be of the type, rating, and voltage ratio to suit the particular application.

All voltage transformers shall comply with all relevant requirements of BS 3941 and shall have an Accuracy Class Designation according to the following table:

Voltage Transformer Function	Accuracy Class Designation
Meeting	1.0
Switchboard indicating instruments	1.0
Motor starter voltmeters	3.0
Protection	3P

Unless otherwise specified, voltage transformers are required for use under service conditions not more onerous than those set out in BS 3941.

Voltage transformers designed for a primary voltage not exceeding 4000 V shall be the air-insulated types, with the windings encapsulated in epoxy resin or other suitable synthetic material.

Unless otherwise specified, all voltage transformers shall be designed for a secondary output voltage of 110V.

Each voltage transformer shall have a rated burden at least 50 % greater than the total burden of the apparatus or instruments, which it is to serve.

The insulation resistance of each voltage transformer shall be indelibly marked on the shipping/ dispatch label.

16-15 MAIN POWER DISTRIBUTION BOARDS

1- General

The Contractor shall supply, install and commission the distribution boards and connection equipment required for the distribution of electric power to all feeders, as indicated on the drawings and described in the specification.

The make, design and arrangement details of the equipment shall be subject to the prior approval of the Engineer.

The equipment shall include all the necessary accessories for a complete and operational system whether indicated in the specification or not.

Particular attention shall be given to the connection of incoming and outgoing feeders to their respective terminals.

The contractor shall make sure that the allocated space is in accordance with the requirements for installation and operation of the equipment as specified and supplied by the manufacturer. Any subsequent inaccuracy in the building shall be corrected as required and directed by the Engineer, and at no extra charge to the Employer.

16-15-2 Main Distribution Boards

1- General Requirements

The main distribution switchboards shall be completely wired and tested at the factory, ready for installation when received at the Site. Suitable sectionalisation shall be accomplished and bracing provided for access of the equipment into the building.

2- Switchboard Construction

It shall be of the totally enclosed, front access indoor type, of size, rating and arrangement as indicated on the drawings. The complete assembly shall be floor mounted, free standing, with matching cases, to form a continuous integral structure.

Switchboard shall consist of the required number of formed and welded sheet steel enclosures required mounting circuit breakers and other specified equipment.

Switchboard shall be completely enclosed on front, sides, top and rear with removable steel plates of not less than 2.5-mm thickness.

All fastening between structural members shall be bolted, not welded, to provide flexibility during installation.

The arrangement shall be used to permit interchanging differently sized device cover plates without additional drilling of structure.

Structures and busses shall be arranged to permit future sections to be added. A suitable cover plate shall be provided for temporary protection.

Switchgear shall be dust, vermin and rodent proof.

All components shall be suitably ventilated where required. A space position shall be fully equipped cell ready to receive a circuit breaker.

All bolted contact connections shall be made with “ Everdure B” silicone bronze alloy hardware and shall be electro- silver plated to a thickness not less than 0005.

Suitable arrangement and equipment shall be provided for extracting and unloading the circuit breakers from their cells.

Approved nameplates, permanently mounted for identification of all major devices and control equipment shall be supplied with each unit of assembly, engraved with lettering.

Nameplates shall be laminated, engraved with 6mm white English letters on a black background.

An earth bar extending the entire length of the assembly shall be provided. The bar shall be sized in accordance with the Regulations.

The switchboard shall be sanded and rust inhibited after fabrication painted one prime coat and two enamel finish coats on both inside and outside surfaces. Color shall be gray.

A special trolley shall be supplied together with the switchboard for removal or installation of the air circuit breakers from either compartment for maintenance or repair.

3- Moulded Case Circuit Breakers

Moulded case circuit breakers shall be of the thermal magnetic type, 600 volts, class, manually operated for normal switching functions and automatically under overload and short circuit conditions .Breakers shall be with ampere trip and frame ratings as indicated on the drawings and containing the general features.

Frame size Ampere	Interrupting Capacity Sym Ampere
.....
100	14.000
400/500	30.000
800/1000	45.000
2000	70.000

4- Busbars

All busbars, switching devices and connections shall be copper of sufficient size to limit the temperature rise to 55 C over an average ambient temperature of 20C outside the enclosure. The busbar rating shall be as indicated on the drawings.

16-15-3 Distribution Boards

1- General

Distribution boards shall be miniature circuit breaker (MCB) boards as indicated on the drawings.

MCB distribution boards shall comply fully with the requirements of BS 5486 Parts 1 and 2.

Where more onerous requirements are specified herein, the conditions of this Specification shall take precedence.

Distribution boards shall be provided with sufficient internal shielding or shrouding to give a minimum index of protection of IP2X against accidental contact with live metal when connecting additional outgoing circuits whilst the board is in a live condition. Spare ways shall be safely blanked.

All interior components shall be mounted on a rigid fabricated chassis capable of being removed and/or reversed for ease of wiring.

Distribution boards shall be provided with a suitable earth terminal and earth bar, with adequate provision for the connection of a circuit protective conductor for each outgoing way.

Terminals for the neutral conductor shall allow the individual connection of conductors having a current carrying capacity equal to the full current carrying capacity of the phase conductor.

When the means of isolating the distribution board from the incoming supply is not to be mounted immediately adjacent to the board, means shall be provided in the distribution board to indicate whether or not the supply is ON.

Distribution board cases shall be fabricated from zinc-coated or heavily rustproof heavy gauges sheet steel and be of all-welded construction. They shall be adequately braced or stiffened, by folding or otherwise, to form a completely rigid enclosure. Exterior corners and edges shall be rounded so as to give a smooth overall appearance.

Distribution boards shall have a side-hinged front cover, attached by means of lift-off hinges, and fitted with cylinder type locking handles. Covers shall be braced or folded in such a manner as to prevent distortion or whip, and shall be fitted with dust-proofing gaskets or edge seals.

Distribution board cases shall provide a degree of protection against contact with live parts and the ingress of dust, solid objects, or moisture.

Distribution board cases shall be of such dimensions that adequate space is available for maneuvering and connecting the incoming and outgoing cables.

Distribution boards shall be provided with detachable end plates.

Each distribution board shall be provided with a durable circuit chart fixed to the inside of the cover or immediately adjacent and bearing typewritten details, in plain language, of the circuits supplied by each of the ways. The chart shall be on heavyweight paper or thin card, and shall be protected by means of a rigid transparent plastic cover, it shall be mounted in such a way that it can easily be removed for correction or alteration, then replaced. The size of the chart shall be such that there is adequate space for recording all of the required information and, in any case, shall not be less than A5 (210mmX148mm).

Each way in the distribution board shall be clearly numbered to correspond with the numbering on the circuit chart.

Each distribution board shall be provided with an engraved plastic label on the outside of the front cover, bearing the designation of the board and its reference number, if any. The label shall be fixed in position by chromium- plated setscrews. Each such label shall be not less in size than 100mmX 30mm, and shall bear the required inscription in white on a black background, using letters and/or digits not less than 5mm high.

Distribution board covers shall incorporate locking facilities.

16-15-4 MCB Distribution Boards

MCB distribution boards shall be the products of one manufacturer.

MCB distribution boards shall be single-pole neutral (SPN), double-pole (DP), triple pole (TP), or triple-pole and neutral (TPN).

All multi-pole boards shall be Type B as defined in BS 5486: Part 12.

MCB distribution boards shall have an integral means of isolation. The means of isolation shall be capable of being padlocked in the OFF position.

The front hinged cover of each MCB distribution board shall be cut away to expose the operating levers of the MCBS.

16-15-5 Electrical Equipment

1- General

Where required, a means of isolation shall be provided on the incoming supply. Provision shall be made for padlocking in the open position.

Neutral conductors shall be insulated from earth to allow use on TN-S systems. Neutral conductors shall have separate connections for each outgoing cable.

Neutral busbars and connections shall have the same rating as the associated phase conductors. Neutral connections shall be clearly labeled with the circuit reference of the associated fuse or circuit breaker.

Phase busbars shall be color marked in sequence red, yellow, blue. The neutral bar shall be color marked black and the earth bar green and yellow. The coloring of bars

shall not be continuous unless it is also the insulating medium otherwise the color marking shall be such that it cannot be mistaken for an insulating covering.

Installed dividing barriers shall be provided between phase contact assemblies and between phase and neutral. The barriers shall be constructed so that it will not be possible to insert a fuse link or circuit breaker between phases or between phase and neutral.

Where required, fuses or circuit breakers of ratings specified in the schedules shall protect outgoing circuits.

Circuit breaker protection shall consist of miniature or moulded case circuit breakers as required. All live parts shall be shrouded or guarded against accidental contact.

Miniature circuit breakers may be plug-in or screw fixing types. Moulded case circuit breakers shall be screw fixed. In all cases fixings and connections shall be from the front.

Outgoing circuits shall be labeled with the circuit reference and, where applicable, the fuse or circuit breaker rating.

2- Instrument Panel

Where required, an instrument panel shall be provided. As a minimum the panel shall contain a 13A switched socket outlet to BS 1363 with stainless steel or brass cover plate, a 30A fuse base and carrier fitted with a 30 A cartridge fuse to BS 88 for supplies to the socket outlet and anti-condensation heater, a residual current item shall be clearly labeled. Screens shall be provided to permit safe access to all parts of the instrument panel.

Meters, instruments, relays, times for street lighting, current transformers and other equipment shall be provided as required. Where earth fault indication is specified, the voltage transformer shall be connected via the 30 amp fuse carrier.

Current transformers and meters shall be in accordance with the relevant section of this Specification. On all circuits without permanent ammeters it shall be possible to use clip-on ammeters.

3- Cabling

All cable access shall be from the front with entry from below.

Cable entry and termination provisions shall be suitable for the size and type of cable specified.

Cable termination arrangements shall be suitable for compression lugs or bolted clamps. Cable support cleats shall be adequate to support the cables in normal service and to restrain them under fault conditions. The arrangement shall be such that all cable termination can be readily made from the front.

4- Mechanical Construction

Clearances within the enclosure shall be sufficient to permit closing and locking of the doors with switches inside in any position and also locked. Electrical clearances and creepage distances between conductors and to earth shall not be less than 25mm.

All parts of equal size and rating shall be interchangeable. The number of joints shall be kept to a minimum. Corrosion proof bolts with locking washers shall secure bolted electrical joints.

Where specified in the schedules, the enclosure shall have provision for expansion by the addition of extra outgoing ways.

Shells shall be constructed of galvanized sheet steel, cast iron or glass reinforced plastic as required.

Roots shall be constructed of galvanized steel, cast iron or concrete as required. Where required, suitable bolting flanges for mounting onto concrete plinths shall be provided. Removable aprons shall be provided to permit installation of cables from below.

Access shall be by means of hinged doors or lift-off covers. Door shall be fitted with locking bars to secure both top and bottom of each door. The means of locking shall be specified.

Natural ventilation shall be provided to limit the temperature rise to the manufacturer recommendations. Ventilation apertures shall not reduce the IP rating below that specified and shall be screened to prevent entry of vermin. Where specified, air inlets and outlets shall be provided with dust filters.

Any equipment, which is not stable on its own supports, shall be fitted for transit and storage with returnable extension feet to provide stability. Any special tools for assembling or locking shall be supplied.

All data plate shall be fixed to the panel detailing information:

- Clients Reference / Serial Number
- Year of manufacture
- Normal current rating of busbar
- Normal current rating of incoming unit
- Gross weight, when fully equipped (kg)
- Manufacturers name and reference number the gross weight shall also be stenciled externally.

16.15.6 Residual Current Devices

This section of the Specification covers residual current devices (RCDS) intended for protection of final circuits rated at 125A or less. RCDS shall be installed on circuits as required.

RCDS shall comply with BS 4293 and with the requirements of the IEE Wiring Regulations. A residual current-operated circuit breaker (RCCB) as described in BS 4293 shall come within the scope of RCD as used in this specification.

When incorporation over current and short circuit trips and used as circuit breakers RCDS shall comply also with BS 4752: Part a. When used as disconnects or switches RCDS shall comply also with BS 5419.

Residual current shall be measured by a transformer, which may be zero-sequence-connected or core balance type.

RCDS shall have rated tripping currents specified.

RCDS shall operate in 0.4 seconds or less.

RCDS shall have the appropriate short-circuit strength for the location in the system at which they are installed and shall be capable of making, carrying and breaking the full-short current. This requirement shall apply whether or not the RCD is the sole or main circuit breaker at that point in the system. Unless used as circuit breakers RCDS shall be connected in series with the overload and short-circuit devices in the system.

RCDS shall not be used as the sole means of protection against direct contact.

Every RCD shall be provided with a test button and an engraved, clearly legible label-starting TEST FREQUENTLY.

RCDS shall be suitable for loads with high crest factors and shall operate correctly irrespective of the harmonic or direct current content of the waveform. RCDS shall not trip out on loss of supply voltage.

RCDS shall be provided with auxiliary contacts as necessary.

16.15.7 Switches, Disconnecters and Fuse-Combination Units

1- General

This section of the Specification shall be read in conjunction with BS 5419. This equipment covered shall comply with BS 5419 and is for use at voltages up to 1000V a.c. and 1200V d.c.

All equipment shall be air-break type unless specifically required otherwise.

The rated making and breaking capacities and the rated conditional short-circuit current for each item of equipment shall be stated by the manufacturer and the appropriate test certificates provided. On-site testing shall be carried out as required to satisfy the relevant sections of this Specification.

Each item of equipment shall be provided with the means to enable it to be locked in the off position. In addition, any item for use as an earthing switch shall be provided with means of locking in the earthed position.

All equipment shall be of the utilization category and class of duty specified.

Equipment shall be de-rated as recommended by the manufacturer if environmental conditions fall outside the standard conditions defined in BS 5419, Section 6.

Enclosures shall be suitable for the environment at the location where the equipment will operate. Flameproof applications are covered elsewhere in this Specification.

Each item of equipment within a cubicle or other enclosure shall be of the withdrawal type for ease of maintenance. It shall be possible to carry out all routine maintenance and changing of fuses and contacts without disconnecting any cables or busbars.

Each item of equipment shall be clearly labeled with its function by means of permanently fixed engraving laminate labels.

2- Switches

Switches shall be switch-disconnects as defined in BS 5419. This means that when in the open position switches shall satisfy the safety isolating requirements for disconnects.

Switches shall be rated for uninterrupted duty and shall be capable of making, carrying continuously and breaking full rated current.

Switches shall be capable of making full short-circuit current and carrying it for seconds.

Switches shall give positive indication of open and closed positions.

Switch mechanisms shall be so designed that switches cannot be opened within 3 seconds of being closed.

The means of operation of switches shall be as specified in the schedules or drawings.

Where switches operate by means of manual operation, the speed of operation shall be independent of the effort of the operator. Charging of springs and closing of the switch shall be one continuous manual operation.

Where switches use stored energy for operation, the energy shall be stored by means of charged springs. Storing of energy and opening or closing of the switch shall be independent operations.

Where specified in the schedules, charging of springs shall be electric but provision shall be made of manual charging in the event of failure of the electrical supply. The electrical supply for charging mechanism shall be specified.

The method of release for opening and closing shall be specified.

3- Disconnection

Disconnectors shall be rated to carry normal full load current continuously and to carry short-circuit current for 3 seconds.

Disconnectors shall not be used in locations where they will be required to make or break other than negligible current.

Disconnectors shall be independent manual operation. The mechanism shall be so designed or arranged that disconnectors cannot open within 3 seconds of being closed.

4- Fuse-Combination Units

Switch-fuses and fuse-switches shall be used for all fuse-combination unit applications. In each case the switch element shall satisfy the requirements for disconnectors. Fuse-disconnectors and disconnected-fuses as described in BS 5419 shall not be used.

Fuse-links shall be cartridge type as specified in this Specification.

5- Equipment Data

The equipment data to be provided by the Contractor prior to ordering any material covered by this subsection shall be submitted to the Engineer for approval and include but not be limited to:-

- Complete technical data on circuit breakers, contactors and other switchgear, including data on operating characteristics, compliance to Standards, dimensions and weights, detailed description operating mechanism etc.
- Complete technical data on instrument transformer protective and auxiliary relays, measuring instruments, including manufacturer's catalogues, operating characteristics, operating curves, detailed description, etc.
- Complete technical data on the construction of the boards, with busbars, equipment plug-in arrangement, access doors, provision for expansion including detailed description, manufacturers catalogues.
- Complete technical data on miscellaneous items including lamps, control and instrument wiring, outgoing and incoming power terminals and wiring, labels,locks, grouting, bracings,etc.

6- Contractor's Shop/Construction Drawings

The Contractor's shop/construction drawings for installation covered by this subsection shall include but not be limited to: -

- Plan, front and side elevations, with indication of all face-mounted equipment, exact dimensions and weights.
- Drawings of arrangement of equipment inside the board.
- One line schematic diagram of circuits.
- Protection circuit diagram
- Installation details, grouting holes foundation details.
- Indication of arrangement of main incoming feeders and outgoing feeders.

16-16 LIGHT AND POWER PANELBOARDS

16-16-1 General

Panelboards shall be totally enclosed, with molded-case breakers bolted to the vertical bars in twin sided arrangement. Branch circuit references are accordingly indicated on the drawings. Example- branch circuit marked 1, 3,5,(2,4,6) in 3 phase,4 wire systems are connected to red ,yellow and blue phases respectively.

Panelboard interiors shall not be installed in cabinets until all conduit connections to the cabinet have been completed.

All unused openings in panelboard cabinet shall be properly closed.

Concealed surfaces of cabinets shall be given a heavy field application of emulsified asphalt prior to installation.

16-16-2 Panelboards

1- General

Panelboards shall be factory assembled and consist of a sub-base assembly and molded case circuit breakers of the rating indicated on the drawings, all enclosed in a sheet steel enclosure.

Sub-base assembly and circuit breakers shall be manufactured on the same manufacturer.

Panelboards shall be rated for the full load plus 25% spare capacity and the next higher rating shall be selected. Panelboard characteristics shown on the schedules are given for general guidance. A number of spare circuit breakers shall be provided as indicated.

Cabinets shall be manufactured from either folded or welded hot dipped galvanized sheet steel and in no case shall the material be less than 2-mm thickness.

Panelboard cabinets shall be supplied with hinged gasket and lockable doors.

All Panelboards shall be keyed alike.

Panelboard steel cabinets shall be finished by etch priming with one bottom coat and one topcoat of stove enamel. Color to be gray to BS 2660.

Panelboards shall be of the NEMA type, enclosure and flush or surface wall mounted as indicated on the drawings.

Directories under glassine shall be provided inside cabinet doors. Directories shall be typed to identify number and description of the associated lines for each circuit on Panelboards.

All Panelboards shall have an identifying nameplate mounted on the outside of the trim or the inside of the door as directed by the Engineer and as shown in the clause 17.356.

Nameplate shall be laminated phonetic with white engraved 20mm letters on a black background. Nomenclature shall be as indicated on the drawings.

2- Bus Assembly

Busbar connections to the branch circuit breakers shall be the "distributed phase" or "phase sequence" type.

Three-phase, four-wire bussing shall be such that any three adjacent single-pole protective devices are individually connected to each of the three different phases in such a manner that two or three-pole breakers can be installed at any location. All current carrying parts of the bus assembly shall be plated.

Main and neutral buses shall minimum 98% conductivity rectangular copper bars, provided with bolted-type lugs as necessary.

Busbars shall be of sufficient cross-sectional area to continuously conduct rated current with a maximum average temperature rise of 55°C above an ambient temperature of 20°C.

Buses shall be suitably braced for short circuit duty of values as shown in the panelboard Schedules at rated duty voltage.

Buses shall be rigidly supported and installed and be so designed that branch circuits can be removed without disturbing adjacent units or changed without additional machining, drilling or tapping.

Necessary bussing, drilling and blank plates shall be provided for installation of future circuits when so indicated in the panelboard Schedules.

All screws and bolts used for making copper connections shall be equipped with lock washers. Riveted bus connections will not be acceptable.

Main shall be equipped with solderless pressure indent type connectors and have means to prevent swiveling or connector.

Neutral busbar shall be full size and shall incorporate one neutral terminal for each single pole and neutral way.

Aluminum shall not be used for any interior panelboards parts.

Back pan or mounting pan on which buses and branches are mounted shall be rigid to properly support the component parts.

Buses, connectors and terminals shall be silver plated to a minimum thickness of 0.15mm.

3- Earthing

An acceptable terminal bar for equipment earthing conductors shall be provided.

Panelboards shall be provided with an earth connector welded to the cabinet.

4- 100 Ampere Frame Size Panelboards

These shall accommodate either single pole or triple pole 100A frame size subcircuit molded case circuit breakers and fitted with busbars rated in accordance with the main incoming circuit breakers.

Panelboards shall be fitted with removable gland plates, top and bottom.

100A frame size panelboards shall be fitted with a main incoming isolating device consisting of a 100-225 A frame size molded case circuit breaker rated as shown on the drawings.

5- Circuit Breakers

Circuit breakers shall be molded case of the thermal magnetic type, manually operated for normal switching functions and automatically under overload and short circuit conditions.

Circuit breakers shall be rated as shown on the drawings and in accordance with the following interrupting ratings base on BS testing procedures at 50 Hz.

Frame Size Ampere	Volts	Interrupting Capacity Symmetrical Amperes
100	230/400	14.000
225	415	20.000
400	415	30.000
800	415	30.000
1250	415	45.000

Trip coil rating –the rating of the over-current relays shall match the full load rating of the circuit breaker.

Breakers shall provide positive trip-free operation on abnormal overloads with quick break contacts under both manual and automatic operation. Stationary and movable contacts shall be of non-welding silver alloy and shall be adequately protected with effective and rapid arc interruption. Each pole of the breaker shall be equipped with an inverse time delay thermal over current trip element and magnetic instantaneous over current trip element, for simultaneous tripping of all poles in multiple pole breakers.

Rating of the circuit breaker as indicated on the schedules or drawings shall be the net derated rating over an ambient temperature of 40 C.

Circuit breakers shall be ambient calibrated for continuous operation at 40C ambient temperature.

6- Shop Drawing/ Equipment Data

The equipment data to be provided by the Contractor prior to ordering any material covered under this subsection shall include but not necessarily be limited to:

- Complete technical data on all type of panelboards and circuit breaker characteristics.
- Manufacturer's catalogue cuts dimensional characteristics of panels.

The Contractor's shop/ construction drawings for installation covered by this subsection shall include but not necessarily be limited to:

- Exact composition of each panelboard with indication of busbar rating, frame and trip rating of all circuit breakers.
- Typical installation details of recessed panelboards with indication of main feeder and branch circuit conduit connections.

16-17 CONDUITS.TRAYS.TRUNKINGS.RELATED FITTINGS AND ACCESSORIES

16-17-1 Conduits-General

The Contractor shall provide all conduits and fittings to the all-various light, electrical fittings and power outlets as shown on the drawings, in full conformity with the regulations and these specifications. Layout of conduits shown on the drawings shall be considered as guide defining principles for conduit runs.

Steel conduits, bends and couplers shall comply with BS 4568:part1. Conduit fittings and components shall comply with BS 4568:part 2.

Non-Metallic conduits and fittings shall comply with the relevant parts of BS EN 50086, BS 6099, BS 4607 and BS 7671.

All metal conduit enclosures and raceways for conductors shall be mechanically joined together to form a continuous electrical conductor and shall be so connected to all electrical boxes, fittings and cabinets as to provide effective electrical continuity and firm mechanical assembly.

Minimum size of conduits shall be 20mm diameter, unless otherwise indicated or approved.

Conduits shall not cross pipe shafts or vent duct openings.

Conduits shall be kept a minimum of 75 mm from pipes. Riser conduits shall be supported at each floor level by approved clamp hangers. The use of running threads at steel conduit joints and terminations is prohibited. Where running threads appear to be necessary a 3-piece union or split coupling shall be used.

Steel conduit entering sheet metal enclosure and outlet boxes, when not terminated in a thread hub, shall be secured in place by 2 locknuts and terminated with an insulating brushing. Locknuts shall be placed on the inside and outside of the enclosure.

Conduits termination at apparatus subject to vibration or movement shall be made in heavy gauge sheathed flexible metallic conduit. Adapters shall have male threads for connection to the rigid conduit system via an adaptable box.

Conduits and fittings installed outdoors shall be steel galvanized conduits rain and watertight provided with neoprene type gaskets.

Galvanized steel conduits installed in wet locations shall be coated with emulsified bitumen, and arranged to be self-draining to specific drain which consist of BS boxes but not boxes containing live terminations.

2- Concealed Conduits

They shall be concealed in reinforced concrete slabs, walls, floors and blockwalling as shown on the drawings.

They shall be installed so as not to damage or run through structural members. Horizontal or cross runs in building type partitions or sidewalls shall be avoided.

Galvanized steel conduits run underground must be coated and painted with two heavy coats of emulsified bitumen before being covered with earth. They shall be covered by at least 60cm of earth if in planting soil and by 30 cm of earth under a walkway.

3- Exposed Conduits

Exposed conduits and extension from concealed conduit systems shall be neatly run parallel with or at right angles to the walls of the building.

Exposed conduit work shall be installed so as not to interfere with ceiling inserts, ceiling lights or ventilation outlets.

Approved hangers, clamps or clips fastened by machine screws to expansion sleeves in inserts or lead anchors, shall support exposed conduit. Conduit shall be supported on each side of bends. Spacing of clamps or hangers for supporting conduits shall not be greater than the distance specified below:

Conduit Sizes Spacing of Supports Diameter

Up to 25 mm	2m
32 – 36 mm	2.5m
50 – 65 mm	7.5m
and 100 mm	3 m

Not more than one exposed conduit shall run to an exposed wall outlet, but a junction box shall be installed near the outlet as a pull box in which the vertical conduit shall terminate.

Exposed conduits shall be tagged where it enters or leaves the floor, wall or ceiling and at intervals of 15 meters. Color of tags shall be red.

4- Expansion Fittings

A conduit expansion fitting shall be provided in each conduit run wherever it crosses an expansion joint in the structure to which it is attached.

A conduit expansion fitting shall be provided in each conduit run which is mechanically attached to separate structures.

5- Capacities of Conduits

Conduits shall have capacities as listed in the following table unless stated otherwise:

Conductor Size mm	Conduit Size diameter				
	10mm	25mm	32mm	38mm	50mm
1.5	7	12	20	-	-
2.5	4	8	12	-	-
4.0	3	6	10	-	-
6.0	3	5	8	-	-
10.0	-	3	6	8	-
16.0	-	-	3	4	5
25.0	-	-	-	4	-
35.0	-	-	4	6	-
50.0	-	-	-	4	-

16-17-2 Conduit-Workmanship

Conduits installed under the ground floors shall be encased in concrete minimum 5cm thick of not less than 320 pound concrete. Wiring for short extensions to outlets in hung ceiling shall be installed in flexible conduit.

Cast-in and buried conduit shall be steel Class 4 or high impact non-metallic or flexible polyethylene. The manufacturer as suitable for the application shall approve conduits.

All buried in concrete work shall be installed on a loop-in system.

Conduit buried in concrete shall have a minimum of 25-mm dept of cover over its entire length.

Conduits in chases shall be held in place by purpose made crampets.

Ceiling point boxes or draw-in boxes shall finish flush with the underside of the ceiling

16.17.3 Surface-Mounted Conduit

Conduit shall be supported in accordance with the Guidance Notes to BS 7671. Where conduit is connected to surface-mounted equipment or accessories it shall be additionally supported within 150mm of each side of the item. Where bends and sets occur, the conduit shall be fixed at a distance of 150mm on each side of such diversion.

Surface mounted steel conduit shall have all exposed threads, vice marks, scratches, etc., treated as follows:

Class 2: Two coats of oil bound enamel paint of the same color as the basic conduit finish.

Class 4: Two coats of either a zinc rich epoxy primer or equal alternative.

Where a color other than the manufactured color is specified for steel conduit, this may be by site applied painting over the manufacturer's specified finish.

Where specified or where necessary because of roughness or other conduits, surface conduit shall be fixed by means of distance saddles. Conduit boxes shall be raised-back type or shall be suitably spaced from the surface in a manner approved by the box manufacturer.

The ceiling shall carry the weight of the conduit and any equipment connected rigidly to it.

Steel conduits or asbestos cement pipes shall be used for passing power feeders, subfeeders and subcircuits through hazardous locations or where surrounding materials are not fire resistance as shown on the drawings.

Steel conduit runs shall not contain more than three-quarter bends between outlets or terminations.

PVC heavy gauge plastic rungs shall not contain more than the equivalent of two quarter bends(180 total) between outlets or terminations.

Changed in direction of plastic conduit rungs shall be made with a minimum radius that shall not cause any apparent deformation in section of the conduit and the wall thickness, such radius shall be not less than manufacturer's recommendations.

The installation of flameproof conduit systems shall comply with the following (and the relevant sections of the following documents):

BS 5354 – Code of practice for the selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres (other than mining applications or explosive processing and manufacture.)

Institute of Petroleum Model Codes of Safe Practice in the Petroleum Industry: Part 1- Electrical Safety Code, and /or Part 2 – Marketing Safety Code.

Conduits shall be galvanized heavy gauge solid drawn to BS 4568: Part 1, screwed to flameproof requirements.

All fittings and boxes, etc, shall be certified flameproof equipment.

Where it is necessary to employ joint, other than a screwed coupler, certified flameproof unions shall be used.

All screwed joints, whether entering switchgear, junction boxes or couplings shall be secured with a locknut.

Stopper boxes shall be included in conduit runs entering or leaving a hazardous area. Stopper boxes shall be filled with compound after all cables have been installed.

Where flameproof unions are used on vertical runs, they shall be fitted with the shouldered portion at the bottom, with a ring locknut. The hexagon locknut shall hold the top portion.

Pull boxes shall be located at convenient intervals in accessible positions.

Separate conduit and raceway installations shall be used for each of the different light power, telephone, etc., systems.

16-17-4 Rigid Steel Zinc Coated Conduit

Conduit shall be heavy gauge, galvanized steel welded type with electric thread.

Conduits shall conform to BS 32. Conduit shall have zinc fused into the outside and inside walls, plus an additional outside protective finish coat of high corrosion resistant enamel.

Manufacturers, General Electric Co.(GEC, England) or approved equal.

This type of conduit shall be used in hazardous locations.

16-17-5 Flexible Steel Zinc Coated Conduits

Conduit shall be galvanized tubing, thread type.

Conduit shall conform to BS 731 :Part 1 for galvanized flexible steel tubing. The conduit shall be formed from a continuous length of spirally wound, interlock, zinc coated strip steel and PVC sheathed.

This type of conduit shall be used for branch circuit wiring between disconnecting or control equipment to the motors.

16-17-6 Conduit Fittings-Type A

- 1) General Conduit fittings for use with rigid steel conduit shall be of the threaded type. Fittings shall be cast malleable iron galvanized or cadmium plated.

- 2) Locknuts: Locknuts for securing conduit to a metal enclosure shall have a sharp edge for digging into the metal and a rigid outside circumference for fastening.
- 3) Bushings: Bushings for terminating all conduits shall be of the installed type, bushings shall have a flared bottom and ribbed sides for fastening. Under edge shall have a phenolic installing ring molded into the bushing. Bushing if the installed type used for earthing shall have a screw type terminal.
- 4) Miscellaneous Fittings: Fittings such as reducers, chase nipples, three piece unions, split couplings and plugs shall be specifically designed and manufactured for their particular application.
- 5) Manufacture: GEC, or approved equal.

16-17-7 Conduit Fittings-Type B

1- General

Conduit fittings for use with flexible steel conduit shall be of the threadless hinged clamp type.

Fittings shall be of galvanized or cadmium plated malleable cast iron.

2- Straight Connectors

Straight terminal connector shall be one piece body with female end having a hinged clamp and deep slotted machine screw for securing conduit. Male end shall be threaded and provided with a locknut.

3- Angle Connectors

45 or 90 terminal connectors shall be the same as specified for straight connectors, except the body shall be of two piece construction with removable upper section.

4- Miscellaneous Fittings

Fittings such as adapters for flexible to rigid steel conduit shall be specifically designed and manufactured for their particular application.

5- Manufacturers

GEC, or approved equal.

16-17-8 Conduit Fittings- Type C

Conduit fittings for use with plastic conduits shall be of the non-breakable, non-flammable, flame retardant plastic heavy molded type.

They shall be specifically designed for their particular application.

Manufacturers, Egatube Ltd or foster Plastic Ltd or approved equal.

16-17-9 Conduit Supports

Conduit straps and supports shall be hot dipped galvanized cast malleable iron straps or structural steel with hot dipped galvanized nuts and bolts.

16-17-10 Expansion Joint-Type A

Expansion joint for steel conduit shall consist of sleeve with fittings to provide for the telescoping of one of the conduits into the sleeve. Movable conduit shall be fitted with an installing bushing and joint shall be weatherproof. Joint shall be malleable iron with a corrosion-resistant gasket.

A bonding jumper or ground clamp shall connect the conduits.

16-17-11 Expansion Joint-Type A1

Expansion joint for steel conduit encased in concrete shall consist of a flexible tube with end fitting to receive the conduit. All parts shall be non-ferrous material and joint covered with rubber tubing.

16-17-12 Pulling Wire

Pulling wire shall be installed in all empty conduits.

Pulling wire shall be a V8 draw- in galvanized steel wire or equivalent strength cord with wooden blocks fastened to ends. The blocks shall prevent accidental removal of the cord or wire.

16-17-13 Installation of Conduit Sleeves

Conduit sleeves shall be rigidly installed so that proper position and alignment will be maintained during construction of forms and pouring of concrete or setting of masonry.

Data System

A network of metal conduit for the computer and work processors and other Entertainment and Security Systems shall be provided for data cable distribution. Refer to division(III) for signal cabling type. Typical outlet terminations are shown on hotel computer and word processor schedules. Minimum conduit size shall be 12 mm for a single cable run. Conduit systems and specific cable requirements shall be closely coordinate with each hardware manufacturer or supplier.

16-17-14 Cable Trays

Cable trays shall be provided as required for proper installation of cables and conduits.

Trays shall be made of heavy gauge perforated sheet hot dip galvanized.

Connection fittings like tees, bends and crossings shall be specially manufactured for the purpose.

All items shall be installed to the manufacturer's recommendations. A minimum clear space of 25 mm shall remain behind all installed runs.

Cable tray or ladder shall not be installed across building or structural expansion joints. On horizontal runs the tray or ladder shall be installed with a 20-mm gap at the expansion joint. Supports shall be installed within 150-mm on either side of the joint. An earth-bonding strap with a minimum cross section of 6 mm² shall be installed across the gap. On ladder systems the distance between the rungs on either side of the gap shall be not greater than the normal rung spacing. Vertical expansion joints of the building structure.

Where covers are specified they shall be of the same material and manufactures as the tray or ladder. Ventilated covers shall be mounted on brackets, which allow the cover to stand clear of the tray or ladder flange to allow for air circulation. Trays and ladders shall be supported so that the maximum deflection between supports is 1/360 of the span length.

Trays and accessories shall be electrically continuous throughout the length and bonded to the earth system. Trays carrying LV or ELV cables shall be bonded to earth with green/yellow PVC insulated stranded copper, single core cable. Tray carrying HV cables shall be bonded to earth with copper strip.

Any cut or damaged metal shall be made good by first treating the surface with a suitable rust-proofing agent, supports shall be constructed from proprietary framing system components. Unless specified otherwise all support system members shall be made of the same material as the tray or ladder.

All steel components shall be hot-dip galvanized to BS 729 after manufacture. Where an exposed galvanized surface has been cut or otherwise damaged it shall be repaired by application of a zinc rich epoxy primer.

Where tray and ladder systems are supported by drop rods additional restraints shall be included to provide adequate lateral support. Restraints shall be installed at all bends and intersections and at intervals not exceeding 15 meters on straight runs. Support rods shall be at least 6 mm diameter. Trapeze or other hangers shall be clamped on the drop rods between two nuts.

16-17-15 Trunking-General

All multi-compartment trunking systems shall maintain the stated segregation throughout, including all accessories.

Trunking shall wherever possible be mounted with the lid on the top.

Surface mounted trunking shall be run truly horizontal or vertical. Where these requirements cannot be met trunking shall run parallel to the building lines.

Manufacturer's standard fitting shall be used for all connection and changes of direction. Trunking shall not be cut or bent to form bends, flanges or attachments.

Gusset bends shall be used where shown on the drawings or wherever necessary to provide sufficient bending radius for the cables.

Site fabricated items shall not be used.

Cable retaining straps supplied by the trunking manufacture shall be fitted at intervals not exceeding 1 meter.

Trunking shall be properly aligned and securely fixed at regular intervals not exceeding 2 metres on

straight runs Where bends, angles or offsets occur additional fixings shall be supplied at a distance not exceeding 150 mm on each side of the accessory.

Where trunking passes through walls, floors and ceilings, proprietary fire barriers shall be installed in the trunking. The fire barrier shall have a rating not less than that of the original construction.

Vertical trunking shall be supplied with a cable support unit at intervals not exceeding 3 metres. Allowance must be made for the space taken by the support unit so as to maintain the effective trunking capacity.

Trunking runs in damp situations shall be arranged to be self draining to specific drain points where a hole shall be drilled in the lower surface of the trunking. Trunking runs shall not drain to enclosures or other electrical apparatus containing live terminations.

16-17-16 Steel Trunking

Trunking and connectors shall be manufactured in accordance with **BS 4678** Part 1.

Trunking installed externally shall be manufactured from galvanised sheet steel in accordance with **BS 4678** protection Class 3. Trunking installed internally shall be of the class specified in the schedule.

Lengths of trunking shall be bonded to each other using copper links, suitably tinned or plated to prevent corrosion and not less than 12 mm wide x 1.5 mm thick, fixed with brass nuts, bolts and serrated washers Links shall be supplied by the trunking manufacturer.

Turnbuckle type lid fixings shall be specifically designed to avoid trapping wires.

Partitions or dividers shall be of the same material and finish as the trunking. The method of fixing shall not cause any long term corrosion or electrolytic action.

Connectors shall span the complete internal surface of the trunking and shall be designed so that the trunking sections mate with butt joints.

Horizontal trunking sizes exceeding 100 mm x 50 mm shall be supplied with cable separators with insulated pins at intervals not exceeding 2 metres.

Where any cutting or damage is caused during erection, the finish shall be made good. All burrs and rough edges shall be removed Where any corrosion has occurred it shall be removed and the area treated with a rust-proofing agent. After this it shall be treated by the application of either a zinc rich epoxy primer and in the case of Class 2 finishes this shall be followed by a coat of colour matching paint.

Any fixings used for securing or fitting shall not cause any long term corrosion or electrolytic action. Black japanned fixing screws shall not be used Where brackets are used they shall be constructed of mild steel angle or channel iron finished to the same standard as the trunking.

Connections to multiple boxes, switch gear and distribution board shall be made with flanged units or bell mouths.

Where trunking crosses settlement and expansion joints a trunking joint shall be made. The connector at this point shall be made with slotted fixing holes to permit a movement of 10 mm in both the horizontal and vertical planes. The earth continuity links across such joints shall be of braided copper tape not less than 15mm wide x 2 mm thick having a resistance from fixing to fixing equal to or less than the links used for the standard trunking joints. The braid shall be long enough to allow for the maximum movement of the trunking. The braid ends shall be folded, and sweated solid.

Expansion joints in long continuous runs shall be provided as recommended by the manufacturer.

16-17-17 Non-Metallic Trunking

Non-metallic trunking and accessories shall comply with BS 4678: Part 4, and shall be made from high impact PVC. The material thickness shall be not less than 1.5 mm. Concealed trunking shall be medium IP 42 and surface trunking shall be heavy IP 53 classification.

Lids shall be of the clip on type and all trunking and accessories shall be of the same manufacture.

The method of jointing the trunking by means of connectors or accessories shall be carried out strictly in accordance with the manufacturer's instructions. Continuous runs of trunking shall be jointed to accommodate an expansion of 5 mm per metre run of trunking for every 25°C rise in ambient temperature.

No gaps shall be left between sections except the minimum necessary to allow thermal expansion. The small expansion gaps shall be protected by PVC tape.

Self-adhesive trunking and accessories shall have additional mechanical fixings.

Wherever fixings are screwed through the sides or bottom of the trunking the holes and drilled through the trunking shall be large enough to avoid splitting or darning the trunking.

16-17-18 Dado, Skirting, Architrave, Cornice and Bench Trunking

Trunking and accessories shall be of a material, colour, number of compartments and the profile shall be as directed by the Engineer.

All trunking components and accessories shall be from the same manufacturer. The range of accessories shall include metal screening inserts and all components necessary to provide segregation between compartments.

Trunking systems for site wiring shall accept standard wiring accessories. Where plug-in busbar systems are specified, a full range matching electrical accessories shall be available, including plug-in pre-wired accessory boxes to enable standard accessories to be installed.

Connections between lengths of trunking, between trunking and accessories and between different styles of trunking, for example between architrave and skirting runs, shall be made using purpose made components supplied by the trunking manufacturer. Site fabricated joints and connections shall not be used.

Where cocket outlets are mounted directly in skirting trunking the height of the socket shall not be below the minimum height stated in BS 7671. This requirement shall also apply to dado trunking mounted above fixed furniture.

Multi-compartment trunking systems shall maintain segregation between compartments throughout the system Isolator spacers or crossover bridges shall be installed at junctions and accessory adaptors.

Where outlets are mounted in trunking the space remaining shall meet the space factor requirements of BS 7671.

Wall and ceiling mounted systems shall incorporate sufficient wire restrainers to ensure that wiring stays in place when the lids are removed.

Where communications wiring shares the same trunking as power wiring for more than 10 m, the communications wiring compartment shall be provided with a continuous metal screen, which shall be bonded to earth.

16-17-19 Cavity Floor, Underfloor and Cast-in Trunking Systems

Flush floor trunking shall be of all metal construction and shall be designed to accept the floor loading specified

Cast-in trunking aystems shall be installed and levelled in accordance with the manufacturer's recommendations. Any installation damage shall be rectified and the installation shall be offered for inspection before being covered.

Flush floor outlet boxes for cast-in systems shall be provided by the trunking manufacturer Boxes shall incorporate a levelling adjustment Electrical segregation and adequate cross section area shall be maintained beneath accessories.

Floor outlet boxes for floor cavity installations shall be connected to the main trunking and busbars by flexible or pliable conduit or integral cable/armour wiring

Floor outlet boxes shall be desinged to carry the floor loadings. The colour, lid recess and carpet trim shall be to the approval of the Engineer.

16-17-20 Electrical Accessories

All outlet boxes, switches, junction boxes, pull and splice boxes, plates, socket outlets, etc. shall be to the latest BS standard.

16-17-21 Shop Drawings/Equipment Data

The Contractor's shop/construction drawings for this part of the electrical work shall include, but not necessarily be limited to the following

- Exact routing of all conduits conduits trays, and trunking
- Exact location of all expansion joints
- Typical installation details

Equipment data for this part of the eledtrical work shall include the following:
Samples and literature on all conduit, raceways, trunking etc. and related fitting to be used.