SECTION 3

LOW VOLTAGE POWER AND LIGHTING INSTALLATIOS

SECTION

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SECTION 3

LOW VOLTAGE POWER AND LIGHTING INSTALLATIOS

16-13 LOW VOLTAGE SWITCHGEAR ASSEMBLES

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 –25C and +55C, and for short periods not exceeding 24 h, up to +70C.

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 muli-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 Complonents

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 Iarnpholder 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 23OV 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, screwlscrew 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 PSSV¥C 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 swithgear 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 obtains 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 0 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 ACBAyS. 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 tennis 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 head 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 currant-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 are interruption

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(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 MVyCCBS 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.
MSyCCBS 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.

Ale 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.

(3) 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.

(4) 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 shal 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

16-15-1 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 continuos 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 of 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 creapage 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 earthling 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 bee 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 disconnecters. 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 bee 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 claus 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 bee 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 bee 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 b 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 in 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 corrosions, existent 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) Manufature: 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, n0n-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 co-ordinate 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 11360 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 b 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 cannol 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 1meter.

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 terin 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 mouthes.

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 bhickness 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 sahll 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 dorming 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.

16-18 WIRES AND CABLES

16-18-1 General

Unless otherwise specifically indicated on the drawings, all wires and cables for all systems described under this specification shall have copper conductors

Copper conductors shall be stranded for cross-sections of 25 mm 2 and above. Signal and control cables shall have solid conductor Flexible cords shall have stranded conductors.

Conductor sizes shall be metric, as shown on the drawings. Conductors with cross-sectional areas smaller than specified shall not be accepted.

The current carrying capacity of conductors has been determined in accordance with the Regulations for the specified type of insulation and the expected conditions of installation. No change will be accepted in the specified type of insulation, unless warranted by special conditions and approved by the Engineer.

Low voltage cables shall be LSF to the latest specifications
The insulation of each conductor shall be colour coded as indicated in clause 96
Colour coding shall be maintained throughout the entire installation.

16-18-2 Installation of Wires and Cables

All wiring shall be installed in accordance with the applicable provisions of approved standards and as indicated on the drawings.

The Contractor shall install as many wires and conduits as required and necessary for a complte electrical system and shall provide adequately for the equipment actually to be installed.

Conductors shall be continuous from outlet to outlet and no splices shall be made exept within outlet or junction boxes. No splices shall be made in pull boxes.

At every outlet and pull box, wires and cables passing through, shall be left slack by an amount equivalent to 15 cm of cable length to allow inspection and connection to be made therein.

No cable bend shall have a radius of less than eight times its diameter.

All conductors to be contained within a single conduit shall be drawn in at the same time.

Unless otherwise indicted, no conductor for light and power wires shall be smaller than 2.5mm2.

All branch circuits for lighting and appliances shall be single conductor cables run inside conduit, unless otherwise noted.

Single cables shall be fixed directly to walls or ceilings, where 2 or more cables are run in parallel, they shall be fixed on galvanised steel perforated trays or on other approved special cable supporting and protecting arrangement.

Main incoming feeder cables from transformer substation to main distribution boards shall be single core, non-armoured, PVC insulated and sheathed copper conductor cables run in ducts or trenches as shown on the drawings.

Feeder cables from MDB's to different distribution panelboards or motor control centres shall be multicore PVC, LSF sheathed copper conductor cables run on cable trays in ducts or trenches or clipped to surface in cable shaft as shown on the drawing.

Sub-feeder cables between distribution panelboards and to different light and power panelboards shall be multi-core LSF cables run on cable trays in ducts or clipped to surface as shown on the drawings.

Cables shall be fixed to the supporting structures with approved galvanised cast steel clamps at distances not exceeding 20 diameter.

Non joints or splices shall be accepted on main and sub-feeders.

Cable clips and saddle, shall be purpose made by the cable manufacturer. The use of bare of PVC covered strip for site fabrication of saddles or clips will not be permitted. Spacing between clips or saddles shall be as directed by the Engineer's Representative.

Unless otherwise indicated on the drawings, the spacing between cables run in the same trench shall be not less than the values given below:

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TYPE OF SERVICE	LATERAL SPACING (mm)	VERTICAL SPACING (mm)
LV cable-LV cable*	50	300
LV cable-HV cable	300	300
HV cable-HV cable	300	300
LV cable-communications cable	300	300
HV cable-communications cable	300	300
*For Single-core cables this shall be the distance between the groups of cables, between the cables in a group.		

Cables shall not be laid direct in the ground if any corrosive agent is present.

16-18-3 Wire and Cables-Light and Power

Cable delivered to the site shall bear the mark of identification authorised by the Standards to indicate compliance with the specification Cables not having this identification mark shall be rejected.

All constitutive components of the cable shall conform to the relevant specifications of the above-indicated Standard.

Single conductor wires for conduit wiring and PVC insulated multi-core nonarmoured cable shall have high conductivity tinned copper wire conductors, insulated with PVC compound and a PVC,LSE sheath for multi-core cables.

Wires and cables shall be 600/1000 volts grade to BS 6004 1969

Where armoured cables are specified single wire armour shall be used.

16-18-4 Flat Twin and Multi-Core Sheathed Cables

Flat twin and three-core sheathed cable for installation within the carcass of a building or on the surface shall be unaromred, PVC insulated, PVC sheathed cables complying with Tables 4 and/or 5 of BS 6004 The minimum size of conductor shall be 1.5 mm2.

PVC cables to BS 6004 shall not be directly embedded in concrete or plaster nor shall they be installed externally without additional mechanical protection.

Cables buried in concrete or plaster shall be enclosed in PVC or steel conduit and shall run vertically unless a horizontal run is unavoidable. Cable shall not be run diagonally across a wall area.

Except in dedicated electrical services spaces, cables installed on the surface shall be provided with protection from mechanical damage by drawing into steel conduit or channeling Cables rising vertically from floor level shall be protected to a height of 1.8 m and cables run horizontally at a height of less than 1.8 m shall be similarly protected Cables descending from above shall also be protected below 1.8 m, except that where

these cables terminate at more than 1.5 m above floor level, such that the length to be protected would not exceed 300 mm, no protection need be provided The conduit diameter shall be at least 1.5 times that of the cable. All burrs and sharp edges shall be removed before the cables are drawn in.

Cables installed on timber joists in floor or ceiling voids or in roof spaces shall be fixed to the sides of the joists within the middle one-third of the depth Cables which have to pass transversely across joists shall be taken through holes drilled in the joists within the middle one-third of the depth No joists shall be notched for the passage of cables Where joists are too shallow for the cables to be installed at least 50 mm from the top or bottom of the joist, the cables shall be protected by enclosure in earthed steel conduit Cables in roof spaces shall not be trailed across the tops of the joists, neither shall they be run on the tops of the joists, nor run below water tanks.

Caples with PVC sheaths shall not be installed in contact with expanded polystyrene insulation

16-18-5 Terminations of Wires and Cables

Terminations shall comply with BS 6081, and suitable for the local temperature range indicated in the schedules Glands shall be used at all terminations. Sealing pots and glands shall be marked with the appropriate cable reference.

All terminations shall be made strictly in accordance with the manufacturer's recommended procedures, a copy of which shall be made available on request.
Installers shall be fully concrsant with be recommended procedures.

Glands and seals shall not protrude into plain hole accessory boxes and prevent the fitting of the accessory. In such cases glands having an internal thread shall be used and shall be secured to the box with an externally threaded brass bush.

Terminations of sheathed MI cables shall be protected by the correct size of plastic gland shroud Any exposed metal sheath remaining after the installation of the cable gland shall be wrapped with tape, as supplied by the cable manufacturer, Before fitting the gland shroud.

Conductors at terminations shall be insulated with continuous lengths of sleeving suitable for the temperature rating of the temiantion Conductors shall be identified by short lengths of colourd sleeving slid over the insulating sleeving or alternatively the insulating sleeving may be self coloured the colours shall be as defined in BS 7671.

Conductors of 6 mm2 or greater cross-sectionsl area shall be terminated with compression or cone grip lugs or in screw clamp or pinch screw terminals. Dies and crimping tools shall be suitable for crimping solid conductors.

Cable ends shall be sealed immediately after cutting either by the permanent seal or by being dipped in bituminous compound.

Unused cores in multi-cord cables shall be bonded to earth.

Large single-core cables shall be terminated in the manner recommended by the manufacturer to reduce losses due to eddy currents or circulating currents. Where more than one cable per phase is required, or several circuits are installed adjacent to each other, cables shall be installed in seprated groups of three phase conductors.

Where glands are installed on non-conducting materials then earth tail seals or sheath earth bond clamps shall be employed The earth tail or clamp shall be bonded to the appropriate earth terminal or bar

Earth tail seals with soldered connections shall not be used in locations where the termination may be required to withstand high temperature.

16-18-6 Joints and Tapes

Joints or taps in wires and cable shall be permanently accessible and, if permitted, shall be made only in tap boxes or cabinet gutters.

Joints of conductors sizes up to 16 mm2 shall be made by barrel type connections with pinching screws, the whole shielded in porcelain or hard moulded bakelite shroud. Shrouds of polytheneor similar non-heat resistant materials will not be permitted.

Joints of conductor sizes larger than 16 mm2 shall be made by clamps protected with.

16-18-7 Wire and Cable Identification

Wires and cables for feeders and sub-feeders, control and sub-circuit wiring shall be colour coded as follows:

Colour Ph
Red A or 1
Yellow B or 2
Blue C or 3
Green Earth

The core insulation shall be coloured as follows:

No.of Cores	Colour
Single-core	Black
Two-core	Red. Black
Three-core	Red, Yellow, Blue
Four-core	Red, Yellow, Blue, Black

Auxiliary and control cables Black with contrastiong numbers

Feeder cables shall be tagged in shafts, pull boxes, trunkings and wiring gutters to panels.

Where two or more circuits are run to or through a control device, outlet box of junction box, each circuit shall be tagged as a guide in making connections.

Tags shall identify cable or circuit number and conductor size in accordance with the Schedules as shown on the drawing.

Tags shall be of soft metal with indented lettering, rust inhibited.

16-18-8 Shop Drawings/Equipment Data

The Contractor's shop/construction drawings for this sub-section shall include but not necessary be limited to:

Typical installation, termination and jointing deails for the various types of cables covered under this sub-section

Number and size of conductors in all final sub-circuits as will be executed by the Contractor and in accordance with the intended final conduit routing.

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

Complete literature on all cables and accessories covered under this sub-section or required for their proper installation.

16-18-9 Transits and Fire Stopping Etc.

Where proprietary cable transits are used, they shall be installed strictly in accordance with the manufacturer's recommended procedures where cables pass through walls, floors, or fire partitions, sleeves shall be installed to facilitate installation and subsequent withdrawal of the cable.

The internal diameter of sleeves shall be at least 12 mm, but not more than 25 mm, larger than the diameter of the cable and the ends of the bore shall be provided with an adequate radius to prevent chafing of the cable sheath.

Sleeves through building fire compartmentation walls and floors shall be heavy-gauge steel Sleeves through non fire-rated walls, ceiling, partitions and the like, shall be heavy-gauge PVC.

Where cables pass through floors the sleeve shall project 50 mm above the floor level. Where cables pass through external walls the sleeve shall project 50 mm on the outside in other cases the length of sleeve shall be such that each end projects by 5 mm beyond the surface of the element through which it passes.

After installation of the cables, the hole(s) through which the cables pass shall be seated with fire resisting material to achieve the same resistance to fire as the structure through which they pass cables passing through external walls shall additionally be sealed with a flexible rubber boot or shroud over the sleeve projection.

16-18-10 Fire Resistant Cables

Cables specified as fire resistant shall be certificate by an independent approved laboratory.

Cables shall be tested to BS 6387 and meet the requirements of the Class specified in the schedules.

Cables to BS 7629 shall be Type 13

Fixings shall be able to withstand the fire for the same duration as the cable. The type of fixing employed shall be consistent throughout the installation.

Cables shall be installed in continuous runs without intermediate joints.

Approved fire resistant cables manufacturers

- Pirelli cables ltd. Or approved equal

16-18-11 Testing

As soon as is practicable after the completion of installation and joining of the cables or of any usable group of such cables the test to prove compliance with this Specification and with the requirements of BS 7671 shall be carried out.

An earth continuity test shall be carried out to verify that the cable armouring and metal sheath, if any, have been properly bonded to earth.

Phase-rotation and phase-correspondence shall be tested to prove that the cables have been correctly connected.

For power-cables a voltage test of 15 minutes duration shall be applied in accordance with the relevant British Standard.

BS 5.167 Appendix B8
BS 63.16 Appendix B8
Bs 672.1 Appendix B8

16-19 LIGHTING EQUIPMENT

16-19-1 General Requirements

All Luminaries shall be manufactured to Bs 45333 part 101 and the relevant section of part 102 (JEC 598-1 and 598-2)

Fixtures shall be installed at mounting heights as detailed on the drawings

Fixtures and/or fixture outlet boxes shall be provided with hangers to adequately support the complete weight of the fixture Design of hangers and method of fastening other than shown on the drawings or herein specified shall be submitted to the Engineer for approval.

Fixtures mounted on outlet boxes shall be rigidly secured to a fixture stud in the outlet box. Hickeys or extension pieces shall be installed where required to facilitate proper installation.

Pendant fixtures within the same room or area shall be installed plumb and at a uniform height from the finished floor adjustment of height shall be made during installation.

Flush mounted recessed fixtures shall be installed so as to completely eliminate light leakage within the fixture and between the fixture and adjacent finished surface.
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Fixtures located on the exterior shall be installed with non-ferrous metal screws finished to match the fixtures.

Certain fixtures as shown in provisional position They shall be exactly located as soon as the final layout of the equipment is known.

Lighting fixtures shall comply with all applicable requirement as herein outlined unless otherwise specified or shown on the drawing. Fixtures shall bear manufacturer's name and the factory inspection label.

Luminaries fitted with high frequency or electronic control gear shall be disconnected before the circuit is tested for insulation resistance.

Unless otherwise stated all Luminaries designed for internal use shall be constructed to IP 20 and be Class.

Luminaries intended for use as emergency lighting either as self-contained or slave type shall be 'F' marked when used in or on surfaces of flammable material.

16-19-2 Fixtures Construction

1) Metal

Metal used in lighting fixtures shall be grade GR ¾ to BS 1030/1031/10051 cold. Rolled mild steel and not less than 0.7 mm or heavier when required to comply with the specification or standards.

Sheet steel reflector shall have a thickness of not less than 0.75 mm

Aluminium reflectors shall have a thickness of not less than 1.6 mm, and coating of minimum thickness 2.5 mm.

The grade of the aluminum used shall be similar to

BS 1470 Cat A Type 1200
BS 1490 (Alloys) LM6, LM24,or LM25

All lighting fixture joints shall be mitred, welded and ground smooth with body tolerance of ± l mm and miters tolerance ± 0.5 mm.

The metal parts of the fixture shall be completely free from burrs and tool marks.

Solder shall not be used as a mechanical fastening device on any part of the fixture.

2) Finish

Ferrous metal shall be bonderised, given a corrosion-resistant phosphate treatment or other approved rust-inhibiting prime coat to provide a rustproof base before application of finish.

Light reflecting surface shall be either in aluminium sheet with a purity of 99.9% and the atuminium shall be of grade 1080A to BS 1470, or finished in a baked white enamel having a reflection factor of not less than 80% all to the drawings and approval of the Engineer.

All parts of reflector shall be completely covered by finish and free from irregularities.

After finish has been applied and cured. It shall be capable of withstanding a I em radius bend without showing signs of cracking. Peeling or loosening from the base metal.

Non-reflecting surfaces such as fixtures frames and trims shall be finished in a baked enamel paint. The colour of the paint shall be in accordance with manufacturer's standard finish unless otherwise directed by the Engineer.

3) Lenses and Diffusers

The diffuser shall be manufactured from Plexiglas/polycarbonate/acrylic as required.

Diffusers shall not be manufactured from polystyrene or other styrene based materials.

Injection moulding shall form diffusers. With a finish as specified.

OR

Diffusers shall be formed by extrusion moulding, with a finish as specified. Subject to the Engineer's approval

Fixtures with hinged diffuser doors shall be provided with spring clips or other retaining devices to prevent the diffuser from moving.

All fixtures shall be provided with the required accessories and hardware for complete installation.

4) Fixtures Schedules

The Contractor's attention is drawn to the selected lighting Luminaries shown in the Appendix to this section of the Specification.

The name of manufactures stated in the above mentioned Appendix are considered as representing the minimum level of standard and the Contractor must adhere to it Alternatives may be submitted for consideration and approval of the Engineer whose decision is deemed to be binding on the contractor and final and no claim shall be considered by the Employer for reasons such as rejection of alternatives proposed by the Contractor.

5) Fixtures Samples

Sample fixtures of all types shall be submitted for approval to the Engineer before orders for the fixtures are placed.

16-19-3 Incandescent Lamps

1) General

Luminaires for incandescent light sources shall be designed to accommodate the specified lamp.

Lamp holders for tungsten halogen lamps shall be of the best quality with ceramic bases suitable for the currents and temperatures achieved during constant use.

Springs and other metal parts in the lampholder assembly shall not deteriorate during use such that poor contact arcing, welding or stackness can occur.

2) El.V Luminaries

Unless otherwise stated Luminaries using low voltage tungsten halogen lamps shall be supplied complete with their own transformer.

Wire wound transformers shall be rated as shown in the luminaries specification sheets (see the Appendix) and comply with IEC 742, Class I /Class 11 and be insulated to Class H of BS 2757.

Electronic transformers shall be designed to IEC 742 and 34C/Comics (PK) 8 and 14 with RFI suppression to a minimum standard of BS 800 and VDE: 0875 and shall comply with the EMC Directive.

Transformers shall be located away from high temperature parts of the lamp and luminaries or any other heat radiating surface.

When installed in ceiling voids, transformers shall be separately supported. Mounted to avoid noise transmission and be capable of subsequent removal. Either through the fitting aperture or through an access panel.

Transformers not containing primary fuse protection shall be provided with accessible local protection.

The size of wiring between the transformer and the luminaries shall be such that the voltage drop is not more than 10%.

Final connections to luminaries shall be carried out using silicon rubber sheathed cables.

Transformers including electronic types shall incorporate internal protection against overload and short-circuit.

Where multipoint transformers are specified voltage regulation shall be a maximum of 60% and each luminaries shall be separately connected to the transformer.

Electronic transformers shall contain a soft start circuit and be self-regulating.

Where low voltage tungsten halogen lamps are to be dimmed, the dimming shall be of the hard-fired type suitable specifically for this type of lamp.
Electronic transformers used in dimmable circuits shall be suitable for dimming .
The dimmer shall be compatible with the transformer and be recommended by the transformer manufacturer.

Transformers used in dimmable circuits shall be down rated as recommended by the manufacturer.

Where dimmers are specified they shall be of the hard firing type suitable pacifically for operating low voltage tungsten halogen lamps.

Lampholders in diachronic or capsule Luminaries shall be easily accessible for relamping.

3) Diachronic and Sealed ELV Tungsten Halogen Lamps

Where sealed extra low voltage lamps are used the Luminaire shall be designed to for the heat dissipation requirements.

Where diachronic lamps are used the internal wiring and Luminaire shall cope with the temperature.

All diachronic and sealed lamps shall be of the captive type and supplied with a GU 5.3 base or similar.

4) Capsule ELV Lamps

Capsule lamps shall not be installed using bare hands.

The envelope of capsule lamps shall be made of quartz glass.

Where capsule lamps are used a protective glass shall be incorporated into the Luminaire design.

5) Mains Voltage Tungsten Halogen Lamps

Luminaries designed to accommodate double-ended mains voltage halogen lamps shall be designed to ensure that a minimum bulb wall temperature of 32C and a maximum pinch point temperature of 350C are achieved.

16-19-4 Fluorescent

1) General

Fluorescent lamps shall comply with the requirements of BS 1853.

All cables shall be secured within the Luminaire body to prevent loose lengths from touching hot surfaces or becoming trapped beneath cover plates. Cable clips or cleats shall be captive and if secured by adhesive, shall not loosen with age.

Unless otherwise specified all fluorescent Luminaries shall be supplied with low loss gear and single pulse electronic starters.

Unless otherwise specified control gear shall have power factor correction to achieve a minimum p.f. of 0.9 lagging.

The control gear enclosure shall be so designed to limit the maximum temperature of ballast to its stated rated temperature (TW) and in all cases to less than 56C.

Where high frequency control gear is specified, the lamp supplied shall be compatible.

All high frequency gear shall be bumt-in for a minimum period of 24 hours before being instant in –a Luminaire.

Aluminum reflectors and louvers shall be made from high purity aluminum (99.0% minimum) with low or very low iridescence. The anodic film shall have a minimum thickness of 2.5 microns.

Louvers and reflectors shall be packed separately from the Luminaire body and protected against damage.

Aluminum louvers shall not be installed until after the building has been thoroughly cleaned.

Louvers shall be installed using bare hands. Any louvers found with finger, palm marks or builders dirt and dust shall be removed and cleaned using a high pressure hose with Kodak 600 dirt emulsifier or a similar method approved by the louver manufacturer. Louvers shall not be wiped clean.

Diffusers shall be made from UV stabilized acrylic or light stabilized pollycarbonate, injection molded.

The diffuser shall not support combustion and shall be self-extinguishing.

2) Compact Fluorescent Lamps

Luminaries containing compact fluorescent lamps shall be designed to ensure the correct working conditions for the lamp.

All fluorescent lamp Luminaries shall be supplied with low loss control gear, single pulse electronic starters and HF Ballasts.

Compact fluorescent lamps shall be 4-pin type to BS 6982.

Compact fluorescent lamps used for emergency lighting us shall be of the 4-pin type (2G7,G24q or G11 bases) or 2-pin type with integral starters (G24-1,2 or 3, or G23)

Where the lamps are used horizontally, they shall be adequately supported along their length.

3) Cold Cathode Lamps

High voltage sub-circuits shall be wired in lead sheathed cable or silicone rubber insulted cable rated at 15kV.
All high voltage installation shall have an isolating fireman's switch.

All installations shall be power factor corrected to a minimum power factor of 0.90 lagging.

Bulk power factor correction for up to 5 sub-circuits will be permitted.

Remote mounted ballast shall where possible be grouped together with bulk power factor correction to give a minimum power factor of 0.90 lagging. The ballast shall be capable of being mounted up to 100 m away from the lamps.

Power factor correction capacitor for dimmed high voltage circuits shall be located in the dimmer panel on the incoming side of the dimmers.

4) Lamp Caps and Holders

All lamp caps and holders shall be to BS 5101 and BS 5042. Lamp holders shall be suitable for the lamp cap or base used.

(1) Fluorescent Lamps

38 mm T12 and 26 mm T8 fluorescent lamps shall be supplied with bi-pin G13 end caps.

Bi-pin fluorescent tube holders shall be to BS 1875. Lamp holders shall be molded polycarbonate area, GRP or equivalent, with integral cable terminals capable of clamping conductors of maximum size 1.5mm2. The Lampholders shall be provided with means for positive fixing to the Luminaire unless otherwise stated. The lamp holders shall be either grip-pin/spring grip/center twist rotary contact types.

(2) Compact Fluorescent Lamps

Compact fluorescent lamps type TC-12D shall be supplied with bases incorporating an integral starter-switch.

Lamp holders shall be molded polycarbonate urea, GRP or equivalent, wit integral cables terminals capable or clamping conductors of maximum size 1.5mm2. The Lampholders shall be provided with means for positive fixing to Luminaire and be of the 2G11 type.

5) Dimming Control

Each Luminaire connected to a dimmer shall include dimmable control gear. The dimmable control gear shall be fed directly from the mains and an additional conductor shall be supplied from the dimmer to the Luminaire to vary the output.

Where dimmable high frequency electronic control gear is specified, the control gear shall be controlled via a separate 0-10 Vd.c circuit or similar.

Lamps of different types or ratings shall be controlled from separate dimmers.

Lamps of dimming circuits shall be of the same color temperature and color appearance. To maintain a constant appearance all lamps on dimming circuits shall be changed at the same time.

16-19-5 Emergency Lighting

1) General

The emergency lighting installation shall fully comply with BS 5266 and emergency Luminaries shall comply with BS 4533 Part 101 and Part 10222.

All equipment used shall be ICEL approved and certified Copies of certificates for all or any equipment supplied shall be obtained as appropriate.

Where lamps are to be used for emergency lighting, the manufacturer of the Luminaries shall supply emergency battery packs.

On satisfactory completion of the installation the emergency lighting system shall be operated for its rated duration. The system shall then be allowed to recharge for 24 hours and tested again.

Illuminance checks at sufficient points to prove compliance with BS 5266 shall be carried out at the start and finish of the first discharge and after the full recharge point, these tests shall be witnessed.

Illuminances, and battery voltages of central systems, at the start and end and after recharge shall be noted and included with the final test certificates.

A cosine-corrected light meter shall be used with a scale range of 0.001-100 lux with a sensitivity of 0.001 lux. All measurements shall be taken after excluding all other light.

Locations for test points must include the following:

(1) half way between Luminaries in corridors and open plan offices and stairs.
(2) critical task areas such as control panels and switchboards; fire fighting points, rotting machinery, operating tables,
(3) area under highest mounted Luminaries
(4) area where widest spacing occurs
(5) changes of direction
(6) thresholds of doorways, forming part of the exit route.

Where there is no defined escape route at least four measurements shall be taken in any area of 100m2 and the average calculated. For large open areas a number of 100 m2 areas shall be tested. Measurements shall be taken quickly

Where the system is designed for 3 hour duration, the measurements shall be taken during the last hour of this period unless the installation is large when the time taken for the measurements should determine the starting time.

On acceptance of the installation a completion certificate of the type suggested in Bs 5266 (Appendix B) shall be issued

A logbook shall be provided which shall form part of the operating and maintenance manuals package.

Where remote batteries, chargers or inventors are mounted at distance greater than 0.5 m away from the luminaries, the interconnecting wiring shall comply with BS 5226. Category.

2) Self-Contained Luminaries

Each luminaries shall contain the charger/sensor unit, battery pack ad inventor. Where these units are supplied separately they shall not be mounted more than 0.5 m away unless the connecting wiring complies with BS 5266.

All luminaries shall be clearly marked giving rated voltage, method of operation, lamp type, wattage, and battery voltage, type and average lift.

Lampholders for combined units shall be clearly identified.

A visible warning label shall be provided indicating that the luminaire may be live although no lamps are operating.

Each luminaire shall have a clearly visible coloured LED (minimum lift expectancy of 20,000 hours) indicating battery under charge.

Luminaries installed in defined escape routes shall have an outer casing which shall comply with the 850'C glow wire lest of IEC 695-2-1

Each luminaire shall contain a protective fuse in the main circuit.

Batteries shall be protected against polarity reversal and complete discharge. (lead acid) or 0.9V (nickel cadmium)

The batteries shall have a minimum lift of 4 years and the date of manufacture (month and year) shall be stamped on the casing.
Photometric data shall be obtained, as appropriate.

3) Salve Luminaries

All luminaries shall be clearly marked, giving rated voltage method of operation and lamp wattage.

Where one lamp way in a multiway luminaire is used for both normal and emergency use the lampholders shall be separately identified.

Where fluorescent tubes are fed from a DC or AC/DC emergency source the Luminaries shall contain appropriate inventors

4) Bluminated Emergency Exit Signs

Exit signs shall be manufactured to meet the appropriate requirements of BS 4533, BS 2560 and 5266.

Each sign shall be internally illuminated by two separate systems of lighting.

The housing shall be designed to maintain an internal ambient temperature below that of the lowest temperature rating of any piece of equipment installed therein.

5) General Battery System

Batteries used shall consist of a number of cells of the :

Lead acid planate type to BS 6290 Part 4.

The Charger shall be capable of restoring 100% of capacity within 24 hours and 80% of capacity within 18 hours.

The changeover contactor shall be manufactured to BS 5424 and BS 764.

Changeover relays shall be mounted in a purpose-built enclosure adjacent to the appropriate sub-distribution board

6) Emergency Lighting Modification Unit (Conversion Kit)

The addition of conversion kits to Luminaries if specified shall only be carried out in the factory of either the original luminaire manufacturer or the suppliers of the conversion kit shall comply with all tests in BS 4533 and carry the F mark when used in or on surfaces consisting of flammable material.

Where only one lamp in a multilamp luminaire is used for emergency lighting or where an additional lamp is incloded in the luminaire, the luminaire shall be photometer under emergency conditions.

Where high frequency electronic ballasts are used for the normal lighting, the conversion unit shall incorporate additional devices to ensure that the ballast resets itself after testing and truns on the lamp.

Self-contained conversion kit shall contain an emergency lighting module and battery pack.

The modules shall contain a battery charger with charge indicator, inverter, low battery voltage disconnect circuit and changeover relay.

A LED charge indicator shall be visible from below allowance shall be made to extend the LED circuit and incorporate it into the luminaire body or into the ceiling adjacent to the luminaire using a purpose made ceiling plate.

The internal temperature of the luminaire shall not exceed the battery manufacturers recommended ambient temperature for their batteries.

Where the ambient temperature of the luminaire exceeds that recommended for the batteries then the batteries shall be mounted externally in a ventilated sheet steel enclosure with a minimum rating of IP 20.

Where remote conversion kits and/or batteries are mounted more that 0.5 m from the luminaire, they shall be interconnected using wiring complying with BS 5266.

Conversion kits deriving their emergency supply from a central battery, shall contain an inverter ballast and changeover relay.

7) Testing

A central means of testing shall be provided in the cubicle for all central battery systems. Operation of the test switch shall simulate a mains failure extinguishing the normal lighting and energising the emergency lighting.

Where the system is maintained up to the local distribution board and nonmaintained thereafter using zonal or sub-circuit monitoring then local test point shall be provided.

The inclusion of test modules into emergency luminaries shall be approved by manufacturer of these modules.

16-19-6 Lamp Control Gear

1) General

The lamp control gear shall be of the correct type and rating for the lamp specified

Electromagnetic interference generated by the lamp control gear, propagating through the mains supply wiring shall be suppressed at the source to within the requirements of EN 55015, BS 800, BS 5394 Electromagnetic interference components shall be to BS 613.

Harmonic currents generated by the lamp control gear in the mains supply wiring shall be limited to the requirements of IEC 82.

The acoustic noise level from the lamp control gear shall not exceed NC25

The lamp control gear shall be ventilated to ensure that under normal operating conditions the maximum continuous rated operating temperature of any control gear component is not exceeded.

The control gear shall be power factor corrected through power factor corrector on MDBS.

Electronic equipment shall be subjected to a test 'bum-in' phase of a minimum 24 hours to ensure the supplied equipment has a minimal failure rate during operation life.

Copies of batch test certifications shall be obtained to confirm these tests.

2) Removable Gear Trays

The lamp control gear shall be assembled on pre-wired gear trays. The gear shall be supplied complete, containing all components.

The gear trays shall be constructed and finished to the same standard as the luminaire body.

Luminaire gear tray connections shall be via fused plug-in terminal blocks.

The lamp control gear shall be pre-wired and assembled in the luminaire.

3) Electrical performance

Electronic Starter-Switch Circuits

Each lamp control gear circuit shall comprise inter alia the following :

(1) electronic starter
(2) current limiting ballast

The electronic starter shall be to BS 3772 section 1

The electronic starter shall operate 38 mm (T12) Argon filled lamps. 26 mm (T8) krypton filled lamps and compact fluorescent lamps. The electronic starter shall incorporate means for identifying the lamp type connected and applying the correct starting conditions.

When starting the lamp, the electronic starter shall pre-heat the lamp electrodes to the full emission temperature described in BS 5717, before applying a single starting voltage pulse the electrode pre-heat period shall conserve lamp life. The electronic starter shall be certified to provide 10,000 starts on a switching eyele as delined in BS 3772.

The period between initiation of staring and lamp ignition, shall not exceed 2.5 seconds for non-defective lamps.

The electronic starter shall incorporate a means for detecting a failed lamp and for preventing starting attempts on failed lamps.

The electronic starter shall be contained in a 2-pin polycarbonate canister to BS 3772. The electronic starter shall be mounted in a starter-switch socket complying with BS 6702.

4) Ballasts

Current limiting inductive ballasts shall be to BS 2818. The ballast core shall be of sufficiently large cross-section to avoid high flux densities and overheating. The ballasts shall be of the 'low loss' super low loss' type.

The maximum permitted losses are as follows:

Krypton 26 mm	Standard (watts) loss	Low Loss (watts)	Super Low Loss (watts)	H.F. (watts)
18W	9-10.5	6.5	40-45	2-3
36W	9-10.5	60-65	40-45	3-4
58W	11-13	80-85	52-5.5	4.5
70W	13	8.5	55-60	

The manufacturer shall state ballast losses for the proposed control gear in the appropriate schedule.

5) Capacitors

Power factor correction shall be done from the automatic power factor corrector on the main distribution boars.

Radio interference suppression capacitors shall be dry type ceramic or equivalent, complying with RS 4017. They shall-be rated at 800V, 50/60Hx.

6) Electronic High Frequency Ballasts

Lamp control shall be effected by electronic control gear operating the controlled lamp at frequencies higher than 2OKFLz, and including means for the limitations of lamp current.

The electronic control gear shall be capable of operating both 26 mm (T8) krypton filled lamps and 26 mm Argon filled lamps.

The control gear shall incorporate means for automatically identifying the lamp type connected and applying the appropriate starting and running conditions.

The control gear shall be supplied complete, with all components in a fully enclose housing. The control gear shall comply with BS 5717. The control gear housing shall be provided with means for fixing to the mounting, and allowing easy removal for replacement. The control gear housing shall incorporate all the cable terminals.

The manufacturer shall stale, for continuous normal operation, the values of:

(1) power consumption
(2) current
(3) earth leakage current
(4) power factor

The manufacturer shall state the maximum current demand during lamp start-up.

The control gear shall pre-heat the lamp electroders under conditions complying with BS 5717, before applying a voltage across the lamp sufficient to cause ignition. The elecrode pre-heal period shall be sufficiently long to conserve electrode life. The period

between initiation of staring and lamp ignition shall not exceed 2 seconds. The control gear shall be certified to provide 10,000 starts on a switching cycle as defined in BS 3772.

The control gear shall incorporate means for detecting and automatically isolating a failed or defective lamp. After lamp replacement the control shall automatically start the non-defective lamp.

16-20 EARTHING SYSTEM

16-20-1 General

The earthing system shall be in full conformity with the requirements of the BS 7430 and the relevant sections of Electricity Association document EA 41-24, together with the general requirements of the IEE Wiring Regulations.

Unless otherwise specified all materials used for earthing shall be specially manufactured for the purpose.

The complete earthing system shall be mechanically continuous to provide an independent fault current return patch to the earthing source.

In every main earth lead a removable earth link should be fitted to enable the electrode system to be disconnected for testing purposes. The link should be installed in a conveniently accessible position and arranged to isolate the earth electrode system when open.

Tees and straight through joints in copper strip should be made either by riveting and sweating or brazing.

Where connections between dissimilar metals must be made, these should be protected by painting over with a moisture resisting bituminous paint or compound, or by wrapping with a protective tape to exclude moisture.

The exothermic process shall make inaccessible earthing connections.

Bolted connections shall be of multiple bolt type. Bolts, washers and stop nuts shall be of high copper alloy, ferrous hardware being not acceptable.

The medium voltage and low voltage earthing shall be separated from each other. The overall resistance to earth of this system shall not, upon completion.

16-20-2 Earth source

Site Earth

The site earth shall consist of earth pits constructed and equipped as shown on the drawings and as may required by the Regulations.

Pits shall be interconnected in parallel and by means of a 70mm2 bare copper conductor.

Earthing pits shall be constructed and equipped consisting of electrode, chamber and cover, connectors, etc.

Electrodes shall be copper covered with high strength steel-cored rods with hardened steel tips for driving and be chamfered at top to prevent mushrooming. Electrode shall be at least 3m long and 16mm diameter.

Earth connectors of the bolted type shall be welded on the top of the rod, to take all incoming and interconnecting cables.

16-20-3 Earth Electrode- Structural Reinforcement

At each down conductor reinforced concrete column positions, the earth electrode system shall be formed by the structural reinforcement.

The reinforcement system shall be tested prior to commencement of concrete works to confirm low resistance continuity readings.

The resistance of earth of the electrode system do not shall nor exceed 1 ohm. The system shall be tested through its various stages of construction, to confirm this requirement.

See relevant item in the Concrete Work Section.

16-20-4 Earthing Conductors

A) General

Earthing conductors connecting the main earthing terminal or bar and electrode system shall be green/yellow PVC installed, stranded copper cable. A minimum of two earthing conductors shall be installed and separately connected to the main earth bar, with bolted tests links of copper and having cross section equal to the main earth bar.

B) Protective Conductors

Protective conductors between equipment earthing terminals or bars and the main earthing terminal or bar shall be made with two 95mm2 stranded copper cables.

Cables shall be connected to remote ends of the equipment earthing terminals, or bar and separately connected to the main earthing terminal or bar.

Protective conductors shall be installed parallel to the building lines, whilst maintaining a minimum route length.

Where a number of protective conductor's follow the same route, these shall be green/yellow PVC covered and installed on a galvanized cable tray and fixed with purpose made cleats.

Connections between main earthing terminal and bars, equipment earthing terminals, etc. and stranded copper cables shall be made with appropriate compression_type lug, bolt, nut and lock washers. Contact surfaces shall be thoroughly cleaned and tinned.

Socket lugs, bolts, nuts, washers, screws, rivets, clamps, cleats or other items which come into direct contact with copper protective conductors bars, strips, cables, etc. shall be non-ferrous and manufactured from brass, bronze or other suitable conducting material which will not cause electrolytic or other corrosion surfaces shall additionally, be tinned and after completion.

Compounded to exclude moisture. Protective conductors, cables, strip, bars, lugs. Etc. shall be installed in visible and serviceable positions.

16-20-5 Items Requiring Special Consideration

1) Fences- Metal

Fences that fall within 2m of the substation earthing system shall be connected to the main substation-earthing network. Connections shall be made regular intervals not exceeding 20m, by 95mm2 PVC cable. Gateposts shall be bonded together via below ground connection to ensure that potential gradients across the posts do not arise.

Where fences are connected to the substation entry system, and where the touch potential could exceed 420V, an additional bare electrode conductor shall be buried in the ground, external to the parameter fence and at a maximum distance of 1m at a depth of 0.5m. This electrode conductor shall be regularly bonded to the fence at intervals not exceeding 20 m. Additional bonds between the fence and earthing conductor shall be made at all points where HV overhead conductor cross the fence.

2) Fence-Plastic Covered Metal Link Type

Plastic covered metal link fencing shall be earthing, as per the requirements of bare metal fencing.

3) Anti-Climbing System

Anti-Climbing system shall be bonded to the main earthing system as per the requirements of Fences Earthing.

4) Earth Rods Installation

Earth rods: While setting earth rods, ensure that resistance associated with individual rods does not overlap. Earth rods are to be located at a distance greater than 600mm from foundations of buildings. Where rock is encountered, a hole of sufficient size is to be drilled before lowering the rod. Conductive filler such as Marconite or Bentonite or equal filler that will not corrode is to be provided around the rod.

16-20-6 Mechanical and Electric Rooms Earth (MERE)

The MERE where used as a main earth lead to the earth electrodes or as an earthing loop shall be 50mmX6mm tinned copper strip. The copper strip should be fixed with fixing clips.

The return paths to site earth shall be made via accessible test links above ground using at least 70mm2 conductors, Test links shall be as close as possible to the earth pits.

16-20-7 System's Earthing

System earthing shall consist of connecting the transformer substations LV neutral to the earthing points, by an insulated conductor connected to an earth electrode in housing as shown on the drawings.

16-20-8 Equipment Earthing

Equipment earthing shall consist of connecting all non- current carrying metallic parts of the electrical/ mechanical installation to the earthing sources of the building.

Non-current carrying metal parts of the electrical installation shall include such items as metal conduits, raceways, outlet boxes, cable armour, cabinets, etc. Apparatus etc. as well as enclosure doors, grilles, barriers. Etc. protecting or shielding electrical equipment from direct access by unauthorized personnel.

The series earthing of one piece of equipment to another will not be permitted. All equipment earthing connections shall be tapped from the applicable source.

Unless otherwise indicated on the electrical drawing cable armour both steel and aluminum will be accepted as equipment earth continuity conductors provided total resistance to earth is within acceptable limit.
Earth continuity conductors other than the metallic conduits, busbar cover and cable armour shall consist of a special green colored installed conductor of the same material, installation and size of the associated sub-circuits.

16-20-9 Earthing of Wiring Devices

Socket outlets, switches, heaters, AC units, etc. shall be earthen by a green colored insulated conductor from the socket outlet earthing terminal to an earthing terminal incorporation in the associated box or other enclosure.

In case of the use of PVC conduits a separate earthing conductor shall be run together with and in the same manner as the sub- circuit wiring but shall not be broken or cut at any of the outlet box terminals.

16-20-10 Earthing of Main Distribution Boards

Earhting of main distribution boards are not to be connected, by bar earthing conductor, directly to main earthing bar at main distribution room and by protective conductor run with incoming feeder from respective supply point.

16-20-11 Earthing of Panelboards

Panelboards shall be earthen by connecting the earth continuity conductor, from the earthing source to the special earthing lug or terminal welded to the panelboard cabinet.

The earth continuity conductor size and arrangement shall comply with the regulations and drawings.

16-20-12 Earthing and Motors

Motors_shall be earthen by connecting a green colored insulated conductor from an earthing terminal in the starter or isolating switch to the motor frame-earthing terminal. The conductor shall be run together with the circuit wiring and terminated in the motor connection box provided the latter is mechanically connected to the frame. If this is not feasible, the earthing conductor shall be extended through an insulated opening in the connection box to the motor base.
Motors and housing in plant rooms shall be in addition connected directly by a visible bare copper earthing conductor (tape) to the nearest point of the earth ring or bar.

16-20-13 Generator Plant Earthing

Generator neutral (star point) is to be connected by insulated earthing conductor through the neutral earthing link or device to main earthing bar. Neutral earthing conductor is to be suitably sized to carry maximum earth fault current for time it takes the system protection to operate with final conductor temperature not exceeding 160C, but not less than 30mm2 per 100KVA of generator rating, with a minimum of 50mm2.

Generator earthing terminal is to be connected to main earthing bar by bare copper conductor of cross section not less than 20mm2 per 100 KVA of generator size, with a minimum of 35mm2.

Switchgear and control gear, earthing terminals or bars of Switchgear and control gear are to be connected by separate protective conductors to respective normal and emergency main distribution board earth bars.

Extraneous conductive parts including steel frames, battery racks, day-tank, pumps and piping are to be connected by bare copper earthing conductors to main earth bar in compliance with bonding regulations.

16-20-14 Exothermic Welds

1) General

The exothermic welding process is a method for thermally welding copper to copper, or copper to steel with equipment and material that requires no outside source of heat.

The exothermic process shall make permanent earthing connections, unless otherwise herein noted or indicated on the drawings.

2) Equipment and Material

All required moulds, tools and cartridges shall be provided.

All equipment required in making welds shall be used in strict accordance with manufacturer's instructions.

The specific type of mould shall be used for each welding position encountered.

16-20-15 Tests on Site and Records

Combined resistance of earth electrodes is to be measured during dry season and checked against specified resistance.

Electrical continuity of all earthing and protective conductors including main and supplementary equipotential bonding conductors is to be checked.

Earth fault loop impedance of all circuits is to be measured and checked against calculated impedance figures.

Operation of residual current protective devices is to be checked.

16-20-16 Shop Drawings/ Equipment Data

The sub-contractors shop/construction drawings for this part of the electrical specification shall include but not be limited to the following: -
Exact location and routing of all earthing loops.
Typical installation details for the various earthing accessories.

16-21 LIGHTING PROTECTION SYSTEM

16-20-1 General

The purpose of the lighting protection system is to minimize the effects of a lightning strike to the building, from above or from the side, and to safely conduct the discharge to earth without side flashing and without danger to personnel.

The system shall consist of an interconnected air termination network, down conductors, bonding conductors, earth electrodes and any other items required to make a complete system. Test joints shall be provided as required to make routine tests of the system.

The entire lightning protection system, shall be product of one manufacturer. Subject to the requirements of this Specification and Engineerural considerations, all items shall be installed in accordance with the manufacturer's recommendations, including fixing to the fabric of the building.

Natural conductive elements of the building such as metal roofs, columns and framing reinforcement, and foundations shall be used as part of the lightning protection system. Where building elements are to be used as part of the lightning protection system they shall be tested during construction to ensure that the resistance is low enough for the purpose. A formal record shall be kept of the resistance readings taken, to reduce the resistance to an acceptable value.

16-20-2 Standards

The lightning protection system shall comply with the requirements and recommendation of BS 6651 and with the relevant section of the earthing code BS 7430.

This Specification does not permit the use of lightning attraction, ionization or dissipation terminals nor of any other devices which purportedly allow a reduction on the number and/or sizes of air termination's and down conductors. This Specification does not permit the use of CO- axial down conductors.

16-20-3 Products/ Materials

The type grade and quality of materials and the dimensions of components shall be as detailed in BS 6651.
All fittings, fixings, supports etc. shall be purpose made for lightning protection.

Joints in conductors shall be kept to a minimum and shall be both electrically and mechanically sound and constructed to prevent the ingress of moisture.

All contact between dissimilar metals or between a metal and a material with which it might react shall be avoided, except as permitted in BS 6651 and provided all the

precautionary measures recommended are employed. If necessary to prevent long-term corrosion, additional precautions shall be taken such as separation or the insertion of an intermediate material with which neither of the dissimilar metals / materials reacts, or by changing the metal or material.

Conductors shall be of high conductivity annealed copper tapes not less than 25mm X3mm.

All components parts shall be copper or copper compatible. In corrosive atmospheres the copper shall be coated with lead.

Fittings and fixings, including screws, for copper conductor shall be of copper alloy such as phosphor bronze, naval brass or gunmetal. No PVC, polypropylene, polycarbonate or any non-metallic fixing shall be used except on membrane roofs where plastic holdfasts or concrete filled holdfasts may be installed.

Joints and crossover connections between conductors shall be made using purpose made connector clamps of the same manufacturers of the conductor.

OR

Joints between flat copper strip conductors shall be made using an exothermic welding process such as Furseweld or an equal alternative.

16-20-4 Air Termination

Air termination's shall consist of a network of conductors on roofs and on the sides of buildings (where required), laid on a grid pattern so that no part of the roof or wall protected is more than 5 meters from a conductor.

Air termination and associated fixtures and fittings shall be of the same manufacturer as the rest of the system.

Where roof conductors cross building expansion joints, a flexible link shall be inserted. The flexible link may take the form of loop (in flat conductors of equivalent cross section to the fixed conductors) or a braided or stranded length of conductor. The circumference of circular conductors shall be not less than 8 times the length of gap to be bridged. The flexible link shall be firmly fixed on both sides of the expansion joint and shall be as short as practicable on condition that it will not be in tension under any designed building movement.

16-20-5 Down Conductors

Down conductors shall be disposed around and inside the building as required by the BS.
If bare down conductors enter the earth directly they shall be insulated for not less than 0.3m both above and below ground level to minimize corrosion at that point, where reinforcing bars are insulated to prevent corrosion, then additional provisions shall be made to ensure electrical continuity.

Where building reinforcement or structural steel is to be used as the down conductor the procedures outlined in BS 6651 shall be followed during construction. If the resistance to earth of the completed building exceeds 10.
Ohms then additional down earth conductors and, if necessary, additional earth electrodes, mats, and plates or ring conductors, shall be installed.

Where connections are made to reinforcement bars or sections used as down conductors, the point where such connections emerge form the encasement or cladding shall be sealed, waterproofed and protected against corrosion by means of an acceptable epoxy resin, cast into place and extending at least 100mm beyond the junction.

16-20-6 Earth Electrodes

Earth electrodes shall be molecularly bonded copper clad steel rods driven vertically into the ground. Threads shall be properly rolled so that the copper cladding is unbroken throughout. Couplings shall be of silicon aluminum bronze and shall be fully threaded to allow metal- to-metal contact of the rods. Couplings shall be counter-bored and of sufficient length to completely cover and protect the threaded portion of the rods to minimize corrosion.

Driving heads for the rods shall be high tensile steel and shall be fully threaded to ensure head-to-rod contact. Driving shall be accomplished by using a purpose made power hammer. Each rod shall be fitted, after driving, with a conductor clamp.

Where the ground is unsuitable for copper clad steel rods, other types of earth electrodes complying with BS 6651 may be used. Where building elements are to be used as the earth electrodes they shall be tested during construction to ensure that the resistance is low enough to make suitable electrodes. A formal record shall be kept of the resistance readings taken.

Appropriate sealing methods shall be used where rods or conductors pass through concrete into earth. Pre-cast concrete inspection pits and puddles flanges or, in tanked structures, more elaborate seals as described in BS 6651, shall be cast in at the time of construction. Permanent waterproofing and sealing shall be accomplished after installation and testing of the earth rods or conductors.

Earth pits shall be pre-cast concrete with reinforced covers. When fully embedded in concrete, earth pits may be of galvanized steel construction or moulded plastic bodies with galvanized steel frames and lids. Pits shall be installed so that they are flush with the finished floor or ground level.

Covers shall be removable for inspection and testing of the earth electrode and shall be inscribed ' Lightning Protection Earth'.

Drilled earth bars shall be fitted in pits where the number of connections exceeds one looped conductor (interconnecting electrodes) plus one external connection. The drilled earth bars shall be copper, not less than 50mmX6mm and mounted on insulators.

16-20-7 Test Joints

All test joints shall be accessible for testing at the time of installation and for future routine tests.

Test joints shall be provided at the bottom of each down conductor so that the integrity of the earth electrodes can be tested separately. Where natural building elements are used as down conductors then test joints shall be provided at the top of the building to measure the resistance to earth.

16-20-8 Bonding

All exposed metalwork on the roof and on the outside of the building shall be bonded to the lightning protection system. Interior metalwork shall be bonded if it is close enough to elements of the lightning system to risk the danger of flashover.The need for bonding shall be assessed by the calculation method given in BS 6651.

16-20-9 Test Certificates

A test certificate shall be provided on completion of the installation to certify that inspection and testing have been carried out in accordance with the Standards.

The test certificate shall contain the resistance measurement of each earth electrode and earth termination network, of each down conductor and of the building as a whole.

In addition to resistance measurements, the certificate shall contain the following information for each reading: -

(1) The date and time
(2) The weather conditions
(3) The type of soil
(4) The condition of the soil(e.g. wet, dry, average)
(5) Any measures taken to reduce soil resistance. Details of the reference earth used for testing.

16-22 MOTORS, STARTERS AND CONTROLS

1) General

Motors, starters and controls shall be wired in accordance with the approved Contractors CO-ordinate wiring diagrams. Free hand field wiring diagrams of sketches shall not be used. The Contractor shall submit for the approval of the Engineer, as soon as possible after award of the contract detailed wiring diagrams based on service requirements as described in the specifications or on the drawings.

2) Installation of Motors

Motors shall be examined for presence of moisture prior to installation. If a doubtful condition exists the motor shall be thoroughly dried or condition referred to the Engineer for a decision.

Motors if not part of a completely assembled unit shall be properly aligned and checked for rotation.

All motors requiring lubrication shall be lubricated according to the manufacturer instructions prior to being placed into service.

Cables runs between motors and starters not indicated on the drawings may be run without protection or armour. They shall be protected by galvanized steel conduit or in ducts and trenches wherever liable to mechanical damage.

Rigid conduit shall not terminate in or be fastened to the motor frame or base.

Flexible conduit shall be installed at all motor connections to prevent transmission of noise or vibration. The length and radius of the flexible conduit shall be sufficient to permit bending of feeder cables without damaging the conductor or its insulation.

3) Installation of Starters and Controls

Starters and controls shall be rigidly secured and installed plumb and level.

Manually operated devices such as push buttons and manual starters shall be located to permit convenient operation and be readily accessible.

Motor nameplates shall be checked for full load current rating and allowable temperature rise to determine correct overload heater elements to be installed in the corresponding starter.

4) Identification

All motor starters and controls shall be provided with a nameplate identifying the system or defining its function.

Control wiring shall be checked by (ringing) or (talking out) all circuits for proper connection before energizing.

After installation of the equipment and checking out the circuits each motor and its controls shall be tested for proper electrical operation on permanent power.

Unless branch circuit protection is provided, motor control units shall be provided with MCCB for short circuit protection of motors, control gear and ancillary equipment.

The control circuit of each starters shall be protected by adequate fuses incorporated in the primary circuit of control transformer of the starter and not in a separate panel.

Contractors shall have robust contacts with contact faces in a vertical or near vertical plane so that dust and grit do not tend to accumulate thereon.

The design of contractors shall be such that some measure of wiping action takes place when closing or opening or the contractors shall be rendered self-cleaning.

5) Disconnecting Devices

Disconnecting devices when not include with electrically operated equipment furnished within a motor control center assembly shall be provided and installed in accordance with this or other divisions of the specifications.

General

Electrical characteristics of disconnects such as voltage class, ampere rating, number of poles shall be as indicated on the drawings and /or as herein specified.

Disconnects shall be horsepower rated and conform to the applicable requirements of BSS Standards and be as herein specified.

Mechanism

The operating mechanisms shall be quick-make, quick-break with the external-operating handle mechanically interlocked with the enclosure cover.

Interlock shall make it necessary for disconnect to be in the OFF position for normal access to the inside of the enclosure.

Enclosures

Enclosure shall have provisions for locking the operating handle in the OPEN and CLOSED position.

Position of disconnect shall be clearly indicated on the enclosure.

The disconnects shall be a non-fusible, single throw safety switch in a separate enclosure, heavy duty industrial type and provided with an are quenching device on each pole. Disconnects shall have means of bypassing the mechanically interlocked door and handle. Isolating switches with ratings 15,30 and 60 amps shall be similar to GEC type HIDUTAC or equal approved 100 amp and over isolating switches shall be similar to GEC type GROMWELL or equal approved.

6) Motor Control, Protection and Isolation

Electrical protection in the event of

- Failure of supply
- Serious drip of voltage
- Flow of excess current

Motors 10 hp and above shall have means of disconnecting from supply in case of serious unbalance of phase winding currents.

Three phase motor starters shall be provided with three external manual reset thermal bimetallic overload relays; single phase motor starters with one overload relay. Relays shall be inherently compensated for variations in ambient temperatures.

Starters shall be of the following types, unless otherwise indicated on the drawings:

- Type A-Automagnetic, non-reversing, direct on line for motors up to 10 BHP and below.
- Type B-Automagnetic, non-reversing, star-delta for motors above 10 BHP up to and including 50 hp.
- Type C-Auto transformer for 50 BHP and above.
- Type D- Manual, non-reversing, direct on line for single-phase motors, (unless otherwise required) two pole toggle unit, fitted with one overload if the motor is not protected by built-in protection.
- Type E-part winding for motors of compressors.

All starters shall have at least two spare normally open auxiliary contacts in additional contacts needed for interlocks.

Isolating devices shall be provided and installed adjacent to the motor. The isolator may be integral with the starters or may be separate.

Isolators shall effectively interrupt the supply on all line conductors and neutral (where it exists). Auxiliary control supply to a starter, other than from main power circuit, shall be effectively isolated by auxiliary contacts on main isolator.

All starters except type D shall be provided with start and stop push buttons as well as red and green indicating lamps Type D starters shall have clear off/on indication of the toggle.

A clear schematic diagram of the circuits and components contained in the case shall be firmly fixed within the lid or cover of each starter, controller, or cubicle.

Individually mounted starters or contractors shall be totally enclosed in galvanized heavy gauge sheet steel suitable for wall mounting.

All current transformers, voltage transformers, relay, etc. shall be incorporated in the motor control centers or units.

7) Motor Control Centers

A) General

Motor control shall consist of grouping of factory assembled and wired, control and starting units to form a complete and fully integrated motor control board.

B) Construction

Motor control center shall be factory assembled, of the totally enclosed, steel construction, and starting type, with structures joined together to form one assembly. Each structure shall be so designed that unit's readily removed or future structures added as required.

A main horizontal copper busbar rated as the main incoming circuit breaker or as indicated on the drawings shall extend across the top of each structure. Each structure shall contain vertical copper busbars of the required capacity, to distribute power to each circuit breaker and starter in the unit busbars shall be braced to the maximum available short circuit current. A neutral busbar rated at half the main busbar capacity shall provided throughout the whole motor control center.

A copper earth busbar shall be provided and extended the full length of the motor control center.

C) Incoming Lines Section

Incoming line connection shall be made with solderless terminal clamps of the four-bolt type.

A main incoming circuit breaker rated as shown on the drawings shall be provided for terminating the incoming supply cables and isolating the busbar system.

D) Control Unit

Control units shall be of the removable plug-in type, plug-in and enclosures shall be constructed of heavy gauge sheet steel. Construction shall provide isolation and baffling of each unit from the others. As part of the enclosures there shall be included plug-in

slabs shall be fabricated of high spinning strength, high conductivity copper, silver plated and mounted on an insulated base.

Units shall contain guide rails for accurate alignment both horizontally and vertically within the structure to eliminate possible damage to bus. All similar units shall be interchangeable within the various motor control center sections.

A space position shall be ready to receive a control unit some time in the future. A space position shall have a blank cover plate.

The compartment door shall be so interlocked that the isolator or breaker must be in the OFF position before the door can be opened.

Fuses shall be high rupturing capacity (HRC) cartridge type. Fuse melting characteristics shall be selected to allow normal starting procedure and provide the circuit protection required by the Regulations.

Putting the disconnect in the OFF position by operating the handle shall simultaneously disconnect the control power within the unit. Where control power is supplied from outside the unit auxiliary contacts shall be provided on the disconnect device.
8) Motor Control Panel

Where motor control and starting equipment are assembled in a panel, the panel shall be of the wall mounted lockable type, fabricated from 1.5mm thick hot-dip galvanized sheet steel and finished by each priming with one prime coat and one top coat of stove enamel both internally. Where installed outdoors panels shall have weatherproof totally sealed water and dust proof enclosures.

Control panels shall contain all necessary breakers, push button switches, indicating lights and all interconnecting and interlock wiring, devices and accessories required for the operation of equipment as specified under the particular relevant specification.

9) Shop Drawings/ Equipment Data

Prior to ordering any equipment and material, the Contractor shall submit to the Engineer for the approval of the necessary shop drawings and equipment data which include, but not necessarily be limited to, the following: -

- Complete technical data on all motor starters, motor protection relays, sensing units, control accessories, etc.
- Constructional details of equipment, particularly motor control centers and motor control panels.
- Manufacturers catalogue cuts.
- Dimensions characteristics and weights of equipment.
- Wiring diagrams of all powers and control circuits.
- Installation details of motor control centers and panels and of control and sensing accessories.

Exact routing of power and control cables, wiring and conduits.
Feeder termination details at motor control centers, starters, motors, isolating switches, and sensing accessories, etc.

End of Section