

**GENERAL SPECIFICATION
FOR
ELECTRICAL INSTALLATION
IN
GOVERNMENT BUILDINGS
OF
THE HONG KONG SPECIAL ADMINISTRATIVE REGION

2002 EDITION**

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**BUILDING SERVICES BRANCH
ARCHITECTURAL SERVICES DEPARTMENT**

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SECTION A1

SCOPE OF SPECIFICATION

A1.1 INSTALLATION TO COMPLY WITH THIS SPECIFICATION

This Specification details the intrinsic properties (including materials and workmanship) required of an electrical installation carried out for or on behalf of the Architectural Services Department, the Government of the Hong Kong Special Administrative Region (HKARS).

A1.2 INSTALLATION TO COMPLY WITH THE PARTICULAR SPECIFICATION AND DRAWINGS

The electrical installation shall comply in every respect with this Specification unless otherwise specified in the Particular Specifications, the Drawings and/or the Standard/Guidance Drawings relating to a particular job or modified by written instruction of the Architect.

A1.3 VOLTAGE COVERED BY THIS SPECIFICATION

Unless otherwise specified, all apparatus, equipment, materials and wiring shall be suitable for use with a 3-phase and neutral, 4-wire, 380/220V $\pm 6\%$, 50 Hz $\pm 2\%$ source neutral earthed system with provision of bonding to the Electricity Supplier's bonding terminal.

A1.4 DEFINITIONS, INTERPRETATION AND ABBREVIATIONS

In this Specification, the following words or expressions shall have the meaning hereby assigned to them except when the context otherwise requires :

“Architect”	means the person named in the Article of Agreement as the Architect or such person(s) as may be authorised from time to time by the Employer and notified in writing to the Contractor to act as the Architect for the purpose of the Contract. The person named or authorised may be described either by name or as the holder for the time being of a public office.
“BS”	means British Standards, including British Standard Specifications and British Standard Codes of Practice, published by the British Standards Institution.
“BSB”	means the Building Services Branch of the Architectural Services Department.
“BS EN”	means European Standard adopted as British Standard.

“Contract”	means the Articles of Agreement, the Tender and the acceptance thereof by the Employer, Drawings, General Conditions of Contract, Special Conditions of Contract if any, Specifications and priced Bills of Quantities or Schedule of Rates. (The word “Contract” may also mean sub-contract as the context requires)
“Contractor”	means the person(s), firm or company whose tender for the electrical installation has been accepted by the Employer and includes the Contractor’s personal representative, successors and permitted assigns. (The word “Contractor” may also mean sub-contractor as the context requires.)
“CSA”	means the conductor cross-sectional area.
“Drawings”	means the drawings referred to in the Contract and any modification of such drawings approved by the Architect and such other drawings as may from time to time be furnished or approved in writing by the Architect.
“Electricity Supplier”	means a person who generates, supplies and sells electricity at low and high voltages for use in an electrical installation.
“Employer”	means the Government of HKSAR.
“EMSD”	means the Electrical and Mechanical Services Department, the Government of HKSAR.
“EN”	means European Standards prepared by European Committee for Electrotechnical Standardisation or European Committee for Electrotechnical Commission Publication.
“FSD”	means the Fire Services Department, the Government of HKSAR.
“Standard/Guidance Drawings”	means the drawings for reference purpose prepared by the BSB to show detailed arrangements of the common standard installations.
“IEC”	means International Electrotechnical Commission Publications.
“IEE”	means the Institution of Electrical Engineers, U.K.
“ISO”	means International Organisation for Standardization Publications.

“Particular Specification” means the specifications referred to as such in the Contract for a particular project.

A1.5 SINGULAR AND PLURAL

Words importing the singular only also include the plural and vice versa where the context requires.

SECTION A2

STATUTORY OBLIGATIONS AND OTHER REGULATIONS

A2.1 INSTALLATION TO COMPLY WITH OBLIGATIONS AND REGULATIONS

The electrical installation shall comply with the latest edition of the following statutory obligations and regulations together with any amendments made thereto:

- (a) Electricity Ordinance, Chapter 406, and other subsidiary legislation made under the Ordinance.
- (b) Code of Practice for the Electricity (Wiring) Regulations issued by the Electrical and Mechanical Services Department, the Government of the HKSAR.
- (c) IEC 60364 “Electrical Installations of Building”.
- (d) Electricity Supplier Requirements.

The Supply Rules and other requirements issued by the relevant electricity supplier.

- (e) IEC, ISO, EN, BS EN and BS.
- (f) Fire Services Department Requirements

The current requirements of FSD, including those specified in the FSD Circular Letters and the current edition of the “Codes of Practice For Minimum Fire Service Installations and Equipment and Inspection, Testing and Maintenance of Installations and Equipment”.

- (g) Code of Practice for Energy Efficiency of Electrical Installations issued by the Electrical and Mechanical Services Department, the Government of the HKSAR.

All equipment provided by the Contractor shall conform to this code of practice.

- (h) Code of Practice for Energy Efficiency of Lighting Installations issued by the Electrical and Mechanical Services Department, the Government of the HKSAR.

All equipment provided by the Contractor shall conform to this code of practice.

A2.2 SAFETY REQUIREMENTS

The electrical installation shall comply with all regulations on safety aspects issued by the Environmental, Transport and Works Bureau, the Labour Department and other authorities from time to time. These include but are not limited to the followings:

- (a) Construction Sites (Safety) Regulations,
- (b) Factories and Industries Undertakings Electricity Regulations,
- (c) IEC 60364-7-704: Construction and Demolition Site Installation,
- (d) Electricity Ordinance, Chapter 406, and
- (e) Construction Site Safety Manual issued by the Environmental, Transport and Works Bureau.

A2.3 CASE OF CONFLICT

In case of conflict between the technical requirements of this Specification and any other requirements, the following order of preference shall apply:

- (a) Electricity Ordinance, Chapter 406 and other Subsidiary Legislation.
- (b) The Particular Specification and/or the contract documents for a particular project.
- (c) This Specification and the Standard/Guidance Drawings.
- (d) Code of Practice for Electricity (Wiring) Regulations.
- (e) The relevant Electricity Supplier Requirements.
- (f) IEC 60364.
- (g) IEC, ISO, EN, BS EN and BS.

SECTION A3
**GENERAL REQUIREMENTS ON MATERIAL,
EQUIPMENT, WORKMANSHIP AND QUALITY**

A3.1 MATERIAL AND EQUIPMENT

A3.1.1 International Standards

Material and equipment shall be of high quality, and shall comply with, where applicable, the appropriate International Standard Specifications prepared by IEC or ISO Technical Committees together with any amendments made thereto.

A3.1.2 Other Standard Specifications

When material or equipment complying with other international standard specifications is offered, the Contractor shall satisfy the Architect that the quality of the equipment offered is equal to or better than that specified in the appropriate International Standards (IEC/ISO).

A3.1.3 The International System of Units (SI)

The International System of Units (Système International d'Unités) of weights and measures shall be used for all electrical materials and equipment.

A3.1.4 Service Conditions

The following service conditions shall apply :

- (a) Climate : Hong Kong (tropical)
- (b) Ambient temperature :
 - Peak -5°C to +40°C (continuously 4 hours)
 - Average 0°C to +35°C (over 24 hours)
- (c) Altitude : up to 2000 m above sea level
- (d) Relative humidity : 99% maximum

A3.1.5 Selection of Equipment

Selection of equipment shall be based on this Specification, the Particular Specification, and technical data contained on the Drawings for a particular installation.

Where items of equipment are interconnected to form an integral part of the complete electrical installation, their characteristics of performance and capacities shall be so matched as to give safe, reliable, efficient and economical operation of the complete electrical installation.

Whenever equipment are called for in the Particular Specifications or Drawings for the electrical installation of a particular job, all these equipment shall conform to the energy efficiency requirements as stipulated in the Codes of Practice for Energy Efficiency of Electrical Installations and Lighting Installations issued by the Electrical and Mechanical Services Department, the Government of the HKSAR.

A3.1.6 Equipment Catalogue and Manufacturer's Specification

Equipment catalogues and manufacturers' specifications related to the proposed equipment shall be in the Chinese or English language, be specific and shall include all information necessary for the Architect to ascertain that the equipment complies with this Specification and Drawings. Data and sales catalogue of a general nature will not be accepted unless prior agreement has been obtained from the Architect.

Equipment catalogues and manufacturers' specifications must be submitted for the examination and agreement of the Architect before any equipment is ordered.

A3.2 WORKMANSHIP

A3.2.1 Tradesmen

All electrical work shall be carried out by or under the direct supervision of the "registered electrical workers" of the appropriate grade in accordance with the Electricity Ordinance.

All tradesmen shall be experienced in the trade and the work carried out shall be consistent with the good practice in Hong Kong and to the satisfaction of the Architect.

A3.2.2 Tool and Instrument

Proper tools shall be used for carrying out the electrical installations. Adequate and accurate testing/measuring instruments shall be used to demonstrate compliance of the electrical installations with the relevant specifications and regulations. The Architect has the right to stop any work on which the correct tools and/or instruments are not being used.

Instruments used for acceptance tests shall be calibrated at appropriate intervals and as required in the Contract for a particular project.

A3.2.3 Safety on Site

Work shall be carried out in such a manner as to comply with all the ordinances, regulations and, etc., as listed in Sub-section A2.1 together with any amendments made thereto.

A3.3 LABEL AND NOTICE

A3.3.1 Inscription of Label and Engraving

Inscription of label and engraving shall be in both Chinese and English characters. Details shall be submitted to the Architect for agreement prior to engraving.

A3.3.2 Material for Label

Label shall be of white plastic with black or red lettering engraved as required. Where distribution board is fitted with labels provided by the manufacturer of the distribution board, these labels may be used in lieu of the white plastic label provided that they are of equivalent quality and approved by the Architect.

A3.3.3 Fixing of Label

Label shall be fixed to switchgear and distribution board by screws. Where drilling and tapping of the equipment is impracticable, approved means of glue fastening may be used subject to prior approval of the Architect.

A3.3.4 Engraving for Electrical Accessory

The front plate of each switch socket or control switch feeding an essential circuit or a fixed electrical appliance, such as water heater, cooker, wall-mounted fan, wall-mounted radiator, room cooler, etc., shall be engraved according to the appliance being controlled. Details of the inscription shall be submitted to the Architect for approval.

Additional engraving to other electrical accessories will be specified in the Particular Specification and/or order by the Architect.

A3.3.5 Warning Notice

Warning notices shall be provided as required by the Electricity Ordinance and the Code of Practice for the Electricity (Wiring) Regulations. In addition, the following warning notices in Chinese and English shall be provided at the appropriate positions :

- (a) A label having minimum size of 65 x 50mm marked with the words 'DANGER - HIGH VOLTAGE' in Chinese characters and English lettering of not less than 5 mm high to be fixed on every container or enclosure of ancillary equipment for discharge lighting installations operating at voltages exceeding "low voltage".
- (b) A label to indicate the maximum voltage present in an item of equipment or enclosure within which a voltage exceeding 250V exists, or items or equipment or enclosure which can be reached simultaneously and a voltage exceeding 250V exists between simultaneously accessible terminals or other fixed live parts : such

voltages are normally not expected to exist with the equipment or enclosure.

- (c) A label to be fixed in such a position that any person gaining access to the live parts of an item of equipment or enclosure, which are not capable of being isolated by a single device and not provided with an interlocking arrangement to isolate all circuits concerned, will be adequately warned of the need of taking special precautionary measures to use the appropriate isolating devices.
- (d) A label with the words 'FOR EQUIPMENT OUTDOORS' for each socket outlet intended to supply equipment used at outdoors or area outside the same equipotential zone.

A3.3.6 Other Labels and Notices

Other labels and notices as required by the Electricity Ordinance or the Code of Practice for the Electricity (Wiring) Regulations shall be provided where appropriate.

A3.4 GUARD AND RAILING FOR MOVING OR ROTATING PARTS OF EQUIPMENT

All moving or rotating parts of equipment shall be provided with an approved guard and railing complying with the Factories and Industrial Undertakings (Guarding and Operation of Machinery) Regulations, together with any amendments made thereto.

Guards shall be of rigid and substantial construction and shall consist of heavy mild steel angle frames, hinged and latched with either heavy galvanised mild steel wire crimped mesh securely fastened to frames or galvanised sheet metal of 1.2mm minimum thickness. All apertures shall be such that finger access to dangerous part is not possible. All sections shall be bolted or riveted. Railings shall be made of 32mm diameter galvanised mild steel pipe and railing fittings.

A3.5 INSULATING MATERIAL

Insulating tapes for low voltage applications shall comply with IEC 60454-3-1 pressure sensitive adhesive tape type F-PVC_p/90/0/T_p (Plasticized PVC) and have a thickness of not less than 0.22mm.

Non-impregnated paper, fabric, wood or press-hemp shall not be used for insulating purposes. Where synthetic resin bonded insulating boards are used, all cut edges shall be sealed with an approved varnish.

When insulating material complying with other standard specifications is offered, the Contractor shall satisfy the Architect that the quality of the insulating material offered is equal to or better than that specified in the appropriate IEC Standards.

A3.6 IDENTIFICATION OF CABLE AND CONDUIT

Cables for control circuits, inter-communication circuits, signalling circuits, and bell wiring shall be identified as required for each particular circumstance. Cables for power and lighting circuits shall be identified in accordance with IEC 60364.

Electrical conduits, where required to be distinguished from pipelines or other services, shall use orange (BS colour reference No. 06 E 51 to BS 4800) as the basic identification colour in compliance with BS 1710.

A3.7 MINIMUM SIZE OF CABLE CONDUCTOR

Cables for lighting and bell circuits shall have CSA of not less than 1.0mm², and those for power circuits shall have CSA of not less than 2.5mm². Internal wiring in factory made panel or equipment may comprise cables of different suitable CSA determined by the manufacturer.

The CSA of any cable shall not be reduced at its point of termination, junction, joints, etc.

Where cables of 1.0mm² are to be terminated, approximately 15mm long of cable insulation shall be removed and half the length of the bare conductor shall be bent into the other half to form a solid part prior to the insertion into the termination.

A3.8 USE OF PVC-INSULATED CABLE AT LOW TEMPERATURE

PVC-insulated cables shall not be installed in refrigerated space or other situations where the temperature is consistently below 0°C.

A3.9 FIXING SCREW AND BOLT

Machine screws and nuts shall be to ISO/R885. Hexagon bolts, screws and nuts shall be to BS EN 24016, BS EN 24018 and BS EN 24034. Wood screws shall be to BS 1210 with countersunk head unless otherwise specified. Bolts, nuts and washers shall be manufactured from non-ferrous materials. Holes for bolts, screws and other fixings shall be drilled or stamped, and no larger than required for clearance of the bolt, screw, etc.

A3.10 FIXING TO WOODEN PLUG

Screws shall not be fixed to wooden plugs unless otherwise specified. Proper methods of fixing, such as expanding plugs of adequate size or other purpose-designed fixing devices approved by the Architect, shall be used.

A3.11 SHEET METAL WORK

Sheet metal boxes, meter chambers, etc. shall be manufactured from plain steel sheets. The thickness of steel sheet shall be as specified in the Particular Specification and subject to a minimum of 1.0mm. Where necessary, suitable stiffeners shall be provided to give adequate rigidity.

Protection against corrosion shall be achieved by means of hot-dip galvanisation, anti-rust painting or enamel, or the use of stainless steel. If stainless steel sheet is specified, it shall be to ISO 683/13, Table 3 “Type of Condition and Surface Condition of Stainless Steel Products” Symbol F9 for matt finish and Symbol F8 for polished finish.

A3.12 PAINTING OF METAL WORK

Painting shall be carried in accordance with the appropriate clauses in the current “General Specification for Building” issued by the Architectural Services Department, the Government of the HKSAR and any amendments or revisions made thereto.

Agreement on the type, brand and colour of the paint to be used shall be obtained from the Architect before the work commences. Undercoat and finish coat shall be of properly matching type and the finish coat shall give a hard gloss finish or as required.

A3.13 WATER PROOFING

Where any work pierces the waterproofing including waterproof structure, the method of installation shall be as agreed by the Architect.

A3.14 MAIN AND SUBMAIN SWITCH ROOM AND ELECTRICAL RISER DUCT/ROOM FREE FROM WATER SERVICE

All main and submain switch rooms, electrical riser ducts/rooms shall be free from any water service.

SECTION A4

OTHER GENERAL REQUIREMENTS

A4.1 SCOPE OF REQUIREMENT

This Section covers the current contractual practices for Contract/Sub-contract/Quotation let by the Architectural Services Department for electrical installation and shall be read in conjunction with the documents of the Contract for a particular project.

The word “installation” shall mean not only the major items of plant and apparatus conveyed by this Specification and the Contract, but also all the incidental sundry components necessary for the complete execution of the work and for the proper operation of the installation, with their labour charges, regardless whether these sundry components are mentioned in detail in the tender documents issued in connection with the Contract.

A4.2 STANDARD/GUIDANCE DRAWINGS

These are standard abbreviations and symbols and standard/guidance drawings prepared by BSB to show details of the common standard installations. The Contractor shall refer to these standards and drawings whenever such are mentioned or specified in the Drawings or the Particular Specification. The same standards shall also be used in the Contractor's "as-fitted" drawings, etc., whenever applicable.

A4.3 DRAWINGS PROVIDED BY THE CONTRACTOR

A4.3.1 Size of Drawing

Drawings submitted by the Contractor shall be of a standard size from A0 to A4 in accordance with ISO 5457 (BS 3429). As-fitted or as-built drawings shall be of A0 or A1 size only.

A4.3.2 Working Drawing

Working drawings shall be dimensioned and showing construction, sizes, weights, arrangements, operating clearances, performance characteristics and the necessary builder's work involved.

Working drawings for conduit layout shall clearly indicate the proposed position and size of conduit runs, together with the number of cables, size and circuiting of the cables therein.

A4.3.3 As-fitted or As-built Drawing

As-fitted or as-built drawings shall show the positions of all conduits, cables, switchgear, distribution boards, luminaires, lightning protection

and earthing and all other items which have been installed. As-fitted or as-built drawings shall be submitted in the media of prints, reproducible copies, microfilms and computer disks all as specified in the contract documents.

A4.3.4 Submission of Drawings during Construction

The Contractor shall submit to the Architect a comprehensive "Submission Schedule" of working drawings within two weeks after the tender is awarded, taking into account of the overall programme of the project. No equipment shall be delivered to site and no work shall be executed until such drawings have been approved. The Contractor shall ensure that working drawings are progressively submitted in accordance with the agreed "Submission Schedule".

Failure of the Contractor to submit the working drawings in good time shall not entitle him to extension of contract period, and no claim for extension of time for completion by reason of such failure will be considered.

The Contractor shall provide at least six (6) copies, unless otherwise specified in the Contract, of the agreed working drawings to the Architect for distribution.

A4.3.5 Submission of Framed Drawings upon Completion

The Contractor shall provide framed drawings to each major switchroom showing the schematic wiring diagrams, tables or charts to indicate the type and composition of circuits, identification and location of item of equipment from that switchroom. The framed drawings shall be fixed to the wall in such a way that it can easily be removed for reference.

A4.4 SUBMISSION OF TECHNICAL INFORMATION DURING TENDER STAGE

When required by the Contract, the Contractor shall submit, together with his tender submission, three copies each of the following, as appropriate :

- (a) One set of fully descriptive technical literature of all materials and equipment to be offered

The literature shall show sufficient details for tender evaluation. Such details shall include construction, dimensions, method of installation, weights, circuit diagrams, materials used, etc.

- (b) Photometric and other relevant data for lamps and/or luminaires

This shall include lamp output, polar curve, upward and downward light output ratio, luminous area and Zonal Classification of each luminaire, and control gear loss, etc.

A4.5 SUBMISSION OF OPERATION AND MAINTENANCE (O&M) MANUALS

Upon completion of the installation, the Contractor shall submit copies of O&M manual to the Architect incorporating all amendments made during the course of the Contract, all as specified in the contract documents.

A4.6 SAMPLES BOARD

A sample board containing samples of electrical cables, conduits, trunking, plugs and sockets, etc., offered by the Contractor shall be submitted to the Architect for approval before the commencement of the installation work. The sample board shall bear the name of the Contractor, the title of the Contract and a list of the samples together with the names of the manufacturers. The approved sample board shall be displayed in the site office throughout the whole of the contract period.

The Contractor shall also supply sufficient samples of materials required for testing purpose.

A4.7 SUBMISSION OF TESTING AND COMMISSIONING PROCEDURE

Upon completion of the installation but prior to acceptance, the Contractor shall submit to the Architect in good time a schedule showing the appropriate testing and commissioning procedures to be carried out. The schedule shall be agreed by the Architect before any testing and commissioning work is carried out.

A4.8 DOMESTIC APPLIANCES SUPPLIED BY THE EMPLOYER

Certain items of domestic appliances will be supplied by the Employer.

The quantities of all domestic appliances supplied by the Employer will be indicated in the Contract for the project. The Contractor shall be responsible for the collection, transportation and safe custody on site of all items so supplied.

Domestic appliances supplied by the Employer may be supplied in loose component parts. The Contractor shall assemble, inter-connect the component parts, subsequently install and set the domestic appliances ready for use by the occupants of the building. The Contractor shall also supply and connect plugs to the domestic appliances if required.

The Contractor shall be responsible for returning all items so supplied to the Employer's designated Stores or Depots when such items are found to be surplus to the requirements.

A4.9 PROVISION OF SPARE FUSES IN MAIN SWITCH ROOM

The Contractor shall supply and install one complete set of spare fuses for each rating of switchfuse or fuseswitch installed. The spare fuses shall be hung on a wooden board fixed at a convenient position inside the main switch room.

The wooden board shall be smoothed on the front face and edges, and shall be painted to the approval of the Architect.

A4.10 REQUIREMENTS DURING MAINTENANCE PERIOD

During the Maintenance Period, the Contractor shall, at no cost to the Employer, attend to all faults and complaints, remedy all defects, replace all malfunctioning items and maintain the complete installation in a clean and tidy condition to the satisfaction of the Architect. In case of emergency calls, the Contractor shall arrive within 3 hours and rectify all defects leading to fault or breakdown within 24 hours at any time during the Maintenance Period.

The Contractor shall also replace all burnt out lamps at no cost to the Employer if the failure of lamps is still within the manufacturer's guaranteed life period. The Contractor will be permitted to charge for the cost of lamps only if they fail beyond the guaranteed life period.

SECTION B1

INSTALLATION OF WIRING SYSTEMS

B1.1 WIRING IN STEEL CONDUIT SYSTEM

B1.1.1 Type of Cable

Wiring system installed in conduits shall be non-sheathed copper cables. Cables for 3 phase circuit shall be 450/750V grade or above.

B1.1.2 Concealed Steel Conduit System

Unless otherwise specified in the Particular Specification or on the Drawings, conduits shall be concealed within walls, floor slabs, false ceilings, or other suitable space.

Chase for conduit to be concealed in wall, column or beam shall be vertical or horizontal.

B1.1.3 Surface Conduit System

Where surface conduits are specified, they shall be fixed by distance (spacing) saddles, and shall run in a vertical or horizontal direction.

Conduit boxes, adaptable boxes and metal boxes for accessories shall be securely fixed to walls, ceilings or other substantial parts of a structure by means of suitable brass screws correctly spaced. The fixing of these boxes shall be independent of the fixing of the associated conduits.

Particular precaution shall be taken in situations where the high temperature cables may be touched, or where they may touch other materials.

B1.1.4 Minimum Size of Conduit

The minimum outside diameter of any conduit shall be 20mm.

B1.1.5 Flexible Conduit

Flexible conduit shall be used as short as possible and in any case shall not exceed a conduit run of 2m. (Note : PVC pliable conduit may be used in place of steel flexible conduit wherever appropriate. In such case, requirements in Sub-section B1.3 shall apply.)

B1.1.6 Conduit Continuity

The steel conduit installation shall be mechanically and electrically continuous throughout and effectively earthed.

Where the circuit protective conductor is formed by the conduits, the terminal of a socket outlet shall be connected by a separate circuit protective conductor having the same cross-sectional area and type as the live conductor to an earth terminal incorporated in the associated metal box or enclosure.

Flexible conduit shall not be used as a circuit protective conductor. A separate circuit protective conductor having the same cross-sectional area and type as the largest live conductor shall be drawn into the flexible conduit for earth continuity. This circuit protective conductor shall be fixed to an earth terminal incorporated, at each end, in the metal boxes or enclosures onto which the ends of the flexible conduit are locked.

B1.1.7 Joint in Conduits

Joint in steel conduits shall be made by means of a solid coupler into which the adjacent ends of the two conduits shall be inserted to approximately half into it and screwed up tightly in order to make the conduit run mechanically and electrically continuous. No threads on either conduit shall be exposed.

Running couplings shall not be used. In case where such a coupling cannot be avoided approval from the Architect must be obtained before it is adopted. In this case, the coupler shall be screwed up tightly onto the short threaded portion of one conduit, the threaded portion of which shall project approximately half way into the length of the coupler. The threaded portion of the mating conduit shall also project approximately half way into the coupler. Electrical continuity shall be ensured by tightening up a hexagon locknut against the coupler. Any exposed threads on either conduit shall be painted with at least two coats of anti-rust paint.

B1.1.8 Provision of Adaptable Box

An adequate number of suitably sized adaptable boxes shall be provided in all conduit runs to enable cables to be drawn in and out easily without damage. Adaptable boxes shall be provided immediately after every two bends, or after a bend plus a maximum straight run of 10m, or after a maximum straight run of 15m.

B1.1.9 Spacing between Conduits

Adjacent or parallel conduits cast in concrete shall be separated by a spacing of not less than 25mm so as to allow concrete aggregate to pass and set between them.

B1.1.10 Termination of Conduits at Metal Casing of Equipment

Where a steel conduit terminates at a metal casing, a coupler and a brass male bush shall be used. The brass male bush shall be screwed into the coupler or adaptor from the inside of the metal casing through a clearance hole drilled in the metal casing to suit the bush. Both the

conduit and the bush shall be screwed tightly into the coupler or adaptor so as to grip the metal casing securely for mechanical and electrical continuity. Threads on the steel conduit shall be at least half the coupler length. Connection between flexible conduit and the adaptor shall be securely fixed. No threads on the metal casing shall be allowed.

In the case of flexible steel conduit, a brass adaptor together with a brass male bush shall be used. The brass adaptor shall comprise two parts, an inner core and an outer ferrule. The inner core shall screw into the bore of the conduit together with an outer ferrule which caps off the end of the conduit, so that the adaptor can provide an extremely strong joint. The core shall lock against the outer ferrule and isolate any sharp cut edges in the conduit.

Where a metal casing is painted or enamelled, the electrical continuity between the conduit and the casing shall be achieved by means of a separate circuit protective conductor connecting the conduit and an earth terminal of the casing. Alternatively, a copper continuity connector may be placed between the bush and the metal casing. The cross-sectional area of the separate circuit protective conductor or the copper continuity connector shall have the same current carrying capacity as the largest live conductor drawn into the conduit in accordance with the IEC 60364. Neither the paint nor the enamel shall be damaged or removed in order to achieve the electrical continuity.

B1.1.11 Conduit Bend

Conduit shall not be bent with an acute angle. The internal radius of the bend shall not be less than 2.5 times the outside diameter of the conduit.

B1.1.12 Conduit Crossing Expansion Joint

Where a steel conduit crosses an expansion joint, special arrangement shall be made to allow relative movement to occur on either side of the expansion joint. A separate circuit protective conductor shall be installed to maintain an effective electrical continuity across the expansion joint. The circuit protective conductor shall have a cross-sectional area rated to suit the largest live conductor drawn into the conduit in accordance with IEC 60364.

B1.1.13 Use of Extension Ring

An extension ring shall be fitted to a conduit box where the plaster wall finish (including plaster) is more than 35mm from the conduit box. Only extension rings of the correct depth shall be used. Under no circumstances shall multiple extension rings be permitted.

B1.1.14 Prevention of Ingress of Foreign Matters

During the building construction, all open ends of the conduit termination, which are liable to be filled with water, moisture or other foreign matters, shall be plugged with approved conduit stopping plugs; paper, rag or similar materials shall NOT be used for this purpose.

Steel conduit boxes in similar circumstances shall also be similarly plugged to prevent concrete aggregate or plaster from entering into the boxes during building construction.

B1.1.15 Prevention of Accumulation of Water or Moisture

The conduits shall be so laid to prevent accumulation of condensed moisture and the ingress of water in any part of the installation.

Approved type of sealant for the prevention of condensed moisture shall be applied to ceiling conduit outlets installed in a cooled space subject to the influx of warm air.

B1.1.16 Conduit Laid Direct in Ground

Steel conduits laid direct in ground or buried in soil shall be painted with two coats of bituminous paint and wrapped with self-amalgamating tapes or other wrapping materials for protection against corrosion and approved by the Architect.

B1.1.17 Fixing of Distance (Spacing) Saddle

Saddles, for the support of surface conduits, shall be provided throughout the entire route at regular intervals. The spacing between adjacent saddles for steel conduits shall not be more than those given on Table B1.1.17.

Each bend of a surface conduit shall be supported by a saddle on either side of the bend, and the saddles shall be fixed as near to the bend as practicable.

Saddles shall be fixed with brass screws in expanding plugs or other purpose-designed fixing devices approved by the Architect.

Table B1.1.17
Spacing of Supports for Conduit

Conduit size (mm)	Maximum distance between supports (m)					
	Rigid steel conduit		Rigid plastic/PVC conduit		Pliable/flexible conduit	
	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical
20	1.75	2.00	1.50	1.75	0.40	0.60
25, 32	2.00	2.25	1.75	2.00	0.60	0.80

B1.1.18 Conduit Installed Outdoors or in Damp Situation

Where steel conduits are installed outdoors or in damp situations, all conduit fittings and conduit accessories shall not be placed in contact with other metals with which they are liable to set up electrolytic action. In addition, where the conduit installation is subject to weather, the conduit fittings and conduit accessories shall be provided with weatherproof sealant or other materials to ensure that the installation is completely weatherproof.

B1.1.19 Swabbing Out of Conduit

Conduits shall be swabbed out and free from moisture before wiring work is to commence. The swabbing operation shall be witnessed by the authorised representative of the Architect. Only approved draw-in tape or steel wire of appropriate size and absorbent cloth shall be used.

B1.1.20 Fire Barrier

Where a conduit passes through fire resistant structural elements, such as walls and floors designated as fire barriers, the opening made shall be sealed according to the appropriate degree of fire resistance of the wall and/or floor. In addition, where a conduit is installed in a channel, duct, ducting, trunking or shaft which pass through such elements, suitable fire-resistant barriers shall also be provided to prevent the spread of fire.

B1.1.21 Identification

Conduits, where required to be distinguished from pipelines or other services, shall use orange (BS colour reference No. 06 E 51 to BS 4800) as the basic identification colour in compliance with BS 1710.

B1.1.22 Cable Capacity of Conduit

The number of cables drawn into a conduit shall be such that no damage will be caused to the cables or to the conduits during their installation.

In determining the size of the conduit, the “unit system” method shall be adopted. The sum of all factors for the cables as given in Table B1.1.22-1 shall NOT be greater than the conduit factor as given on Table B1.1.22-2.

Table B1.1.22-1

**Cable Factors for
Single Core Insulated Copper Cables**

Conductor cross- Sectional area (mm ²) (See Note 1)	Cable factors for cables in conduits (See Note 2)		Cable factors for cables in trunking
	For short run	For long runs or run with bends	
1.0 Solid	22	16	5.8
1.5 Solid	27	22	7.1
1.5	31	22	8.1
2.5 Solid	39	30	10.2
2.5	43	30	11.4
4.0	58	43	15.2
6.0	88	58	22.9
10.0	146	105	36.3

Notes :

1. Unless otherwise noted, all cables are stranded cables.
2. “Short run” means a straight conduit run not exceeding 3m long. “Long run” means a straight conduit run exceeding 3m long.

Table B1.1.22-2

Conduit Factors

Length of conduit Runs (m)	Conduit diameter (mm)								
	20	25	32	20	25	32	20	25	32
	Straight run			Run with one bend			Run with 2 bends		
1	460	800	1400	303	543	947	286	514	900
1.5	460	800	1400	294	528	923	270	487	857
2	460	800	1400	286	514	900	256	463	818
2.5	460	800	1400	278	500	878	244	442	783
3	460	800	1400	270	487	857	233	422	750
3.5	290	521	911	263	475	837	222	404	720
4	286	514	900	256	463	818	213	388	692
4.5	282	507	889	250	452	800	204	373	667
5	278	500	878	244	442	783	196	358	643
6	270	487	857	233	422	750	182	333	600
7	263	475	837	222	404	720	169	311	563
8	256	463	818	213	388	692	159	292	529
9	250	452	800	204	373	667	149	275	500
10	244	442	783	196	358	643	141	260	474

- Notes** :
1. The size of conduit, which will satisfactorily accommodate the cables, is that size having a factor equal to or exceeding the sum of the cable factors.
 2. For cables and/or conduits not included in these tables, the number of cables to be drawn into a conduit shall be such that the resulting space factor does not exceed 40%.

B1.1.23 Method of Drawing Cables into Conduit

Conduit system shall be completely erected before cable is drawn in and there shall be adequate means of access for drawing cable in or out.

Cables shall be drawn into a conduit by using approved draw-in tape or steel wire of the appropriate size. Under no circumstances shall the use of lubricants, e.g. grease, graphite, talc powder, etc., be permitted to assist in the drawing the cables.

B1.1.24 Segregation of Cables of Different Circuit Categories

Separate conduits shall be provided for cables of different circuit categories or using different voltage levels.

B1.1.25 “Looping-in” Wiring System

Each cable in a run shall be of one continuous length and wired on the “loop-in” system. No joint in cable run shall be allowed.

B1.1.26 Grouping of Cables in Conduit

Conduits running from a distribution board to the final distribution point may each contain all live conductors of a number of final circuits provided that the effective current-carrying capacity of all circuits, upon taking the correction factors into consideration, shall exceed the rating of their respective over-current protection devices and all conditions as stipulated in Sub-section B1.1.22 above are satisfied.

For conduits serving final circuits direct from a distribution board or from an adaptable box used as a final distribution point, each conduit shall contain all live cables of one final circuit only except in the case of lighting final circuit where two circuits with 1.0mm² or 1.5mm² cables will be permitted in a 20mm diameter conduit.

The neutral cable of a lighting final circuit using single core cables may be routed in the conduit direct to the lighting point without passing through the switch box.

B1.1.27 Termination of Bonding Conductors at Conduit Installation

For surface conduit installations, the supplementary bonding conductors shall be terminated at the nearest conduit or conduit box forming an integral part of the conduit installation.

For concealed conduit installations, the supplementary bonding conductors shall be terminated at a copper earthing terminal fitted inside a metal box forming an integral part of the conduit installation. The metal conduit box shall be located as near as possible to the bonding position and the exposed part of the supplementary bonding conductor shall be made as short as possible.

B1.2 WIRING IN STEEL TRUNKING SYSTEM

B1.2.1 General

Where steel trunking is specified, they shall be installed neatly on the surface of the walls, columns, beams or flushed with floor screeding and shall be installed along a vertical or a horizontal plane.

The complete trunking installation shall be mechanically and electrically continuous throughout, and effectively earthed.

Wiring system in trunking installation shall consist of non-sheathed copper cables or sheathed copper cables. Cables for 3 phase circuit shall be 450/750V grade or above.

Cables in each final circuit and/or in each sub-main shall be bunched and tied or clipped together.

Particular precaution should be taken in situations where high temperature cables may be touched or where they may touch other materials.

B1.2.2 Provision of Cable Retaining Bar and Cable Support

Surface trunking, which is installed in such a position that the cables might fall out when the cover is removed, shall be fitted with cables retaining bars or other suitable devices to prevent the cables from falling out.

Surface trunking installed vertically with length exceeding 5m shall contain sufficient supporting devices such as pin racks within the trunking to prevent strain on the cables due to the weight of the cables, and to prevent vertical movement of the cables.

B1.2.3 Cable Capacity of Trunking

The number of cables put into a trunking shall be such that no damage is caused to the cables or the trunking during their installation.

In determining the size of the trunking required for a particular installation, the “unit system” method shall be adopted. The sum of all factors of the cables, as given in Table B1.1.22-1 shall NOT be greater than the trunking factor as given in Table B1.2.3.

Table B1.2.3

Trunking Factors

Trunking Dimensions (mm x mm)	50 x 37.5	50 x 50	75 x 50	75 x 75	100 x 50	100 x 75	100 x 100
Trunking Factors	767	1037	1555	2371	2091	3189	4252

Notes :

1. The size of trunking which will satisfactorily accommodate the cables is that size having a factor equal to or exceeding the sum of the cable factors.
2. For sizes and types of cables and sizes of trunking other than those given in Tables B1.1.22-1 and B1.2.3, the number of cables installed shall be such that the resulting space factor does not exceed 40%. The space factor is expressed as the ratio (expressed as percentage) of the sum of the overall cross-sectional areas of cables to the internal cross-sectional area of the trunking in which the cables are installed. The effective overall cross-sectional area of a non-circular cable is taken as that of a circle of diameter equal to the major axis of the cable.

B1.2.4 Correction Factor of Grouping

Where more than one circuit of single-core cables or more than one multi-core cables are enclosed in a common trunking, suitable correction factor for grouping, as recommended by IEC 60364, shall be applied in determining the size of the cables to be installed. The effective current carrying capacity of all circuits, upon taking the correction factors into consideration, shall exceed the rating of their respective over-current protection devices and all conditions as stipulated in Sub-section B1.2.3 above are satisfied.

B1.2.5 Segregation of Cables of Different Circuit Categories

Where a common trunking is used to accommodate cables for different circuit categories, they shall be effectively segregated by means of partitions or dividers except in the case where trunking is manufactured using two smaller pieces of trunking attached together with a common cover. The partitions or dividers shall be adequately secured to the body of the trunking.

For underfloor (duct) trunking, the partitions or dividers shall also be of full depth to provide support and strength to the top surface of the assembly.

B1.2.6 Connection to Equipment

Connection between trunking and equipment shall be by a screwed coupler and brass male bushes, or a standard flange coupling or an adaptor neck, fabricated or cast. For direct attachment of trunking to equipment, cable entries shall be provided with smooth bore bushes or grommets and the return edge of the lid of the trunking shall be left intact.

B1.2.7 Connection to Distribution Board

Where connection is made between trunking and a distribution board, the connectors for cable entry shall be sized to accept all cables from all available circuits including circuits marked as “spare”.

B1.2.8 Fixing of Surface Trunking

Individual pieces of trunking shall be independently supported by means of at least two fixed points per piece. On straight runs, supports for trunking shall be fixed at regular intervals with maximum spacing as given in Table B1.2.8. For runs with bends, supports shall be fixed as near to the bend as practicable.

Overhead trunking shall be suitably supported by means of mild steel hangers, brackets or other approved means, so that no visible sag is observed when loaded with cables. These supports shall be painted with at least two coats of an approved anti-rust paint to prevent corrosion.

Table B1.2.8

Spacing of Supports for Cable Trunking

Trunking cross-sectional area (mm ²)	Maximum distance between supports (m)			
	Steel trunking		Plastic/PVC trunking	
	Horizontal	Vertical	Horizontal	Vertical
Exceeding 300 but not exceeding 700	0.75	1.0	0.50	0.50
Exceeding 700 but not exceeding 1500	1.25	1.5	0.50	0.50
Exceeding 1500 but not exceeding 2500	1.75	2.0	1.25	1.25
Exceeding 2500 but not exceeding 5000	3.0	3.0	1.50	2.00
Exceeding 5000	3.0	3.0	1.75	2.00

- Notes :**
1. The spacing tabulated above assume that the trunking is not exposed to mechanical stress other than that due to the weight of the enclosed cables, and the trunking and fittings.
 2. The above figures do not apply to trunking which is used for supporting luminaires or other equipment.

B1.2.9 Cables through Trunking

Cables penetrating through trunking shall be protected by conduits except insulated and sheathed cables if such cables form part of a surface wiring system. In such case, the holes in the trunking, through which such cables penetrate, shall be fitted with suitable rubber grommets or insulated bushes.

B1.2.10 Fire Barrier

Where a trunking passes through a fire resistant structural element, such as floor and wall, having specified fire resistance, the opening thus formed shall be internally and externally sealed with approved type of fire resisting material according to the appropriate degree of required fire resistance.

B1.2.11 Prevention of Electrolytic Action

Where a trunking is installed in a damp situation, or where a trunking is likely to be exposed to weather, the trunking shall be kept away from other metalwork with which electrolytic action is liable to incur.

B1.2.12 Prevention of Ingress of Water

Every entry to a trunking shall be so placed as to prevent or to be protected against ingress of water.

B1.3 WIRING IN PLASTIC CONDUIT OR PLASTIC TRUNKING SYSTEM

B1.3.1 General

Where wiring in plastic conduits or plastic trunking is specified, they shall comply, where applicable, with the relevant clauses in Sub-sections B1.1 and B1.2.

PVC conduit shall be heavy duty conduit and shall not be used for installation where the ambient temperature exceeds 60°C or below minus 5°C.

Conduits may be corrugated, plain or reinforced. Suitable conduit cutter shall be used for cutting rigid PVC conduit.

B1.3.2 Pliable Conduit

Pliable conduit shall be used as short as possible and in any case shall not exceed a conduit run of 2m. Pliable conduit shall not be used in situations where they would be subject to continuous flexing.

B1.3.3 Joint in PVC Conduit

Joint in PVC conduit shall be made by means of a solid PVC coupler into which jointing cement shall be applied to the outer surface of the conduit to be joined in turn and then shall be inserted firmly into a coupler and twist a quarter turn to spread cement evenly in order to make the conduit run mechanically continuous.

B1.3.4 Plastic Boxes

PVC adaptable boxes and PVC boxes for enclosure of electrical accessories shall be interchangeable with the steel boxes complying with relevant IEC.

PVC boxes shall be provided with a brass earthing terminal complete with screw for the connection of circuit protective conductor. They shall not be used for suspension of luminaires or other equipment, where considerable heat will be produced or where the mass of the luminaire or equipment exceeds 3 kg.

Where a concealed conduit system is used in floor slab or wall, a system of PVC rigid conduit fitted with a “screwed to plain PVC converting adaptor” firmly screwed into a deep pattern type cast iron ceiling mounted “BESA” box shall be employed for the suspension of luminaires or other equipment. The system shall also be suitable for the suspended load at the expected working temperature. The threaded

portion of the mating converting adaptor shall project to cover the full threaded portion of the “BESA” box and shall be screwed up tightly in order to make the conduit run mechanically continuous. Any exposed threads on the “BESA” box shall be painted with at least two coats of anti-rust paint.

B1.3.5 Termination of PVC Conduit at Casing of Equipment

Where a PVC conduit terminates at a casing, a coupler and a PVC bush (i.e. a “plain to screwed” PVC coupler) with a male PVC bush or a “screwed to plain PVC converting adaptor” with a female PVC bush shall be used. In the case of flexible conduit, a rigid PVC glands or a PVC adaptor together with a PVC male bush shall be used.

Where PVC adaptor with male bush are used, the male bush shall be screwed into the coupler or adaptor from the inside of the metal casing through a clearance hole drilled in the casing to suit the bush. The bush shall be screwed tightly into the coupler or adaptor so as to grip the casing securely for mechanical continuity. Threads on the male bush shall be long enough to cover the full threaded portion of the coupler. The jointing cement shall be applied on the surface of pliable conduit prior to insertion into the coupler/adaptor and twist.

B1.3.6 Conduit Bend

Conduit bend shall be made by the use of purpose made solid elbow or , for PVC conduit not exceeding 25mm diameter, by bending the conduit itself . Conduit bend shall not be bent with an acute angle. The internal radius of the bend shall not be less than 4 times the outside diameter of the conduit.

In case of the conduit bend is made by bending the PVC conduit, the conduit bend shall be made by using the appropriate size of conduit bending springs. Conduit shall be fixed in position as soon as possible after bending.

B1.3.7 Allowance for Thermal Expansion

Due allowance shall be made for the expansion of PVC tubing at high temperature. Expansion coupling or other fittings shall be installed in a straight run of 10m or less. Saddles or clips shall be of sliding fit.

B1.3.8 Fixing of Trunking

The trunking shall be fixed and supported in the normal way by screws, but the holes in the trunking shall always be made slightly oversize to allow for the movement of expansion. Washers shall be used under the head of the screw which shall not be over-tightened.

The spacing between adjacent supports for trunking shall not be greater than those given in Table B1.2.8.

B1.3.9 Earthing

A PVC insulated cable shall be drawn into the conduit or trunking system to serve as the circuit protective conductor (CPC), the cross-sectional area of which shall comply with the IEC 60364 for the size of the largest live conductors enclosed.

B1.4 SURFACE WIRING SYSTEM

B1.4.1 Type of Cable

Where surface mounted wiring is specified, sheathed copper cables shall be used for fixed installation. Cables for 3 phase circuit shall be 450/750V grade or above. Cables shall not be buried in concrete or plaster.

Flexible cables or flexible cords shall be used for connection to apparatus, appliances or equipment via an appropriate wiring accessory. Flexible cables or flexible cords shall not be used in fixed installation, except for final connection to a fixed equipment.

B1.4.2 Minimum Size of Live Conductors and CPC

Cables shall have CSA not less than 1.0mm^2 for 5A/6A circuits, 1.5mm^2 for 10A circuits and 2.5mm^2 for 15A/16A circuits.

Flexible cables and flexible cords shall have CSA not less than 0.75mm^2 .

The minimum CSA of a CPC shall be 1.5mm^2 if the CPC is integrated in a cable carrying the associated live conductors. The minimum CSA of a separate CPC shall be 2.5mm^2 if protection against mechanical damage is provided (e.g. sheathed cable), and 4mm^2 if mechanical protection is not provided (e.g. non-sheathed cable).

CPC shall be properly sized in accordance with Section B6.

B1.4.3 Identification of Cable Core

For non-flexible cables, the phase conductors shall be coloured red or yellow or blue, as appropriate, and the neutral conductor shall be coloured black.

For flexible cables or flexible cords, the phase conductor shall be coloured brown, and the neutral conductor shall be coloured blue. Where there are more than one phase conductors in a flexible cable or flexible cords, the coding L1, L2 and L3 shall be used.

All circuit protective conductors shall be coloured exclusively in green-and-yellow.

B1.4.4 Joint in Cable or Cord

Joints in cables or cords shall not be allowed unless approved by the Architect. In such case, the joints shall be electrically and mechanically sound, be protected against mechanical damage and any vibration liable to occur.

B1.4.5 Installation of Non-flexible Cable

(a) General

All cables shall be run in a vertical or horizontal direction, and shall be secured flat on the surface of walls, columns, partitions or ceilings, etc. throughout the entire route, including at bends. Fixing onto the ceiling shall be avoided unless the cable is required to feed a point on the ceiling.

Where required, the cables may be run under floors, between partitions or inside ceiling voids provided that they are enclosed in ducts, conduits or trunking which comply fully with the relevant clauses in Sub-sections B1.1, B1.2 and B1.3.

When cables are routed along or cross steel joints, beams, stanchions, etc. they shall be enclosed in steel or rigid PVC trunking/conduit.

Cables shall not be run as a span between beams, trusses, etc., without rigid support throughout their length.

(b) Protection to Cable Susceptible to Damage

Cables susceptible to damage shall be protected by means of metal channels. Where protection is required for cables running up a wall from the floor, the metal channel shall be fixed to a minimum height of 1.5m above finished floor level.

(c) Cable Passing through a Building Structure

Where cables pass through a building structure such as a wall or column, the cables shall be drawn through PVC sleeves inserted into the building structure. The size of the PVC sleeves shall be such that the space factor shall not exceed 40%. The gap between the structure and the sleeve and that between the cables and the sleeve shall be completely filled with cement or approved fire-resisting material.

Cables crossing an expansion joint shall be formed into a loop such that any movement in the joint shall not stress the cables.

(d) Cable Passing through Metal Work

Rubber grommets or insulated bushes shall be used to protect the cables passing through metal part of a distribution board, a luminaire, a metal box or any other metal work.

(e) Segregation from Other Services

Cables shall be run at least 150mm clear of all other non-electrical services.

(f) "Looping-in" Wiring System

The cables shall be wired on the "looping-in" system. Cable joints of any type in cable runs shall not be allowed.

(g) Neutral Conductor at Switch Position

The neutral conductor of a twin core cable for a lighting final circuit shall be looped through an insulated connector enclosed in the moulded box or pattress accommodating the switch.

(h) Termination of Cable

Cable terminated at a moulded box or pattress, a luminaire or other fittings shall have the overall protective sheath carried into the moulded box or pattress, luminaire or other fittings for a minimum of 13mm.

The CPC shall be terminated at the earth terminal provided in the moulded box or pattress housing the wiring accessories.

Where it is not required to terminate the CPC in an accessory, it shall not be cut back or removed. Instead, it shall be coiled away from the live terminals or any bare conductors and shall be insulated and sleeved with a green-and-yellow PVC sleeve.

(i) Bending Radius of Cable

The internal bending radii of cables shall not be less than the values given in Table B.1.4.5-1.

Table B1.4.5-1

Bending Radius of Non-Flexible Cable

Overall diameter of cable (D)	Minimum internal radius of cable bend
Not exceeding 10mm	3D
Exceeding 10mm but not exceeding 25mm	4D
Exceeding 25mm	6D

(j) Fixing of Cable

Cables having an overall diameter not exceeding 10mm shall be fixed by means of buckle clips. Cables of other diameters shall be fixed by means of cables saddles.

Where a number of cables running together on the surface of walls, columns, partitions or ceiling such that their aggregated width exceeds 50mm, a 13mm thick hard wood batten of adequate width shall be fixed along the cable route for mounting the cables. The hard wood batten shall be finished with one coat of approved priming on front and edges, and waterproof compound treated at the back. Lengths of the batten shall be properly fitted together and fixed in position by counter-sunk brass screws in rawlplugs.

(k) Fixing of Clip

Buckle clips shall be fixed and secured by pins driven into surface of wall, column, partition or ceiling. The head of every pin shall be level with the surface of the clip so that no damage to the sheath of the fixed cables can occur.

Every hole in the buckle clip shall require a fixing pin.

A separate buckle clip shall be required for every cable of size above 2.5mm² twin with CPC, or of equivalent size. Not more than two cables shall be allowed in one clip under all circumstances.

Buckle clips shall be provided along the entire cable route at regular intervals not exceeding 250mm on horizontal runs and 400mm on vertical runs.

A clip shall also be provided at a distance not exceeding 75mm from a termination and from both sides of a bend.

(l) Fixing of Cable Saddle

Cable saddles shall be securely fixed by fixing screws. Saddles shall be provided along the entire cable route at regular intervals. The spacing between adjacent saddles shall not exceed the values given on Table B1.4.5-2.

Table B1.4.5-2

Spacing of Cable Saddles for Non-flexible Cable

Overall diameter of cable (mm)	Maximum spacing (mm)	
	Horizontal run	Vertical run
Not exceeding 20	350	450
Exceeding 20	400	550

A saddle shall also be provided at a distance not exceeding 150mm from a termination and from both sides of a bend.

(m) Correction Factor to Current Rating of Cable

Where more than two twin cables are fixed together, or when the cables are installed at or in thermally insulated materials, etc., suitable correction factors, as recommended by IEC 60364 shall be applied in determining the size of the cables to be installed. The effective current carrying capacity of each cable shall be calculated and ensured that it is within the intended operating value of the circuit.

B1.4.6 Installation of Flexible Cable and Flexible Cord

(a) Connection to Portable Equipment

Flexible cables or flexible cords for connections to portable appliance or equipment shall have suitable length (preferably 1.5m to 2m) to avoid undue risk of mechanical damage.

(b) Connection to Fixed Equipment

Exposed lengths of flexible cable or flexible cord used for final connections to fixed equipment or appliance shall be as short as possible.

(c) Connection to Luminaire

Where a flexible cord supports or partly supports a pendant luminaire, the maximum mass acting on the cord shall not exceed 3 kg for flexible cord of 0.75mm², and shall not exceed 5 kg for flexible cord of larger conductor CSA.

B1.5 TOOL AND WORKMANSHIP

B1.5.1 Approved Tool

Only tools which are proven to be suitable shall be used.

Conduit bushes, couplers and similar items shall be tightened with bush spanner or other suitable tools approved by the Architect.

Conduit bends shall be formed on an approved bending machine, and the conduits shall not be flattened or with protective coating damaged at the bends.

Suitable cutters shall be used for cutting PVC conduits or trunking.

B1.5.2 Cutting in Metal Work for Conduit or in Trunking

Holes in metal work for the termination of conduits shall be drilled on site with a twist drill of the correct size or by means of an approved hole cutting device.

Holes in trunking shall be drilled, punched or cut by ring saw.

After cutting, burrs and sharp edges on the metal work or trunking shall be removed to prevent abrasion of cables.

B1.5.3 Making Good of Damaged Coating

Where the protective coating on a steel conduit or trunking has been damaged after installation, such surface shall be effectively restored by at least two coats of anti-rust paint or other suitable coating to prevent corrosion.

SECTION B2
INSTALLATION OF POWER CABLES,
CABLE TRAYS AND CABLE LADDERS

B2.1 GENERAL

B2.1.1 Scope

This Section covers the installation of power cable, which includes those listed in Sub-section C2.2 of Section C2. It also covers the installation of the associated cabling facilities, including cable trays and cable ladders.

Unless otherwise specified elsewhere, all cables shall have copper conductors.

B2.1.2 Electromagnetic Interference

To minimize the electromagnetic interference generated from single core cables, the following arrangements shall be adopted :

- (a) All the single core cables shall be of the same conductor, same cross sectional areas, same type, same construction and from the same manufacturer.
- (b) All the single core cables shall be of equal length, and shall follow the same route of installation.
- (c) The single core cables shall not be able to operate individually.
- (d) The layout of single core cables shall be arranged as shown in Sketch B2.1.2(d) at the end of this Section B2.

B2.2 CABLE MOUNTED ON SURFACE

Unless otherwise specified, power cables shall be mounted on the surface of wall or ceiling or other building structure. They shall be cleated in position by approved type cable cleats or cable saddles. Cable cleats or cable saddles shall be provided along the entire cable route according to the Table B2.2.

When specified, power cables may be supported on cable trays or cable ladders. In such cases, the requirements of Sub-sections B2.9 and B2.10 shall apply.

For vertical cable runs exceeding 100m, tension releasing sections shall be provided in accordance with the recommendation of the cable manufacturer, failing which, a tension releasing section shall be provided for every 100m vertical run.

TABLE B2.2

Spacing of Cable Cleats or Cable Saddles for Power Cable

Type of cable	Overall diameter of cable, d (mm)	Support spacing	
		Horizontal (mm)	Vertical (mm)
Cables with copper conductors	$d \leq 15$	350	450
	$15 < d \leq 20$	400	550
	$20 < d \leq 40$	450	600
	$40 < d \leq 60$	700	900
	$d > 60$	1100	1300
Cables with aluminium conductors	$d \leq 20$	1200	550
	$20 < d \leq 40$	2000	600
	$40 < d \leq 60$	3000	900
	$d > 60$	4000	1300

B2.3 CABLE LAID IN ENCLOSED TRENCH

When more than one power cables are laid in an enclosed trench, the cables shall be installed in accordance with Table 52H of IEC 60364. Correction factors shall be applied to the current ratings as indicated in IEC 60364, where applicable.

B2.4 CABLE ENCLOSED IN DUCT

B2.4.1 General

Cables laid in ducts shall be sheathed and armoured. Where mineral insulated cables are specified, they shall be with PVC or XLPE outer cover as specified.

Where the ducts are formed from wood, cables shall be held in position by clips, saddles, or approved fixings.

The space factor in a cable duct shall not exceed 35%.

B2.4.2 Drawing-in of Cables

Prior to the drawing-in of the cables, the cylindrical ducts shall be cleaned with a cylindrical brush of appropriate size.

Attachment to facilitate the pulling of cables through a duct shall be made to the cores, insulation, inner and outer sheaths and not to the armour in order to avoid twisting. Attachment to the armour will only be permitted for small cables with the approval of the Architect. When pulling power cables into small ducts, an emulsion of graphite powder and soft soap in water may be used for brushing onto the cable surfaces where they enter the duct to reduce friction during pulling. The use of

other materials having equivalent functions or performance will not be precluded provided that such materials or methods shall not damage the cables and that the prior approval of the Architect has been given.

When pulling-in lead-sheathed insulated power cables, the following precautions shall be taken :

- (a) Maximum stress in sheath - 10,000kPa (with stocking pulling grip).
- (b) Maximum stress in conductors - 70,000kPa (with pulling eye attached to conductors).
- (c) Maximum pull shall be limited to 220,000 Newtons.

B2.4.3 Internal Barrier

In every vertical duct, which is designed as totally enclosed without ventilation, internal barriers shall be provided to prevent the air at the top of the duct from attaining an excessively high temperature. The distance between adjacent barriers shall be the distance between floors. Where the floor to floor distance exceeds 5m, additional barriers shall be provided at an interval not exceeding 5m.

B2.4.4 Fire Barrier

Where a cable duct passes through fire resistant structural elements, such as floor or wall designated as fire barriers, the opening thus formed shall be sealed with fire resistant materials having the same degree of fire resistance as the structural element. In addition, suitable internal fire barriers shall also be provided. An internal fire barrier may also serve as an internal barrier described in Sub-section B2.4.3 above.

B2.4.5 Draw-in Pit

Where cables in a duct are inaccessible for the greater part of their length, adequate number of draw-in pits shall be provided at every turning point and at regular intervals of not greater than 15m. Sufficient room shall be available in the draw-in pits to enable the cables to be manoeuvred without damage. In the case of armoured cables, the draw-in pits shall be concrete or brick lined and shall be fitted with a waterproof heavy cast iron lid. Draw-in pits shall not be filled with sand or other materials.

Where a change in direction in a duct occurs, provision shall be made to enable the cables in the duct to have adequate radii of curvature in accordance with the relevant requirements in this Section.

B2.4.6 Segregation of Cables of Different Circuit Categories

Separate ducts shall be provided for cables of different circuit categories. However, cables of different categories may be allowed to pass through the same draw-in pit provided that they are properly and appropriately segregated.

B2.4.7 Sealing of Duct Entry to Building

After the cables have been installed, both the cables and the exposed duct end shall be sealed to form a gas, water and fire barrier. Open ends of spare ducts shall be closed with tapered hardwood plugs and then sealed similarly.

B2.5 CABLE BURIED DIRECT IN GROUND

B2.5.1 Protection to Cable

Power cables buried direct in ground shall be armoured. They shall be buried at a depth of not less than 450mm and shall be protected by means of approved cable cover tiles. The bottom of the cable trench shall be covered, to a depth not less than the diameter of the largest cable, with a bedding layer of sand or fine soil. On top of the cables, an after layer of sand or fine soil, to a depth of 100mm, shall again be provided. The sand or fine soil shall not be larger than 13mm sieve. Particular care shall be taken to ensure that there shall be no pebbles or small stones in the bedding layer or after layer of the fine sand or soil. The cables shall then be covered, throughout the entire route, by approved type cable cover tiles which shall be laid on top of the after layer.

B2.5.2 Cable Marker

The route of all power cables buried direct in ground shall be clearly indicated by cable markers laid on the ground. The cable markers shall be engraved with the following wording :

"DANGER - BSB ELECTRIC CABLES"

Cable markers shall be placed at regular intervals not exceeding 60m apart and also at positions where the cable route changes direction.

At the position of each underground junction box, a cable marker shall also be installed. Such markers shall be engraved, in addition to the wordings mentioned above, the appropriate information, such as "3 way Joint Box".

B2.6 BENDING RADIUS OF CABLE

The internal bending radius of every power cable shall not be less than the appropriate values given in Table B2.6.

Table B2.6

Bending Radius of Power Cable

Type of cables	Overall diameter (D)	Minimum internal bending radius
IEC 60502, IEC 60811, IEC 60189, IEC 60227 and BS 6724		
Circular Copper conductor, non-armoured	10mm to 25mm Above 25mm	4D 6D
Circular copper conductor, armoured	Any	6D
Solid aluminium or shaped copper conductor, armoured or non-armoured	Any	8D
IEC 60055-1, IEC 60055-2		
Single core	Any	15D
Multi-core	Any	12D

B2.7 CABLE JOINT AND CABLE TERMINATION

B2.7.1 General

Joints and terminations of all power cables shall be made by skilled cable jointers who shall be approved by the Architect before work commences.

No reduction in the number of strands of a cable core shall be allowed at a cable joint or termination.

Ferrules, compression connectors and bare portions of cable core resulting from a jointing or terminating process shall be insulated with an approved type of insulating tape or heat shrinkable tubing after completion of process. Such insulating tape or heat shrinkable tubing shall have equal or better electrical and mechanical properties as those of the original insulation removed, and shall be adhered to the cores, securely and permanently. The final thickness shall be in a smooth contour throughout the whole length.

Every compression joint shall be of a type which has been the subject of a test certificate as described in IEC 61238. When a compression joint is made, the appropriate tools specified by the manufacturer of the joint connectors shall be used.

B2.7.2 Joint Box and Terminating Box

Boxes for joints in all power cables shall be of cast-iron, compound filled and of adequate size. The boxes shall be fitted with suitable armouring clamps and glands. The armouring of the cables shall be terminated at the armouring clamps and the inner sheath shall pass through the gland.

The box shall be warmed thoroughly before the compound is poured to allow total adhesion between the compound and the box. The compound shall then be allowed to cool and topped up before the box is closed. No air locks shall be formed within the box.

Plastic shells fitted with suitably sized armour bond and filled with approved type cold pouring encapsulating compound may be used as alternative for jointing PVC insulated power cables. The complete jointing kit, including plastic shell, compound, insulating tape, etc. shall be from the same proprietary manufacturer who is specialised in manufacturing products for this purpose. The jointing method and procedure as laid down by manufacturer shall be followed strictly.

B2.7.3 Identification at Joint or Termination

At each joint or termination, a non-ferrous metallic label shall be fixed to the cable giving the size and identification of the cable, e.g. 50mm² 4-core XLPE/SWA/PVCS copper cable to "Services Block".

B2.7.4 Earth Continuity across Joint

A circuit protective conductor having adequate cross sectional area shall be installed and connected to maintain the effectiveness of the earth continuity across every cable joint.

B2.7.5 Straight-through Joint for Copper Conductors

In such joint, the two conductors shall be butted together after the strands have been soldered solid and shall be jointed by means of a weak back ferrule, soldered to the cores. Soldering shall be carried out by pouring tin-man's solder over the cores and weak back ferrule. Under no circumstances shall direct flame from a blow lamp be used for soldering.

As an alternative, conductors may be jointed by approved type compression connectors using the appropriate tools and connectors.

B2.7.6 Tee-joint for Copper Conductor

When two cables with copper conductors are tee-jointed, the branch conductor shall be connected to the main conductor by means of claw type or weak back ferrules. The strands in both branch and main conductors are to be sweated solid before sweating to the ferrule. Soldering shall be carried out as detailed in Sub-section B2.7.5 above.

B2.7.7 Joint for Aluminium Cables

(a) Soldered Joint

Prior to making a soldered joint, each conductor shall be cleaned by means of steel wool or similar abrasive and then tinned by pouring solder, specially made for use with aluminium, over the cores. Both cores shall then be inserted in a weak-backed aluminium ferrule and butted together. The ferrule shall then be closed. Soldering shall be completed by pouring the solder over the ferrule, after applying a layer of flux recommended by the cable manufacturer for this purpose.

(b) Compression Joint

Alternatively, the aluminium cores may be jointed by means of an approved type compression joint. A compression joint shall be made by inserting the aluminium cores to be jointed into the opposite ends of an aluminium compression jointing tube, which shall have the correct size for the conductors. The tube shall then be compressed onto the cores by means of a compressing tool. The tool used and the working procedure adopted shall be as recommended by the cable manufacturer.

B2.7.8 Termination of PVC-insulated or XLPE-insulated Cable with Copper Conductors

PVC-insulated or XLPE-insulated cables shall be terminated in a gland fitted with an armour clamp. Provision shall be arranged to enable a watertight seal to be made between the gland and inner sheath. The gland body shall be provided with an internal conical seating to receive the armour clamping cone and a clamping nut which shall secure the armour clamping cone firmly to the armour wires ensuring that the armour wires are tightly clamped between the armour cone and conical armour seating. The spigot on the gland body shall be threaded to suit standard conduit accessories. A shroud of PVC or alternative approved materials shall be fitted to cover the body of the gland and the exposed armour wires.

The copper cores shall be soldered to the cable lugs or cable sockets by the "damp sweat" method as described in Sub-section B2.7.5 above.

B2.7.9 Termination of PVC-insulated or XLPE-insulated Cable with Aluminium Conductors

Terminating gland and armour clamp for power cables with aluminium conductors shall be made from aluminium. Termination of gland and clamping of armour shall be the same as for copper core armoured cables as described in Sub-section B2.7.8 above. Cores shall be terminated in a hot tinned brass or copper lug, which should be shaped

in a vice or by means of a hammer to suit the sector shape of the conductor. The core shall be tinned, and then soldered into the lug.

As an alternative to terminating cores in a tinned brass or copper lug, a compression termination may be used. In such case, the cores shall be inserted into the sleeve of an aluminium compression type cable lug. The sleeve shall then be compressed onto the cores by means of a compressing tool. The tool used and the working procedure adopted shall be as recommended by the cable manufacturer.

Prior to connection to the terminal, the cable lug shall be painted with an anti-oxidizing paste. The anti-oxidizing paste shall be suitable for preventing the creation of electrolytic action due to contact between the aluminium lug and copper or brass terminal, for an indefinite period. Alternatively, copper/aluminium bimetal cable lugs may be accepted.

B2.7.10 Use of Heat Shrinkable Tubing

With the consent of the Architect, heat shrinkable tubing and accessories may be used for cable joints or terminations. All tubing and accessories shall be specially designed for this purpose and shall be suitable for use with the type and construction of cable to be jointed or terminated.

The heat shrinkable materials shall have electrical and mechanical properties equal to or better than those of the cable insulation and sheath, where applicable. After the application of the heat, the heat shrinkable materials shall seal the interfaces between the heat shrinkable materials or between the heat shrinkable materials and the cable surfaces.

Whenever heat shrinkable tubing and accessories are used, the complete kit shall be from the same proprietary manufacturer who is specialised in manufacturing products for this purpose. The method and procedures adopted shall be strictly as those laid down by the manufacturer.

B2.7.11 Other Methods of Joint and Termination

Methods for jointing or terminating a power cable, other than those specified in this Sub-section, will not be precluded provided :

- (a) that the method used shall be proven to be capable of affording the degree of safety and efficiency not less than that achieved by those specified in this Sub-section,
- (b) that the method used shall satisfy the requirements of IEC 60364 and other relevant Standards, and
- (c) that prior agreement of the Architect has been obtained.

B2.8 SPECIAL REQUIREMENTS FOR MINERAL INSULATED CABLES

B2.8.1 Cable Route

Mineral-insulated cables shall be run neatly on the surface of the walls, columns, beams or ceilings in a vertical or horizontal direction, and at least 150mm clear of all plumbing and mechanical services. The use of conduit and/or cable trunking to enclose such cables shall be kept to the minimum.

B2.8.2 Cable Support

Mineral-insulated cables shall be adequately supported by saddles which shall be of the same manufacturer as the cables. Saddles shall be provided throughout the entire cable route at regular intervals. The spacing between adjacent saddles shall not exceed the values given Table B2.8.2. Saddles shall also be provided at a distance not exceeding 150mm away from a termination and from both sides of a bend.

Table B2.8.2

Spacing of Saddles for Mineral-insulated Cable

Overall diameter of cable (d) mm	Maximum spacing	
	Horizontal run	Vertical run
$d \leq 9$	600mm	800mm
$9 < d \leq 15$	900mm	1200mm
$d > 15$	1500mm	2000mm

B2.8.3 Bending Radius

The minimum internal bending radius for a mineral-insulated cable shall be 6 times the overall diameter of the cable.

B2.8.4 Cable Loop for Prevention of Vibration and Low Temperature Cold Store

A loop shall be introduced in a cable immediately before its entry into an equipment which is subject to vibration or occasional movement. A clear space of at least 10mm shall be maintained at the point in the loop where the cable passes over itself.

Cable loop or similar means shall be provided for mineral-insulated cables serving and running inside low temperature cold store.

B2.8.5 Cable Termination

Cable terminations shall generally comply with IEC 60702-2.

The cable to be terminated shall be cut, screwed, sealed with cold compound and fitted with brass terminating glands, nuts, compression ring, gland body, sealing pot, disc and sleeves. The conductors shall be carried unbroken through the sealing pot to the terminal sockets or clamping screws.

Sealing shall be properly carried out to protect the cable ends from moisture and the insulation shall be thoroughly dry before the sealant is applied. The sealing material and material used to insulate the conductors when they emerge from the insulation shall have adequate insulating and moisture-proofing properties which shall be retained throughout the range of temperature they may be subjected to in service.

Where a mineral insulated cable is terminated at an insulating casing or enamelled/painted metal casing, the sealing pot shall be provided with a copper circuit protective conductor, complying with the requirements of IEC 60228 and IEC 60228A, and of an appropriate size in accordance with IEC 60702-2.

Where more than one cable terminate at a galvanized or zinc coated enclosure, the gland plate shall be of brass or insulating materials.

PVC shrouded terminating glands shall be used when the cables are fitted with PVC outer covering.

Only tools recommended by the manufacturer of the cables shall be used and the manufacturer's recommended methods of cable termination shall be adopted in all cases.

B2.8.6 Insulation Resistance

The insulation resistance between the cores and between each core and the sheath shall be measured before the cable end is sealed. The measured resistance shall be infinity on a 500V insulation resistance tester. If the reading is less than infinity, the cable shall be heated by means of a blow lamp or similar device so that moisture is driven out to the open end of the cable. Heating shall be continued until the measured insulation resistance reaches infinity, and sealing shall be applied immediately. The insulation resistance shall be measured again when the cable end has been sealed to ensure infinite resistance.

For mineral-insulated cable with outer covering, adequate length of the outer covering shall be cut out in the event of low insulation resistance to allow dehydration by the application of blowlamp as described above. After the process is completed, the section of outer covering shall be re-installed as specified.

B2.8.7 Bonding of Cable Sheath to Metalwork

Where a mineral-insulated cable passes through or makes contact with any metal, the metal and cable sheath shall be effectively bonded together.

B2.8.8 Laying of Single-core Cables

Single-core mineral-insulated cables running together shall be laid with the cable sheaths in contact. Mineral-insulated cables for 3-phase circuits shall be laid in trefoil formation. Where cables used are rated at 100A or above, gland plates of apparatus shall be of brass.

B2.8.9 Protection from Mechanical Damage

Mineral-insulated cables shall be protected by steel conduits or steel sheathings where they are exposed in vulnerable positions. Where cables pass through floors, ceilings and walls, the openings or holes through which the cables pass shall be made good with cement or other non-combustible material. Where they pass through steel work, the openings shall be bushed.

B2.9 INSTALLATION OF CABLE TRAYS

B2.9.1 Connection between Adjacent Lengths of Tray

Connections between adjacent lengths of tray, tee or bend pieces, shall be made by butt joints and fixed by mushroom-head steel roofing bolts and nuts complying with BS 1449 : Part 1.

The connection shall be mechanically strong so that no relative movement between the two lengths can occur.

B2.9.2 Cutting of Tray

Cable trays shall be cut along a line of plain metal only, i.e. they shall not be cut through the perforation. All cut edges of the galvanized cable tray shall be prepared and treated with a cold galvanized paint.

B2.9.3 Hole in Tray

Holes cut in a cable tray for the passage of cable shall be provided with grommets. Alternatively, they shall be bushed or lined.

B2.9.4 Fixing of Tray

Cable trays shall be fixed securely to the walls, ceiling or other structure by means of mild steel hangers or brackets of adequate mechanical strength. The hangers or brackets shall be painted with anti-rust epoxy paint unless otherwise specified. Fixings for cable trays shall be disposed at regular intervals not exceeding 1.2m for straight run and at a

distance not exceeding 225mm on both sides from a bend or intersection.

A minimum clear space of 20mm shall be left behind all cable trays.

B2.9.5 Fixing of Cable on Tray

Saddles for securing multi-core cables to the cable tray shall be made from PVC covered metal strip, and shall be shaped to the form of the cables to be secured. The saddles shall be fixed to the cable tray by means of corrosion resistant cheese-headed screws and nuts. The shanks of the screws shall not protrude beyond the nuts by more than three threads. Where saddles exceed 150mm in length, intermediate fixings shall be provided such that the maximum spacing between screws shall not exceed 150mm.

Single-core cables shall be secured to the cable tray by clamps made of wood or other non-ferrous materials specially designed to suit the dimension of the cables. The clamp shall be secured to the cable tray by means of bolts, washers and nuts.

Cable saddles or cable clamps shall be provided along the entire cable route with their spacings in accordance with the manufacturer's recommendation.

B2.10 INSTALLATION OF CABLE LADDER

B2.10.1 Dropout Plate for Cable Exit

Dropout plate of width same as the cable ladder shall be provided to support the cables locally as they exit a ladder down between the rungs.

B2.10.2 Flexible (Expansion) Couplers across Building Expansion Joint

The cable ladders shall be jointed by flexible (expansion) couplers across the expansion joints of the building structure. The selection and installation details of such flexible couplers shall be recommended by the manufacturer and submitted to the Architect for acceptance. Rigid fitting across the expansion joints shall not be allowed.

B2.10.3 Ladder Covers

Unless otherwise specified, proprietary ladder covers (ventilated or closed as specified) shall be fixed onto the cable ladder following the installation details recommended by the manufacturer.

B2.10.4 End Connectors

The end of a run of cable ladder shall be fixed to the wall or slab with proprietary end connectors. If it is far from the wall or slab, a proprietary "stop end" connector shall be fixed to the end of a cable

ladder run in order to give a neater appearance. Installation details shall follow the manufacturer's recommendation.

B2.10.5 Earthing

The cable ladders shall be bonded and earthed throughout. Across all joints of the cable ladder, copper connectors shall be fixed onto the cable ladder in order to maintain the earth continuity. Factory-made attachment points shall be provided near the joints for fixing the earth continuity connectors. The length of the copper connectors shall be slightly longer than the length between the two attachment points to allow for movement at the joints due to expansion or some other reasons.

B2.10.6 Minimum Inside Radius of All Bends

The inside radius of all bends of the cable ladder system shall not be less than 300mm.

B2.10.7 Supports

Supports shall be properly spaced at distance not exceeding 1500mm for straight run to satisfactorily support the weight of the ladder and cables. They shall also be provided at a distance not exceeding 300mm on every side from a bend or intersection.

B2.10.8 Spare Capacity

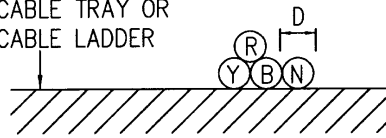
If size of cable ladder is not specified in the Particular Specification or on the Drawings, a 25% additional capacity in excess of the space required for the initial cabling installation shall be allowed for subsequent additions or alterations.

B2.10.9 Safety Working Load

The weight of cables per span of the cable ladder shall be uniformly distributed and shall not exceed the maximum working load specified by the manufacturer.

Sketch B2.1.2(d)
Design and Installation of LV Single-core Cable to
Minimize Electromagnetic Interference

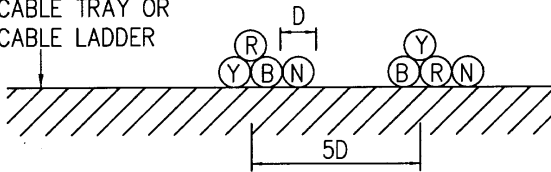
CABLE TRENCH OR
CABLE TRAY OR
CABLE LADDER



ONE CABLE PER PHASE

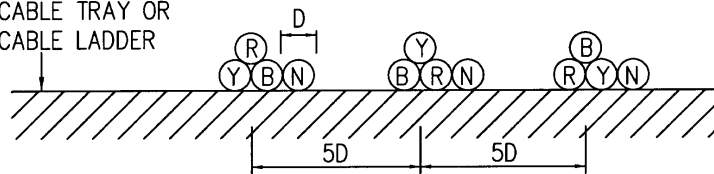
NOTE : R = RED PHASE
Y = YELLOW PHASE
B = BLUE PHASE
N = NETURAL
D = DIAMETER OF SINGLE-CORE CABLE

CABLE TRENCH OR
CABLE TRAY OR
CABLE LADDER



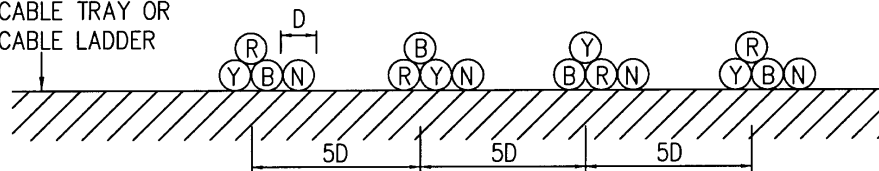
TWO CABLES IN PARALLEL PER PHASE

CABLE TRENCH OR
CABLE TRAY OR
CABLE LADDER



THREE CABLES IN PARALLEL PER PHASE

CABLE TRENCH OR
CABLE TRAY OR
CABLE LADDER



FOUR CABLES IN PARALLEL PER PHASE

SECTION B3

INSTALLATION OF GENERAL LIGHTING AND POWER

B3.1 INSTALLATION OF LIGHTING SYSTEM AND LUMINAIRES

B3.1.1 Pendant

Tube pendant shall comprise a dome cover and a biscuit ring and a piece of screwed steel conduit of suitable length to give the required mounting height of the luminaire.

Plain pendant shall comprise a ceiling rose and a cord-grip lampholder connected by a flexible cord having a suitable length to give the required mounting height of the lamp shade.

B3.1.2 Luminaire Mounted on Pattress

When a luminaire is not provided with facility for a surface cable entry, the luminaire shall be mounted on pattress. The cable shall then enter the luminaire from the rear through a slot and a hole formed in the pattress.

B3.1.3 Ceiling Rose

Ceiling rose shall not be used for the attachment of more than one outgoing flexible cord or cable unless it is specially designed for multiple pendants.

B3.1.4 Cable in Enclosed Luminaire

Cables within an enclosed type luminaire shall be of heat resistant type. Cables entering the luminaire shall be protected by heat resistant insulating sleeves. The sleeves within the luminaire shall be extended to a distance of 150mm outside the luminaire.

Heat resisting cables shall be selected in accordance with the appropriate tables given in IEC 60364.

B3.1.5 Stroboscopic Effect

Luminaires, other than those using tungsten filament lamps or fluorescent lamps with electronic ballast, installed over rotating machinery, shall be arranged so that at least two luminaires connected to different phases are used to illuminate the moving parts of the machinery. Alternatively where different phases are not available or the use of which is impracticable, separate tungsten filament lamps shall be used in addition to gas discharge lamps to eliminate the stroboscopic effect.

B3.1.6 Painting

Unless otherwise specified, lighting equipment and luminaires other than those indicated to be self-finished such as stainless steel, anodized aluminium, etc, shall have factory-finished.

Metal parts such as cover plates for adaptable boxes, blanking plate for any boxes and conduit pendants, etc. shall be painted white or a suitable colour to match the interior finish of a particular location.

B3.1.7 Special Requirements for Outdoor Luminaires

Outdoor luminaires shall be able to withstand the weather. Metal work should be protected against corrosion, and parts which have to be removed for access to the interior shall be provided with proper gaskets to restrict the entrance of moisture and dirt. Mounting brackets shall be heavily galvanized and stainless steel or galvanized bolts and nuts shall be used.

The adjustment bolts and nuts of a luminaire which is mounted on high level shall be captive to prevent accidental loss during servicing. Safety chains shall be provided to hold the luminaire from falling. A luminaire installed in a location within hand reach shall be of robust construct, fitted with an impact-resistant transparent or diffusing front panel, and shall have secret key fixings for the panel to the body of the luminaire. Where necessary, wire guards shall be fitted over the front panel to give extra protection.

B3.2 INSTALLATION OF WIRING ACCESSORIES

Wiring accessories, including lighting switches, socket outlets and domestic type switches for electrical appliances, shall be designed for flush mounting.

Where surface wiring installation is specified, wiring accessories shall be fixed onto moulded boxes or pattresses. In conduit installation, they shall be fixed onto moulded, galvanized steel or cast iron boxes.

Where a waterproof or flameproof configuration is required, wiring accessories shall be mounted as the particular circumstances demand.

The front plate of a switch or socket outlet shall be labelled in accordance with Sub-section A3.3.

B3.3 INSTALLATION OF DOMESTIC SWITCHES

B3.3.1 General

Switch for domestic and similar purposes shall be mounted at a height of 1350mm above finished floor level unless otherwise specified.

B3.3.2 Lighting Switch

When lighting switches are mounted adjacent to one another, they shall be grouped in a single enclosure (multi-gang box) and shall share a common switch plate, subject to a maximum of three lighting switches per single-gang plate.

Lighting switches installed adjacent to a door shall be located on the handle side of the door, and shall be as near to the door as practicable.

B3.3.3 Time Switch

Time switch shall be housed in a factory or purpose made metal enclosure provided with a removal cover of durable clear plastic material.

B3.3.4 Application in Bathroom

No switch shall be installed inside a toilet or a room containing a fixed bath or shower. All control switches shall be located immediately outside the room.

B3.4 INSTALLATION OF SOCKET OUTLETS

B3.4.1 General

Socket outlet intended for supplying a fixed or stationary appliance shall be located as near as possible to the appliance.

Socket outlet shall be mounted at a height of 1350mm above finished floor level in kitchens, sculleries, ironing rooms and the like. In other locations, they shall be mounted at 300mm from finished floor level, 75mm from surface top measured from bottom of socket outlet or as specified.

B3.4.2 Shaver Supply Unit

The complete unit shall be enclosed in a galvanized metal box for flush mounting, or a galvanized cast iron or plastic surface box for surface mounting.

B3.4.3 Socket Outlet at Hazardous Area

The installation of socket outlets in hazardous areas should be avoided as far as possible. Where it is absolutely essential to install a socket outlet in such area, the socket outlet shall be type 'e' - increased safety conforming to IEC 60309-3 and shall be controlled by a sparkless switch. The socket outlet shall be interlocked with the plug so that removal or insertion shall not be possible unless the controlling switch is in the OFF position. The plug shall have shrouded pins and the design of the pin contacts shall be such as to guard against development

of hot spots or sparking. Requirements for wiring installation in hazardous areas are specified in Sub-section B7.4.

B3.4.4 Socket Outlet of Surface Conduit System

In plant room, switch room or similar area where surface conduits are installed, socket outlets shall be metalclad or bronze front plate.

B3.4.5 Socket Outlet for Different Voltage System

Socket outlet and plug for one voltage system shall not be interchangeable with those for use at other voltage and/or frequency systems in the same installation.

B3.4.6 Application in Bathroom

Shaver supply units complying with BS EN 60742 can be installed inside a room containing a fixed bath or shower and inside a toilet. Socket outlets inside such a room, if so required under the contract, shall be installed in accordance with requirements of Code 26A(3)(j) of Code of Practice for Electricity (Wiring) Regulations.

B3.5 INSTALLATION OF MEASURING INSTRUMENT

B3.5.1 Mounting of Current Transformers Associated with Watt-hour Meter

Current transformers, if required to be associated with a watt-hour meter, may be mounted inside the meter chamber, or in a separate current transformer chamber, as dictated by the circumstances of each particular job. When current transformers are mounted in the meter chamber, separate partitioned compartments with separate front access covers for the current transformers and meters respectively shall be provided. Suitable engraved labels shall be fixed on the covers to identify the installed equipment therein.

B3.5.2 Identification of Instrument

Each measuring instrument shall be identified by means of a label fitted under the associated instrument. This label shall denote the function of the circuit connected to the meter.

B3.5.3 Mounting Position of Selector Switch

Selector switch for ammeter or voltmeter shall be mounted immediately below the meter with which it is associated.

SECTION B4

INSTALLATION OF DOMESTIC APPLIANCES

B4.1 GENERAL

B4.1.1 Connection to Appliances

Domestic appliances shall each be connected to the electrical supply through a suitable wiring accessory and a suitable length (preferably 1.5m to 2m) of flexible cable or PVC insulated cables enclosed in a flexible conduit.

For portable appliance, plug and socket shall be used. For fixed appliances, the wiring accessories shall be opened or removed only by means of a tool.

Wiring accessories shall meet the requirements of Section C3 and shall be installed as near as practicable to the appliances to be connected. Fuse-links shall comply with IEC 60127 and shall have current ratings suitable for the appliances to be controlled.

Flexible cables for final connection to domestic appliances shall be white in colour unless otherwise specified, and shall be circular, sheathed, twin with CPC to IEC 60189 and IEC 60227 (PVC-insulated) or to IEC 60245 (rubber-insulated), all with copper conductors. The cores of the flexible cables shall have identification colours in accordance with Section C1.

B4.1.2 Use in Bathroom and Toilet

No portable appliances shall be installed in a toilet or room containing a fixed bath or shower. Fixed appliances installed in such a room shall be located out of reach by a person using the bath or shower, and the controlling switches shall be located outside the room.

This restriction does not apply to insulating cord switches, remotely operated switches using mechanical actuators with linkages incorporating insulating components, switches supplied from Separated Extra Low Voltage and shaver supply units.

B4.1.3 Engraving for Identification

The front plate of every switched socket outlet, fused connection unit or control switch feeding a fixed domestic appliance shall be engraved in accordance with Sub-section A3.3 to indicate correctly its function.

B4.1.4 Earthing of Appliance

All domestic appliances except Class II equipment to BS 2754 shall be effectively earthed to the main earth via a circuit protective conductor. Where the cables for final connection to a fixed appliance is enclosed in a flexible conduit, effective earthing shall be achieved by means of a separate circuit protective conductor drawn into the flexible conduit.

B4.1.5 Appliance Requiring Exclusive Circuit

The following types of domestic appliances shall be supplied from an exclusive final circuit :

- (a) Household electric cooker
- (b) Water heater other than oversink water heater
- (c) Water boiler
- (d) Room cooler
- (e) Appliance having a nominal power rating of 3kW or above

B4.2 CEILING FAN AND CEILING-MOUNTED ROTARY FAN

B4.2.1 Method of Supply

Supply to a ceiling fan or a ceiling mounted rotary fan shall be by means of a 2A fused connection unit with earthing facilities and controlled by a 5A D.P. switch with pilot light for maintenance purpose.

In conduit installation, the fused connection unit shall be circular, suitable for mounting on a circular conduit box to IEC 61035.

In surface wiring installation, the fused connector box shall be square, suitable for mounting on a moulded box or plastic pattress to IEC 60670.

B4.2.2 Fixing of Fan

Every ceiling fan shall be suspended from a substantial hook fixed securely to the ceiling structure.

Rotary fans shall be fixed direct to the ceiling structure.

B4.2.3 Fan Regulator

Fan regulators shall each be controlled by a 5A D.P. switch with pilot light and shall be fixed on the surface of walls.

In a concealed conduit installation, the fan regulator shall be mounted on a back-plate over a recessed 35mm deep IEC 60670 box where the conduit shall be terminated. The back-plate shall be made of galvanized sheet steel of 3mm thick with suitable grommeted hole for cable entry.

In a surface conduit installation, the fan regulator shall be mounted on a special fabricated box made of 1.5mm thick galvanized sheet steel and having the same size as the regulator. The conduit shall be terminated at this specially made surface mounted box through which the cables shall enter the fan regulator.

In a surface wiring installation, the fan regulator shall be mounted on a wooden block. Groove shall be formed at the back surface of the wooden block to suit the cables, and holes shall be drilled to enable the cables to enter the fan regulator from the rear.

B4.3 WALL-MOUNTED FAN

Supply to a wall mounted fan shall be by means of a 2A fused connection unit and shall be controlled by a 5A D.P. switch.

Wall mounted fans shall be fixed by means of wall mounting bracket supplied with the fans or sit on a mounting bracket or batten made of teak wood or other material approved by the Architect.

B4.4 EXHAUST FAN

B4.4.1 Fixing of Fan

Exhaust fans shall be installed on the structural opening by means of a steel mounting plate. Where an exhaust fan is intended to draw exhausted air through a fume cupboard, the fan shall be ducted to the fume cupboard by means of a pipe made of low smoke emission and halogen free PVC and of suitable size and length.

B4.4.2 Method of Supply

Supply to a domestic type/fume cupboard exhaust fan shall be by means of a 2A fused connection unit similar to that for a ceiling fan, and shall be controlled by a 5A D.P. switch.

Supply to an industrial type exhaust fan shall be by means of a fused connection unit and shall be controlled by a 20A D.P. switch with pilot light.

B4.5 ELECTRIC FIRE OR HEATER

B4.5.1 Wall-mounted Radiator

Supply to wall-mounted radiators shall be obtained through a fused connection unit and shall be controlled by a 20A D.P. switch with pilot light.

B4.5.2 Panel Fire

Panel fires rated at 3kW or less shall be supplied and controlled by a 15A 3-pin switched socket outlet with pilot light. The switched socket outlet shall be installed at a height of 300mm above finished floor level unless otherwise specified.

B4.5.3 Tubular Heater

Tubular heaters shall be supplied and controlled by a 13A 3-pin switched socket outlet with pilot light. A wire guard complete with end plates made of hot-dip galvanized steel shall be provided to prevent falling fabric from contact with the heater tube as to create a fire risk.

B4.6 WATER HEATER AND WATER BOILER

B4.6.1 Oversink Water Heater

Supply to an oversink water heater shall be by means of a 13A fused connection unit controlled by a 20A D.P. switch with pilot light at a distance not less than 2m from any water taps. The front plate of the fused connection unit shall have an outlet hole and the necessary cordgrip for the flexible cable.

In a surface wiring installation, the fused connection unit and the 20A D.P. switch shall each be mounted on a moulded box or plastic pattress to IEC 60670.

B4.6.2 Other Type of Water Heater

Supply to a domestic water heater, other than oversink type, shall be controlled by a 20A D.P. switch with pilot light.

In a concealed or surface conduit installation, the PVC insulated cables shall be enclosed in a conduit from the control switch to a standard circular conduit box fitted with a dome cover and then through a flexible conduit from the dome cover to the water heater. The dome cover and the conduit box shall be fixed as near to the water heater as practicable.

In a surface wiring installation the control switch shall be mounted on a moulded box or plastic pattress. Final connection to the water heater shall be taken direct from the control switch via a flexible cable, twin with CPC. The control switch shall be fixed as near to the water heater as practicable.

B4.6.3 Water Boiler

The installation of a water boiler shall be similar to that for water heater except that the control switch shall have a rating of 30A.

B4.7 TEA URN

Tea urns having a rating of 3 kW or less shall be supplied and controlled by a 15A 3-pin switched socket outlet with pilot light. The switched socket outlet shall be fixed at a height of 1350 mm above finished floor level unless otherwise specified.

B4.8 HOUSEHOLD ELECTRIC COOKER

Supply to a household electric cooker shall be controlled by a cooker control unit of rating not less than 45A unless otherwise specified. The control unit shall be installed at a height of 1350mm above finished floor level.

In a concealed or surface conduit installation, the PVC insulated cables from the control unit shall be enclosed in a conduit and terminated at an insulated terminal block inside a 47mm deep IEC 60670 conduit box. The PVC insulated cables shall then be changed into PVC insulated and sheathed cable twin with CPC before connecting to the cooker. The insulated terminal block shall be mounted on the wall at 300mm above finished floor level. The PVC insulated and sheathed cable twin with CPC shall be 1.5m to 2m long to allow the cooker to be moved for cleaning purpose.

In a surface wiring installation, PVC insulated and sheathed cable twin with CPC shall be used throughout.

B4.9 HAND/FACE DRYER

The supply to an electric hand/face dryer shall be by means of a fused connection unit complete with an integrated 20A D.P. switch and pilot light. The front plate of the fused connection unit shall have an outlet hole and the necessary cord-grip for the flexible cable. Hand/face dryer shall be installed at such a height so as to allow the nozzle to be 1150mm above finished floor level in male toilet and 1100mm in female toilet.

B4.10 ROOM COOLER

B4.10.1 Method of Supply

Supply to a room cooler shall be by means of an insulated terminal block and a control switch, both of which shall have a current capacity of not less than the rated value of the room cooler. The control switch shall be D.P. with pilot light, installed at a height of 1350mm above the finished floor level.

B4.10.2 Position of Terminal Block

The insulated terminal block shall be installed adjacent to the room cooler and shall be on the same side of the room cooler as where the flexible cable enters the room cooler. In case it is not possible to ascertain where the flexible cable enters the room cooler, the insulated terminal block shall be installed on the left side of the room cooler, as viewed from the front.

B4.11 REFRIGERATOR

Supply to a refrigerator shall be by means of a 13A switched socket with pilot light. For general purpose, the socket shall be mounted at a height of 1350mm above finished floor level.

SECTION B5
INSTALLATION OF BUSBAR TRUNKING SYSTEM

B5.1 GENERAL

Busbar trunking including accessories shall be tailor-made to suit the actual site measurements, and working drawings shall be submitted for perusal by the Architect. Adequate clear space shall be allowed for inspection and maintenance of the installation.

B5.2 SITE STORAGE AND PROTECTION

B5.2.1 Busbar trunking shall be stored in a dry clean location with adequate air circulation to prevent condensation. The storage area shall be free from dirt, fumes, water and physical damage.

B5.2.2 Work on the busbar trunking installation shall not commence unless the builder's work on the accommodation for the busbar trunking has been completed and is in a dry and clean condition with lockable door and kerb.

B5.2.3 Busbar trunking shall be handled with great care to avoid damage to internal components, enclosure and finish. Busbar shall not be dragged across floor and shall not be subjected to torsion, denting, impact or rough handling.

B5.3 BUSBAR IDENTIFICATION

Each bar shall be painted to indicate the phase to which it is connected, at each accessible position to the busbars and in each tee-off unit.

B5.4 JOINT IN BUSBAR

Joints shall be properly clean and free from contamination before joint. Joints in busbars shall not cause any loss in mechanical strength, electrical continuity, current carrying capacity and short circuit capacity of the busbars compared with an unjoined busbar.

Joints shall be properly aligned before the final tightening of all joint bolts. Bolts shall not be over or loosely tightened. Bolt tightening shall be done either by means of a torque wrench to a strength figure as specified by the manufacturer or in accordance with the manufacturer's special procedure.

B5.5 EXPANSION UNIT

Expansion units shall be provided to take up the axial expansions or contractions of the busbar trunking system under normal service conditions. In particular, expansion units shall be provided where both ends of the busbar trunking system are fixed and normal expansion or contraction is restricted, and where the busbar trunking system is installed across a building expansion joint. For every 30m of busbar trunking, an expansion unit shall also be provided or else the manufacturer's recommendation shall be followed.

B5.6 FEEDER UNIT

A feeder unit shall be provided for each busbar trunking system for connection of incoming supply.

B5.7 TAP-OFF UNIT CONNECTION

Interconnecting conductors if provided between the busbars and tap-off units shall have a current rating not less than that of the tap-off units. The temperature rise of interconnecting conductors under normal service conditions shall not exceed that of the busbars specified in Sub-section C5.4.

B5.8 FIRE BARRIER

Where busbar trunking passes through compartmentation wall or slab a proper fire barrier made of non-hygroscopic material having a fire-resistance period of not less than that of the corresponding compartmentation wall or slab shall be provided.

B5.9 BUSBAR TRUNKING ACCESSORIES

Bends, tees and intersection units shall be installed in such a way that no loss in mechanical strength, electrical continuity, rated current and rated short-circuit capacity shall be incurred due to insertion of bends, tees or intersection units.

B5.10 SUPPORT OF BUSBAR TRUNKING SYSTEM

Busbar trunking system shall be securely fixed to the building structure according to manufacturer's recommendations. For horizontal run of busbar trunking system the hanger support shall be suitable for heavy mechanical load as stated in IEC 60439-2. All fixing bolts, nuts and screws of hangers/ brackets shall be heavily electroplated or galvanized.

The supports shall be spaced at regular intervals such that the clearance and creepage distances be maintained under normal service and short-circuit conditions.

B5.11 EARTHING

A 25 x 3mm copper tape shall be fixed to and run along the full length of the busbar trunking system to ensure earth continuity. The copper tape shall be supported at intervals not more than 400mm horizontally and not more than 500mm vertically. It shall be connected to the main earthing terminal on each floor. A warning notice bearing the words “Safety Electrical Connection - Do not Remove” with Chinese translation shall be displayed in a conspicuous position for every 10m horizontal run and/or one label per floor for rising main. Provision of copper tape may be exempted if the enclosure of busbar trunking can satisfy the second paragraph of Sub-section B6.7.4 that follows.

B5.12 REQUIREMENTS FOR AIR-INSULATED BUSBAR TRUNKING SYSTEM

B5.12.1 Application

Unless otherwise specified, air-insulated busbar trunking system shall be used for vertical rising mains or short horizontal run only.

B5.12.2 Busbar Supports

- (a) For vertical busbar trunking system, suspension units shall be provided at the top of each run. A built-in thrust block and an intermediate suspension unit shall be provided at every 30m interval. Insulated thrust blocks or other thrust-absorbing device shall be provided at the bottom of each run and after each flexible joint.
- (b) The busbar trunking system shall be terminated in a stop-end unit.

B5.12.3 Tap-off

Branch circuits shall be connected to the busbars by tap-off units or cable clamping devices. Drilling of busbars shall be permitted only if the mechanical strength will not be impaired and the current density of the busbars will not be increased after drilling.

B5.12.4 Fire Barrier

At the position of the fire barrier, the busbars shall be insulated with self-extinguishing heat shrinkable insulating sleeves of suitable operating temperature extended to approximately 150mm on each side of the fire barrier.

B5.12.5 Mounting Brackets

Mounting brackets shall be provided for supporting the busway from the building structure. The brackets shall have the same finish as the enclosure and shall allow not less than 20mm adjustment clearance from the wall.

B5.13 REQUIREMENT FOR ALL INSULATED BUSBAR TRUNKING SYSTEM

B5.13.1 Application

All insulated busbar trunking system shall be generally used for a combination of extensive vertical and horizontal run of busbar mains or in an environment where weather-proofing or water-proofing of the system is required.

B5.13.2 Busbar Jointing

Two sections of the busbar trunking shall be joined by connecting the joint-ends of the busbars in an interleaved manner. The contact interconnection pressure shall be maintained by insulated bolts inserted through the joint. Bolts shall be tightened up either by means of a torque wrench to a strength figure as recommended by the manufacturer, or in accordance with the manufacturer's provision of special torque-indicating tightening device.

The joint shall be covered up by metal cover plates of same type of material and finish as the busbar casing so that the degree of protection against ingress of dust will not be less than that of an unjoined busbar trunking system.

B5.13.3 Expansion Unit

Expansion units shall be so constructed that any change in length on both the conductors and the casing so caused by thermal expansion and contraction in all direction can be absorbed easily and cause no distortion of the busway whatsoever.

B5.13.4 Tap-off Unit

Bolt-on tap-off unit shall be properly fixed on the busbars in accordance with the manufacturer's design. Drilling of the busbars for connection of cables will not be permitted.

B5.13.5 Supporting Hangers and Fixing Brackets

Supports for the busbar trunking system shall be by means of hangers and brackets supplied by the same manufacturer as the busbar trunking system. Unless otherwise specified, the hangers shall be spaced at intervals of not more than 2m for horizontal mounting and 3m for vertical mounting, or in accordance with the manufacturer's recommendation. In addition, for vertical mounting, the busbar trunking system shall be supported on every floor.

Hangers and brackets shall be properly aligned with building structure and adjusted to ensure the alignment and leveling of the busbar trunking as required in the manufacturer's standard and recommendation. Additional guide brackets in the intermediate position between two supports shall be provided, if necessary, to balance the offset loading of the tap-off unit.

SECTION B6

INSTALLATION OF EARTHING SYSTEM

B6.1 GENERAL

All metalworks associated with an electrical installation but not forming part of a live conductor, including exposed conductive parts and extraneous conductive parts, shall be solidly and effectively bonded and earthed in accordance with IEC 60364 and the Code of Practice for the Electricity (Wiring) Regulations.

B6.2 MAIN EARTHING TERMINAL

A solid copper main earthing terminal of ample size shall be provided for every electrical installation at a position near the main incoming switch or switchboard for the connection of :

- (a) the circuit protective conductors,
- (b) the main equipotential bonding conductors,
- (c) the functional earthing conductors,
- (d) the earthing conductors and
- (e) the lightning protective system bonding conductors.

to create the equipotential zone. The main earthing terminal shall be connected to Earth via an earthing conductor to an earth electrode or a group of electrodes.

Where an installation distributes to a number of buildings or units, a separate main earthing terminal shall be provided for each individual building or unit at the point of intake thereby creating a separate equipotential zone in each building or unit.

B6.3 EARTH ELECTRODE

B6.3.1 Types of Earth Electrode

The following types of earth electrode are permitted :

- (a) rod electrode
- (b) tape electrode
- (c) plate electrode

Unless otherwise specified in the Particular Specification or Drawings, rod electrode shall be installed.

Metalwork of public gas or water services shall not be used as the sole protective earth electrode.

B6.3.2 Rod Electrode

Rod electrode shall be of mild steel inner core with a bonded hard drawn copper sleeve of an approved type. The overall diameter of the rod shall not be less than 15mm and the thickness of the copper sleeve shall not be less than 0.25mm. The minimum length shall be 2.4m. Additional lengths, whenever required, shall each be of 1.2m, connected together by a coupling. The penetrating end of the rod electrode shall be a hardened steel point.

Rod electrode shall be driven into the ground within an earth pit. Only approved tools e.g. electric hammer or pneumatic hammer shall be used for this installation.

In case the earthing resistance achieved by one rod is not sufficiently low for the purpose required, additional lengths or additional rods shall be installed. For the latter application, additional rods shall be driven into the ground outside the resistance area of the previously installed rod(s). Under normal circumstances, a mutual separation of 3.5m is considered adequate.

B6.3.3 Tape Electrode

Tape electrode shall be untinned copper strip of not less than 25 x 3mm in cross section. Tape electrode shall be used only if specified by the Architect.

In case where several tapes are required for connection in parallel to achieve a low earthing resistance, they may be installed in parallel lines or they may radiate from a point.

B6.3.4 Plate Electrode

Plate electrode shall be of copper not less than 3mm in thickness, having dimensions as indicated on the Drawings or Particular Specification subject to a maximum of 1200 x 1200mm.

In case the earthing resistance achieved by one plate is not sufficiently low for the purpose required, additional plates shall be installed. The plates shall be installed outside the resistances area of the previously installed plate(s).

B6.3.5 Electrode in Deep Bored Hole

As an alternative, electrode may be buried in a deep bored hole of 20 to 30m deep and of about 100mm diameter provided by the builder where the soil conditions are unfavourable. In such case, a 15mm diameter rod electrode (connected together to form the required length) or annealed copper tape of 25 x 6mm shall be inserted into the full length of the deep bored hole. The clearance between the electrode and the surrounding of the deep bore hole shall be filled completely by a mixture of 60% bentonite and 40% of gypsum to 125% (by volume) mixed to give a thick slurry, which shall be grouted into the deep bored

hole and then allowed to solidify. The grouting shall not trap any air in the deep bored hole.

B6.3.6 Connection between Electrodes

All electrodes shall be inter-connected together to form a complete earthing system by means of 25 x 3mm annealed copper tapes or stranded bare copper conductors of 70mm². The copper tapes or conductors shall be enclosed in PVC sleeve or pipe laid at a minimum depth of 600mm below the ground surface. The connecting copper tapes or conductors shall be run in direct lines between the rods.

Connections shall be brazed to achieve good and reliable joints to withstand the anticipated fault current.

B6.4 EARTHING CONDUCTOR

B6.4.1 Conductor Material

Earthing conductor shall be copper tapes 25 x 3mm in cross section. For outdoor applications, copper tapes shall be tin plated. Aluminium conductors shall not be used as earthing conductors.

B6.4.2 Connection to Electrodes

Earthing conductor shall be connected to the earth electrode(s) by means of approved copper connector-clamps such that the connection can only be disconnected by means of a tool. The connection shall be contained within a concrete lined earth pit with a substantial removable cover to ensure accessibility and maintainability.

B6.5 MAIN EQUIPOTENTIAL BONDING CONDUCTOR

B6.5.1 Conductor Material

Unless otherwise specified, main equipotential bonding conductor shall be of copper.

B6.5.2 Bonding Position

Main equipotential bonding conductor shall connect the extraneous conductive parts of other services within the premises to the main earthing terminal of the installation. Such extraneous conductive parts shall include main water and gas pipes, other service pipes and risers and exposed metallic parts of the building structure liable to transmit a potential. Connection shall be made as near as practicable to the point of entry of the non-electrical services into the premises concerned, and shall be on the installation side of the possible breaks in the system, such as gas meter or water meter. Where practicable, the connection shall be made within 600mm from the meter outlet union or at the point of entry to the building if the meter is outside the building.

B6.5.3 Bonding Method

Main equipotential bonding conductor shall be securely and reliably connected to extraneous conductive parts of the non-electrical services by means of a copper connector-clamp of an approved type suitable for the particular application. All contact surfaces shall be cleaned and free from non-conducting materials, such as grease or paint, before the connector-clamp is installed.

B6.6 SUPPLEMENTARY BONDING CONDUCTOR

B6.6.1 Conductor Material

Unless otherwise specified, supplementary bonding conductor shall be of copper.

B6.6.2 Application in Bathroom

In a room containing a fixed bath or shower, all simultaneously accessible conductive parts (either exposed or extraneous) shall be locally connected by means of supplementary bonding conductors.

B6.6.3 Application in Other Areas

Supplementary bonding of extraneous conductive parts shall be required whenever such conductive parts are likely to be accessible simultaneously with other extraneous conductive parts or exposed conductive parts, and are not electrically connected to the main equipotential bonding by means of permanent and reliable metal-to-metal joints of negligible impedance.

B6.6.4 Bonding Method

Supplementary bonding conductor shall be solidly and effectively connected to the extraneous or exposed conductive parts by means of a copper connector-clamp of an approved type suitable for the application. All contact surfaces shall be cleaned and free from non-conducting materials, such as grease or paint, before the connector-clamp is installed.

For surface steel conduit installation, the supplementary bonding conductor shall be terminated at the nearest steel conduit or conduit box forming an integral part of the conduit installation.

For concealed steel conduit installation the supplementary bonding conductor shall be terminated at, via a telephone cord outlet plate, a copper earth terminal fitted inside a IEC 60670 metal box forming an integral part of the conduit installation. The IEC 60670 metal conduit box shall be located as near as possible to the bonding position and the exposed part of the supplementary bonding conductor shall be made as short as possible.

B6.7 CIRCUIT PROTECTIVE CONDUCTOR (CPC)

B6.7.1 General

Circuit protective conductor (CPC) may be formed by a separate cable, the metallic sheath or armour of a cable, part of the same cable as the associated live conductor, rigid steel conduits, trunking or ducting, or the metal enclosure of the wiring system. Flexible conduits and the exposed conductive parts of equipment shall not form part of the circuit protective conductor.

B6.7.2 CPC for Socket Outlet

For every socket outlet, a separate circuit protective conductor shall be provided connecting the earth terminal of the socket outlet and that inside the enclosure accommodating the socket outlet.

B6.7.3 CPC for Flexible Conduit

For every length of flexible conduit, a separate circuit protective conductor shall be provided inside the conduit to ensure the earth continuity of the installation between the two ends of the flexible conduit.

B6.7.4 CPC for Busbar Trunking and Busway

A copper tape, 25 x 3mm in cross section shall be provided for the entire length of a busbar trunking or busway. The copper tape shall be bonded to the busbar trunking or busway at intervals not exceeding 3m and at the position of each tape-off point.

Subject to the prior agreement of the Architect, the provision of copper tapes for a busbar trunking or busway may be exempted provided that the enclosure of the busbar trunking or busway can be proven to satisfy the full requirements of the circuit protective conductor in accordance with relevant regulations of IEC 60364.

B6.7.5 CPC for Ring Final Circuit

For wiring system using PVC insulated, PVC sheathed cables, the circuit protective conductor of every ring final circuit shall also be run in the form of a ring having both ends connected to the earth terminal at the origin of the circuit.

B6.8 JOINTS IN PROTECTIVE CONDUCTORS

Provision shall be made in an accessible position for disconnecting a protective conductor from the main earthing terminal or the earth electrode to permit testing and measurements of earthing resistance. Such joints shall only be disconnected by means of a tool, shall be mechanically strong and shall be tinned to maintain the electrical continuity reliably.

No switching device shall be inserted in a protective conductor except for the following :

- (a) Where an installation is supplied from more than one source of energy, one of which requires a means of earthing independent of the means of earthing of other sources and it is necessary to ensure that not more than one means of earthing is applied at any time, a switch may be inserted in the connection between the neutral point and the means of earthing, provided that the switch is a linked switch arranged to disconnect and connect the earthing conductor for the appropriate source, at substantially the same time as the related live conductors.
- (b) Multipole linked switching or plug-in devices in which the protective conductor circuit will not be interrupted before the live conductors are disconnected and will be re-established not later than when the live conductors are re-connected.

B6.9 IDENTIFICATION AND LABELLING

B6.9.1 Colour Identification

All cables used as protective conductors, including earthing conductors, main equipotential bonding conductors, supplementary bonding conductors and circuit protective conductors shall be identified by the colour combination “green and yellow”. Such colour combination shall not be used for other identification purposes.

Bare conductor used as protective conductor shall also be made similarly identifiable, where necessary, by the application of tapes, sleeves or discs, or by painting with the above colour combination.

B6.9.2 Label for Earthing and Bonding Connections

Every point of connection for earthing and bonding shall be provided with a warning notice in accordance with Sub-section A3.3.

B6.10 SIZING OF PROTECTIVE CONDUCTOR

B6.10.1 General

The cross sectional area of a protective conductor, other than an equipotential bonding conductor, shall be determined by the formula given in Regulation 543-01-03 of BS 7671 or selected in accordance with relevant Regulation of IEC 60364 (Regulation 543-01-04 of BS 7671).

Where a protective conductor does not form part of a cable and is not formed by or not contained in, steel conduit, trunking, ducting or other metallic enclosure of a wiring system, the cross sectional area shall not be less than 2.5mm² copper or equivalent if protection against mechanical protection is provided (e.g. sheathed cable), and 4mm² copper or equivalent if mechanical protection is not provided (e.g. non-sheathed cable). When a separate cable is used as a CPC, the cable shall be insulated to IEC 60227, IEC 60189 (BS 6004 : 1975, Table 1a) or better unless its CSA is greater than 6mm².

B6.10.2 Equipotential Bonding Conductor

The cross sectional area of a main equipotential bonding conductor shall not be less than half of the cross-sectional area of the associated earthing conductor of the installation subject to a minimum of 6mm² and a maximum of 25mm².

The cross sectional area of a supplementary bonding conductor shall be determined in accordance with relevant Regulation of IEC 60364.

B6.11 EARTH FAULT LOOP IMPEDANCE

B6.11.1 Automatic Disconnection Time

For the purpose of automatic disconnection, means of protection shall be provided at the main switch. The type and setting of the protective devices shall be so selected that they can properly discriminate from the Electricity Supplier's protection.

For installation other than socket outlet circuit where protection against indirect contact is afforded by an overcurrent protective device, the earth fault loop impedance of a final circuit and the characteristic of the protective device shall be so co-ordinated that the automatic disconnection of supply shall occur within 5 seconds in case of an earth fault of negligible impedance.

B6.11.2 Maximum Earth Loop Impedance

For installation other than the socket outlet circuit where protection against indirect contact is afforded by overcurrent protective device, the earth fault loop impedance of any final circuit shall not exceed the maximum values given in the relevant tables in the Code of Practice for

the Electricity (Wiring) Regulations for automatic disconnection time of 5 seconds.

B6.11.3 Condition for Compliance

To comply with the requirement, the following formula shall be fulfilled for each circuit:

$$R_A I_a \leq 50 \text{ V}$$

where : R_A is the sum of the resistances of the earth electrode and the protective conductor(s) connecting it to the exposed conductive part.

I_a is the current causing the automatic operation of the protective device within 5 seconds. When the protective device is a residual current device, I_a is the rated residual operating current.

B6.12 USE OF RESIDUAL CURRENT-OPERATED CIRCUIT BREAKER

B6.12.1 General

Every socket outlet circuit shall be protected by a residual current device. The residual current device shall have a rated residual operating current not exceeding 30mA and an operating time not exceeding 40ms at a residual current of 150mA as governed by IEC 61008-2/IEC 60755.

Residual current-operated circuit breaker (RCCB) shall be installed for any final circuit where the earth fault loop impedance is too high to allow sufficient earth fault current to operate the overcurrent protective device within the specified automatic disconnection time of 0.4 second or 5 seconds. In such case, the product of the rated residual operating current in amperes of the residual current-operated circuit breaker and the earth fault loop impedance in ohms of the circuit shall not exceed 50.

Residual current-operated circuit breaker shall meet the requirements specified in Sub-section C4.7.

B6.12.2 Application in Household Installation

RCCD used for protecting socket outlet circuits in a household or similar installation shall have a rated operating residual current not exceeding 30mA.

B6.12.3 Equipment Outside an Equipotential Zone

For equipment used outdoors or outside an equipotential zone and supplied via a socket outlet rated at 32A or less or via a flexible cable or cord having a similar current carrying capacity, protection shall be afforded by a residual current-operated circuit breaker having a rated residual operating current not exceeding 30mA. Earth connection for such socket outlet shall be isolated from the rest of the earthing system and shall be obtained from a separate earth electrode via an insulated earthing conductor.

SECTION B7
MISCELLANEOUS INSTALLATIONS

B7.1 TELECOMMUNICATION SYSTEMS

B7.1.1 Scope

This Sub-section covers the conduit installation for the following systems:

- (a) Telephone,
- (b) Computer Network,
- (c) Inter-communication and Public Address (PA) Systems,
- (d) Staff Paging, and
- (e) Broadcast Reception System.

Separate conduits shall be provided for each of these systems. Galvanized draw-wires of adequate size shall be provided in all empty conduits.

B7.1.2 Conduit for Telephone, Computer Network, Inter-communication and PA Systems

Conduits shall be of steel not smaller than 20mm in diameter, and shall be installed in accordance with Section B1 of this Specification.

B7.1.3 Outlet Box for Telephone Point

At each telephone outlet position, the conduit shall be terminated at a IEC 60670 conduit box of 35mm deep with a moulded blank plate unless otherwise specified. Outlet boxes shall be located at 300mm above finished floor level measured from the bottom of the box unless otherwise as stated on the Drawing.

B7.1.4 Outlet Box for Computer Point

At each computer outlet, the conduit shall be terminated at a IEC 60670 box of 35mm deep with moulded cover plate. Outlet boxes shall be fixed at positions as specified on the Drawing.

Computer sockets will be provided and installed by others.

B7.1.5 Outlet Box for Inter-communication and PA System

At each inter-communication or PA outlet position, the conduit shall be terminated in a 35mm deep IEC 60670 box with moulded blank plate unless otherwise specified. The box shall be fixed at positions as stated on the Drawing.

B7.1.6 Conduit for Staff Paging System

Unless otherwise specified, conduits for staff paging system shall be not less than 20mm in diameter and shall be installed in accordance with Section B1 of this Specification. Sub-section B7.1.5 shall also be applicable to this type of installation.

B7.1.7 Conduit for Broadcast Reception System

Conduits for Broadcast Reception System shall be of steel, not smaller than 25mm in diameter unless otherwise specified, and shall be installed generally in accordance with Section B1. They shall be kept clear of power and telephone conduits and shall be arranged to cross them at right angles whenever possible. Bends shall have an internal radius of not less than 115mm. Draw-in boxes shall be provided at intervals of not exceeding 6 metres and at all 90° change of direction.

B7.1.8 Outlet Box for Broadcast Reception System

At each broadcast reception outlet position, the conduit shall be terminated in a 47mm deep, 75mm square steel box with galvanized sheet metal over-lapping cover plate. The box shall be fixed at skirting level or otherwise as stated on the Drawing. The metal overlapping cover plate shall be finished as the wall colour.

B7.2 BELL AND AUDIBLE WARNING SYSTEM

B7.2.1 Class-change Bell System for Schools

“Class-change” bell system shall be suitable for use on mains voltage, and shall normally be located in the General Office of the school unless otherwise specified. The supervisory panel of the bell system shall be engraved with the words "Class-change" in English and Chinese characters.

B7.2.2 Bell for Mains Voltage

Bells for operation at mains voltage shall be ironclad, weatherproof, with approximately 150mm diameter round gong suitable for conduit entry.

B7.2.3 Call Bell and Door Bell Systems

Bells and buzzers shall operate at extra low voltage obtained from a double wound transformer which shall be connected to the mains supply through a 2A fused connection unit. Unless otherwise specified, cables shall be 1.0mm² PVC insulated for conduit wiring installation, or 0.75mm² PVC twin flexible cable for surface wiring installation.

B7.2.4 Bell and Buzzer for Extra Low Voltage

Bells shall be of the underdome type having a gong of approximately 75mm diameter and shall be fixed to a substantial frame. Buzzers shall be contained within an insulating plastic case, and shall be approximately 75mm square in size. Both the bells and buzzers shall have large solid terminals and rubbing contacts.

B7.2.5 Bell Transformer

Bell transformers shall be air-cooled and double wound complying with EN 60742. One side of the secondary (extra low voltage) winding shall be earthed. The reactance of the transformer winding shall be of such a value that a continuous short circuit across the terminals of the secondary winding shall not damage the transformer, or cause dangerous overheating.

The windings, core and terminals of the transformer shall be contained within an insulating plastic case.

B7.2.6 Call Bell Push

Call bell pushes for indoor use shall be of flush pattern with white or ivory colour front plate.

Call bell pushes for outdoor use, or for areas where they may be subjected to rain or water, shall be weatherproof.

B7.2.7 Mounting of Call Bell Push

In conduit installations, bell pushes shall be fixed in 35mm deep, IEC 60670 conduit boxes. In surface cable installations, bell pushes shall be fixed on a plastic pattress.

Bell pushes shall not be mounted on doors without the written approval of the Architect.

B7.2.8 Table-type Push

Table-type pushes shall be single or multiple way as specified. They shall have a plastic base, and a plastic or metal top plate with adequate and approved holders for labels.

B7.2.9 Table-type Push in Concealed Conduit Installation

Table-type pushes in concealed conduit installations shall be connected to a length of 0.75mm² PVC insulated and sheathed flexible cord, comprising sufficient number of cords to suit the number of ways in use on the push panel. The flexible cords shall be taken to a conduit concealed in the floor slab. One end of the conduit shall terminate underneath the desk, and the other end shall enter a 35mm deep concealed IEC 60670 conduit box, mounted just above skirting level on

the wall. The flexible cord shall enter the conduit through a compression gland, and shall be connected to a terminal block mounted in the IEC 60670 conduit box, to which the extra low voltage wiring shall be connected. Where spare conduits are placed in floor slabs, they shall be plugged with a metal screwed plug to keep out dirt and moisture.

The IEC 60670 conduit box shall form part of the extra low voltage conduit system.

B7.2.10 Bell Indicator

Bell indicator shall be in a form of flashing light or indication light as specified. The indicators shall be fixed onto a cabinet of approved type with proper labels. Reset facilities shall be provided to resume the normal operation after acknowledge the bell indication.

B7.2.11 Segregation of Circuits

Cables for operation at extra low voltage shall not be routed in the same conduit where other cables are operating at higher voltages.

B7.3 FIRE SERVICE INSTALLATION

B7.3.1 Scope

This Sub-section covers the conduit and trunking installation for manual/automatic fire alarm systems and other fire service installations. The installation shall be carried out and completed to the standard called for in the relevant sections of the latest edition of the General Specification for Fire Service Installations in Government Buildings, Hong Kong.

B7.3.2 Conduit and Trunking Systems

Conduits and trunking for fire service installations shall be of steel, complying with the relevant clauses in Section B1 of this General Specification.

Conduits for fire service installations shall be completely separated from those for all other services. Where trunking system is used, a separate channel shall be used exclusively for fire service wiring.

Conduits and trunking shall be routed and installed in such a way as to give maximum protection against mechanical damage. Where it is unavoidable to run conduits or trunking for fire service installations across other conduits, water pipes, air conditioning ducts, etc., they shall be installed first and fixed closest to the structure.

The routes shall also avoid areas of high fire risk such as lift wells, open staircases and unenclosed vertical shafts.

Galvanized iron draw-wires of adequate size shall be provided in all empty conduits.

B7.3.3 Use of Flame Retarding Cables

Where specified, flame retarding cables or mineral insulated (MI) cables shall be used in lieu of conduit/trunking system. In such case, the cables used and their installation shall comply with the relevant requirements as specified in Sections B2 and C2.

B7.4 INSTALLATION IN HAZARDOUS AREAS

B7.4.1 General

- (a) Electrical equipment and wiring of electrical installations exposed to potentially explosive atmospheres shall be constructed and protected to the requirements specified for hazardous areas to the relevant parts of IEC 60079.
- (b) Electrical equipment and wiring of electrical installations in buildings and premises for the storage, manufacture or packing of dangerous goods in Categories 1 to 10 shall comply with the provisions of CAP 295B Dangerous Goods (General) Regulations.
- (c) Electrical equipment and wiring of electrical installations in building and premises for Categories 2 and 5 Dangerous Goods including those in building and premises for liquid petroleum gas storage and for petrol filling stations shall, in addition to subparagraph (a) and (b) above, comply with the requirements specified for hazardous areas in the Electricity Safety Code Part 1 and 15 of the Institute of Petroleum Model Code of Safe Practice in the Petroleum Industry or Marketing Safety Code of the Institute of Petroleum or equivalent.

B7.4.2 Electrical Equipment Selection

- (a) Type of protection of electrical equipment for achievement of safety shall be in accordance with the zone of risk listed in Table B7.4.2(a).

Table B7.4.2(a)

**Selection of Electrical Equipment and Systems
according to Zone of Risk**

	Type of Protection	Zone in which the protection may be used
'ia' 's'	intrinsically-safe apparatus or system special protection (specifically certified for use in Zone 0)	0, 1, 2
'd' 'ib' 'p' 'e' 's' 'm'	flammable enclosure intrinsically-safe apparatus or system pressurization, continuous dilution and pressurized rooms increased safety special protection encapsulation	1, 2
'N' 'o' 'q'	type of protection N oil-immersion sand filling	2

NOTES :

- Zone 0 Zone in which an explosive atmosphere is continuously present or present for long periods
- Zone 1 Zone in which an explosive atmosphere is likely to occur in normal operation
- Zone 2 Zone in which an explosive atmosphere is not likely to occur in normal operation, and if it occurs it will exist only for a short time.

- (b) The maximum surface temperature of the T class of an electrical equipment shall not exceed the ignition temperature of the gases or vapours involved. Relationship between T class and maximum surface temperature is shown in Table B7.4.2(b).

Table B7.4.2(b)

Relationship between T Class and Maximum Surface Temperature

T Class	Maximum Surface Temperature (°C)
T1	450
T2	300
T3	200
T4	135
T5	100
T6	85

- (c) The gas and vapour classification of electrical equipment which provides guidance for the safety usage of equipment in the type of gaseous prevalent environment shall conform with IEC 60079-12.

B.7.4.3 Wiring System

The wiring system shall be :

- (a) PVC insulated cables drawn into steel conduits complying with Sections B1 and C1, or
- (b) Flame retarding PVC outer sheathed fire retarding cable enclosed in conduits or trunking complying with Sections B2 and C2, or
- (c) Multi-core armoured cables complying with Sections B2 and C2, or
- (d) Mineral insulated copper sheathed cables with copper conductors complying with Sections B2 and C2.

Where single core metal sheathed or armoured cables are used, precautions shall be taken to avoid dangerous sheath voltages or currents.

B7.4.4 Conduit Fitting, Cable Glands, Terminal Box and Enclosure

Unless otherwise specified, conduit fittings, cable glands, terminal boxes and enclosures of apparatus (including accessories) shall be suitable for use with Group IIA and Group IIB inflammable gases and vapours as specified in IEC 60079-12 with temperature classification of T6 (85°C). Conduit fittings, cable glands and terminal boxes shall carry the registered flameproof mark and manufacturer's certificate number.

B7.4.5 Screw or Bolt

Screws or bolts for securing individual components of apparatus and luminaires shall only be removed by the using of a tubular box spanner complying with BS 2558 or a hexagon wrench key complying with BS 2470.

B7.4.6 Luminaire

Unless otherwise specified, luminaires shall comply with BS 4683 and shall be suitable for use in Zone 1 where gases exist is of Group IIA or Group IIB classification as specified in IEC 60079-12 with temperature classification of T4 (135°C). Where tubular fluorescent luminaires are specified, they shall have starterless ballasts.

B7.4.7 Conduit Pendant

At all tube pendant points, a three-way (tee) circular or rectangular junction box shall be provided. The conduit down drop shall be fitted direct to the threaded spout of the box. Screwed pendant covers shall not be used.

B7.4.8 Cables or Conduits Passing through Floor, Wall or Partition

Where cables or conduit passing through a floor, wall or partition that forms a gas or fire barrier, the hole provided for them shall be made good with material determined as incombustible in accordance with the method of BS 476: Part 4 to the full thickness of the floor, wall or partition. Alternatively, cable glands or cable transits may be used for this purpose.

Where a run of conduit, irrespective of size, passes from a hazardous area to a non-hazardous area, a stopper box or sealing device shall be inserted at the hazardous area boundary or, failing this, on the side remote from the hazardous area.

B7.4.9 Precautions to Prevent Passage of Inflammables Gases or Vapours

Where trunking, ducts, pipes or trenches are used to accommodate cables, precautions shall be taken to prevent the passage of inflammable gases or vapours from one area to another and to prevent the collection of inflammable gases or vapours in trenches. Such precautions shall involve the sealing of trunking, ducts and pipes and the adequate ventilation or sand filling of trenches.

B7.4.10 Equipotential Bonding of Conduit

The metallic portion of conduit shall be electrically bonded to the rigid system by either a separate conductor or terminating devices.

B7.5 EXTERNAL LIGHTING SYSTEM

B7.5.1 Scope

This Sub-section covers lighting installations (mainly pole mounted) for street lighting, security lighting, floodlighting and general area lighting.

B7.5.2 Specification and Drawing

External lighting installations shall be installed in accordance with the Particular Specification and Drawings. Unless otherwise specified, poles and luminaires shall comply with the Standard/Guided Drawings .

B7.5.3 Luminaire

The type of lamps and luminaires to be used shall be as specified in the Particular Specification and Drawings. Unless otherwise specified, the luminaires shall be securely mounted on the poles by the method indicated on the Standard/Guided Drawings.

For those not mounted on poles, they shall be fixed on wall or hanger, plinth or the like dedicated for the mounting of the luminaires. In such case, the installation shall comply with Section B3.

Where specified in the Particular Specification, a safety chain shall be provided between the luminaire and the lamp pole to ensure that the luminaire will not be dropped down in case the luminaire support fails. The chain shall be galvanized steel and of adequate strength to support at least three times the weight of the luminaire.

B7.5.4 Construction of Lamp Pole

Unless otherwise specified, lamp poles shall be constructed of mild steel pipe of one, two or three sections of diameter and modules, all as specified on the Standard/Guided Drawings. The lamp poles shall be hot dipped galvanized to BS 729. Pole caps, cat ladders and platforms shall be fitted where shown and as required. Material samples and working drawings shall be submitted when requested by the Architect. The poles shall be finished overall with at least two coats of primer and two coats of finishing paint after erection in accordance with Sub-section A3.12. The colour of the finishing paint shall be as directed by the Architect.

If imported lamp poles are offered, the Contractor shall submit evidence to substantiate that the lamp poles are structurally sound and are suitable for use in the local environment, in particular under typhoon conditions at a wind speed of up to 160 knots. Such evidence may be by means of manufacturer's calculation and certificates.

All lamp poles shall be earthed by approved means via the armour of the underground armoured cables.

B7.5.5 Foundation of Lamp Pole

Lamp poles shall be securely bolted down in an upright position to the foundations constructed in accordance with the Standard/Guided Drawings. Should there be any queries on the construction of the foundations, the Architect's advice shall be sought.

B7.5.6 Service Box

A mild steel service box shall be provided on each pole at an appropriate height above ground level to accommodate the MCB control box. The construction of the service box and the MCB control box shall be as shown on the Standard/Guided Drawings.

Each lamp circuit shall be protected by an MCB. Where the CSA of the incoming/outgoing cable cores are larger than that which can be accommodated by the terminal of the MCB, a fixed insulated connector block of adequate rating shall be installed with a tail to the MCB. Alternatively, a copper busbar may be used.

Where the service box serves more than one circuit, the supply to the MCB shall be by means of a copper busbar of adequate rating. The phase conductors of the incoming/outgoing cables shall then be terminated to the busbar by means of cable sockets.

Each control box shall be fitted with a neutral block of adequate rating and having sufficient number of ways for the incoming/outgoing cable cores. It shall be securely fixed to the base of the control box by means of a 6mm thick paxolin block.

The service box shall be fitted with a 3mm thick galvanized mild steel cover made waterproof with a 3mm thick soft rubber or neoprene gasket. The cover shall be fixed by means of four M6 brass fixing bolts and washers and shall be hinged. Provision shall be made in the batten plate of the box for supporting and terminating up to three numbers of incoming/outgoing XPLE or PVC/SWA & PVCS cables by means of suitable cable glands. The cable sizes shall be as specified in the Particular Specification or on the Drawings.

B7.5.7 Underground Cable to Pole

Underground cables for external lighting systems shall be copper cored, XPLE or PVC insulated, steel wire armoured and PVC sheathed cables (XPLE or PVC/SWA & PVCS) unless otherwise specified. Cables shall enter and leave the pole below ground level and each cable shall terminate in a gland fixed to the MCB control box. The cable cores between the glands and the terminals shall not be in tension.

Underground straight through joint will not be permitted without written agreement of the Architect.

All underground cables shall be laid inside cable trenches or ducts. If these ducts are provided by the builder, the Contractor shall ascertain that the quantity, size and associated arrangement of the ducts are suitable for drawing of cables in future. Draw pits of adequate sizes shall be provided for a straight run of approximately 12m, at position where cable route changes direction or as and where required.

B7.5.8 Cable between Service Box and Luminaire

Cables from the neutral terminal block and the MCB to the luminaires shall be PVC insulated and PVC sheathed having CSA as specified. Arrangements shall be made to prevent the cores from being under tension where they are attached to terminals. All cables shall be contained within the poles. Rubber grommets shall be installed where cable passes through metal work.

Where sustained arc voltage of a discharge lamp exceeds 250V, the cables used for connecting the lamp and the control-gear shall be of 600/1000V grade to IEC 60502 or as recommended by the lamp manufacturer. The length of cables shall not exceed the limit as recommended by the manufacturer.

Where flexible cables are recommended by manufacturer for termination at the luminaire, PVC insulated and PVC sheathed flexible cables shall be used. Such cables shall enter the luminaire by means of suitable waterproof compression glands.

Where four or more floodlights are mounted on a pole, the flexible cables shall be connected to the luminaires by means of a mild steel connector box with waterproof hinged cover. The connector box shall be fitted near to the top of the pole, all as shown on the Standard/Guided Drawings.

B7.5.9 Switch Fitted to Pole

Where specified switches may be mounted on the pole for local control. Switches mounted on the pole shall be fixed onto it by tapped holes and brass fixing screws. The switches shall be waterproof or contained within a waterproof type galvanized metal case, with an external galvanized metal operating knob or handle. Switches shall be fitted at least 2m above finished ground level.

B7.5.10 Control Gear for Discharge Lighting

Control gear for discharge lamps shall be contained within a galvanized steel box mounted on the pole or inside the concrete gear-cabinet provided by others as shown on the Drawings. When mounted on the pole, the steel box shall be watertight and positioned at a height higher than normal working level in such a way that a ladder is needed for access. The box shall be of adequate size to accommodate all control gear, cable and connections. The method of construction shall be similar to the service box.

B7.5.11 Testing of Illumination Level

Testing of the illumination level and distribution of external lighting installations shall be carried out after dark under the direction of the Architect. All labour, instruments and materials necessary to carry out the test shall be provided including adjustment of the luminaires to

achieve the desired illumination level and performance to the satisfaction of the Architect.

B7.5.12 Numbering of Lamp Pole

All lamp poles shall be marked with appropriate identification numbers. The numbers shall commence consecutively from the source of power supply in the clockwise direction. The numbering proposal shall be submitted with the shop drawings to the Architect for approval.

The number shall be etched on a stainless steel plate which shall be fixed onto the pole by tapped holes and two brass fixing screws. The numbers shall not be less than 50mm tall.

A framed drawing indicating the location of lamp poles and pole numbers shall be provided in the appropriate switch room. The framed drawing shall be fixed onto the wall in such a manner that it can easily be removed for reference.

B7.6 LIGHTNING PROTECTION SYSTEM

B7.6.1 Installation of Lightning Protection System

Lightning protection systems shall be installed in accordance with the Particular Specification and Drawings, and as directed by the Architect.

B7.6.2 Scope

This Sub-section covers lightning protection systems applicable to buildings and similar structures. It does not cover the protection of overhead lines and other specialized applications. The installation shall conform to the requirements and recommendations set out in the British Standard BS 6651 "Code of Practice for Protection of Structures against Lightning".

B7.6.3 Type of Lightning Protection System

A lightning protection system shall comprise air termination connected by down conductors to earthing electrodes. In larger schemes more than one of any or all of the above items may be used. Air terminations may be interconnected by means of roof horizontal conductors.

B7.6.4 Air Termination

Air termination shall consist of vertical or horizontal conductor(s) or combination of both.

No part of the roof shall be more than 5m from the nearest horizontal conductor. For larger flat roofs, this shall be achieved typically by an air termination network mesh of approximately 10m x 20m.

On a reinforced concrete structure, the air termination shall be connected to the designated reinforcing bars in the number of positions required for down conductors.

All metallic projections on or above the main surface of the roof which are connected, intentionally or fortuitously, to the general mass of the earth should be bonded to, and form part of, the air termination network.

B7.6.5 Down Conductor

The dimensions of down conductors to be used shall be either of the following :

- (a) annealed tinned copper strip 25 x 3mm
- (b) annealed copper rod 12mm diameter
- (c) steel reinforcement bar 12mm diameter

Where the steel work of the structure is used as down conductor, co-ordination with the Building Contractor is required to ensure the continuity of the steel work. In this connection the ends of the steel work shall be connected to the lightning protection system by a jointing method which is suitable for bonding dissimilar metals and approved by the Architect. A test joint shall be provided at each connection.

When down conductors adhered on the external wall are specified, they shall be fixed by means of suitable spacer saddles at regular intervals of not exceeding 1m apart. The down conductor shall follow the most direct path possible between the air termination network and the earth termination network. When more than one down conductors are installed, they shall be arranged as evenly as practicable around the outside walls of the structure starting from the corners.

Each down conductor shall be connected to an earth termination.

B7.6.6 Test Joint

Test joints shall be of phosphor bronze, gunmetal or copper. They shall comprise a heavy circular base, to which a heavy circular cover of the same material shall be bolted. The flat copper conductor shall be overlapped and placed so that they are clamped between the cover and the base by means of at least four screws or studs.

The test joints shall be positioned so that they shall not be tampered with by unauthorized persons. In cases where this is not possible, the earth tape/rod connector clamp shall be used as an alternative test point in place of the test joint.

B7.6.7 Earth Termination

Unless otherwise specified, earth termination shall be of rod electrodes complying with Sub-section B6.3.

Each earth termination shall have a resistance to earth not exceeding the product given by 10Ω times the number of earth terminations to be provided. The whole of the lightning protection system shall have a combined resistance to earth not exceeding 10Ω . Where, due to local conditions, it is difficult to obtain a value of less than 10Ω by the sole use of rod electrodes, alternative or additional methods, e.g. the use of deep bore holes, the installation of tape or plate electrodes complying with Section B6, may be used at the discretion of the Architect.

B7.6.8 Spacer Saddle

Spacer saddles shall be of high quality metal. For copper conductors, brass or gunmetal shall be used.

Non-metallic spacer saddles shall only be used when down conductors are provided with PVC sheathing.

B7.6.9 Connection to Earth Termination

Down conductors and bonding conductors shall be connected to the earth electrode in accordance with Sub-section B6.4. Each connection shall be separately clamped and shall be fitted with a warning notice in accordance with Sub-section A3.3

B7.6.10 Bonding to Other Services

Lightning protection systems shall normally be kept segregated from the metalwork of other services. Minimum isolation clearances as given in BS 6651 shall be maintained. However, in certain circumstances, e.g. where fortuitous contact with other systems cannot be avoided, earth electrodes for lightning protection may, at the discretion of the Architect, be bonded to other such services including the metal sheath and armouring of low voltage cables, the consumer's low voltage earth system, metal water pipes and steel reinforcement for the foundation and structure. Cables and earthing systems belonging to the Supply Authorities, the Telephone Company and other authorities shall not be bonded except with the written permission of such Authorities. Gas pipes shall not normally be connected to any earth electrode.

B7.6.11 Bond

Bonds for use in connecting the lightning protection system of other metal work shall be of soft annealed copper strip of 25 x 3mm. Bonds connecting movable items to the lightning protection system shall be of flexible copper strand 475/0.5mm diameter or equivalent. Connections to other metalwork shall be of negligible resistance, metal to metal and mechanically sound with non-ferrous nuts, bolts and washers using clamps where necessary.

B7.6.12 Joint in Conductors

Joints in roof conductors and/or down conductors shall be made by double riveting or by suitable tape clamps. When clamps are used, the tape clamps shall each be provided with at least 4 screws or bolts. All such joints shall be tinned and shall have negligible resistance and good mechanical strength.

Alternatively, connectors may be jointed together by means of exothermic or thermal welding utilizing the high temperature reaction of powdered copper oxide provided that the proper material and equipment are used in accordance with the manufacturer's recommended process.

B7.6.13 Testing

On completion of the installation, the lightning protection system shall be tested for continuity between air terminations and earthing terminations and the resistance shall be recorded. The earthing resistance of each earthing electrode shall also be tested and recorded. The tests shall be carried out in accordance with Part D of this Specification and shall be submitted to the Architect for approval.

All instruments used for testing shall be properly calibrated.

SECTION C1
WIRING SYSTEM:
CABLES, CONDUITS, TRUNKING AND ACCESSORIES

C1.1 CABLES IN WIRING SYSTEM

C1.1.1 Type of Cable

Cables in wiring system shall be one or a combination of the following types.

C1.1.2 Non-sheathed Cables

Non-sheathed cables shall be to:

- (a) 450/750V PVC insulated, single-core, non-sheathed copper cables, with rigid conductor for general purpose, suitable for conductor operating temperature not exceeding 70°C – code designation 60227 IEC 01 of IEC 60227-3, or
- (b) 450/750V PVC insulated, single-core, non-sheathed copper cables with flexible conductor for general purpose, suitable for conductor operating temperature not exceeding 70°C – code designation 60227 IEC 02 of IEC 60227-3, or
- (c) 300/500V heat resistant silicone rubber insulated copper cable, suitable for conductor operating temperature not exceeding 180°C - code designation 60245 IEC 03 of IEC 60245-3, or
- (d) 300/500V heat resistant ethylene-vinyl acetate rubber or other equivalent synthetic elastomer insulated, single-core, non-sheathed copper cable, with solid conductor, suitable for conductor operating temperature not exceeding 110°C – code designation 60245 IEC 06 of IEC 60245-7, or
- (e) 450/750V heat resistant ethylene-vinyl acetate rubber or other equivalent synthetic elastomer insulated, single-core, non-sheathed copper cable, with solid or stranded conductor, suitable for conductor operating temperature not exceeding 110°C – code designation 60245 IEC 04 of IEC 60245-7, or
- (f) 450/750V low emission of smoke and corrosive gases thermosetting insulated, non-sheathed, single-core copper cable, with solid or stranded conductor, suitable for conductor operating temperature not exceeding 90°C – code designation H07Z-U and H07Z-R of BS 7211.

C1.1.3 Sheathed Cables

Sheathed cables shall be to:

- (a) 600/1000V PVC insulated, PVC sheathed copper cables with or without armour, single-core or multi-core, suitable for conductor operating temperature not exceeding 70°C – IEC 60502-1, or
- (b) 600/1000V PVC insulated, thermoplastic polyethylene (PE) sheathed copper cables with or without armour, single-core or multi-core, suitable for conductor operating temperature not exceeding 70°C – IEC 60502-1, or
- (c) 600/1000V cross-linked polyethylene (XLPE) insulated and sheathed copper cables with or without armour, single-core or multi-core, suitable for conductor operating temperature not exceeding 90°C – IEC 60502-1, or
- (d) 600/1000V ethylene propylene rubber (EPR) insulated and sheathed copper cables with or without armour, single-core or multi-core, suitable for conductor operating temperature not exceeding 90°C – IEC 60502-1, or
- (e) 300/500V light PVC insulated and sheathed copper cable with solid or stranded conductor, suitable for conductor operating temperature not exceeding 70°C – code designation 60227 IEC 10 of IEC 60227-4, or
- (f) 300/500V PVC insulated, PVC sheathed copper cable with solid or stranded conductor, single-core, flat twin or 3-core, suitable for conductor operating temperature not exceeding 70°C – national type (Table 7) of BS 6004, or
- (g) 300/500V PVC insulated, PVC sheathed copper cable with solid or stranded conductor and circuit protective conductor, single-core, flat twin or 3-core, suitable for conductor operating temperature not exceeding 70°C – national type (Table 8) of BS 6004, or
- (h) 300/500V PVC insulated, PVC sheathed copper cable with stranded conductor and with or without circuit protective conductor, single-core or flat twin, suitable for conductor operating temperature not exceeding 70°C – national type (Table 9) of BS 6004, or
- (i) 450/750V low emission of smoke and corrosive gases thermosetting insulated and circular sheathed copper cable with solid or stranded conductor, twin, 3-core, 4-core or 5-core, suitable for conductor operating temperature not exceeding 90°C – national type (Table 6) of BS 7211, or

- (j) 300/500V low emission of smoke and corrosive gases thermosetting insulated and sheathed copper cable with solid or stranded conductor and circuit protective conductor, single-core, flat twin or flat 3-core, suitable for conductor operating temperature not exceeding 90°C – national type (Table 7) of BS 7211, or
- (k) 300/500V fire resistant, low emission of smoke and corrosive gases thermosetting insulated and circular sheathed copper cable with uninsulated circuit protective conductor, twin, 3-core or 4-core, suitable for conductor operating temperature not exceeding 90°C – BS 7629-1.

C1.1.4 Flexible Cables

Flexible cables shall be:

- (a) 300/500V ordinary PVC insulated and sheathed flexible copper cable, suitable for conductor operating temperature not exceeding 70°C – code designation 60227 IEC 53 of IEC 60227-5, or
- (b) 300/500V ordinary tough rubber insulated and sheathed flexible copper cable, suitable for conductor operating temperature not exceeding 60°C – code designation 60245 IEC 53 of IEC 60245-4, or
- (c) 450/750V rubber insulated, heavy polychloroprene or other equivalent synthetic elastomer sheathed flexible copper cable, suitable for conductor operating temperature not exceeding 60°C – code designation 60245 IEC 66 of IEC 60245-4, or
- (d) 300/500V PVC insulated, non-sheathed copper cable, single-core or twisted twin, suitable for internal wiring and conductor operating temperature not exceeding 70°C – code designation H05V-K of BS 6004, or
- (e) 300/500V PVC insulated, non-sheathed heat resisting copper cable, single-core or twisted twin, suitable for internal wiring and conductor operating temperature not exceeding 90°C – code designation H05V2-K of BS 6004, or
- (f) 300/500V braided, silicone rubber insulated, unsheathed copper cable, twisted twin, suitable for conductor operating temperature not exceeding 180°C – code designation H05SJ-K of BS 6007, or
- (g) 300/500V flexible copper cable, suitable for use with appliance and equipment intended for domestic, office and similar environments to BS 6500, or

- (h) 300/500V ordinary duty rubber insulated and sheathed flexible copper cable, 3-core or 4-core, suitable for conductor operating temperature not exceeding 60°C – code designation H05RR-F of BS 7919, or
- (i) 450/750V heavy duty rubber insulated, PCP or equivalent synthetic elastomer sheathed flexible copper cable, single-core, circular twin, 3-core, 4-core or 5-core, suitable for conductor operating temperature not exceeding 60°C – code designation H07RN-F of BS 7919, or
- (j) 450/750V heavy duty heat resisting ethylene propylene rubber (EPR) or equivalent synthetic elastomer insulated and CSP or equivalent synthetic elastomer sheathed flexible copper cable, single-core, circular twin, 3-core, 4-core or 5-core, suitable for conductor operating temperature not exceeding 90°C – code designation H07BN4-F of BS 7919.

C1.2 STEEL CONDUIT AND ACCESSORIES

C1.2.1 Steel Conduit

Steel conduits, except flexible conduits, shall be of heavy gauge, screwed, longitudinally welded. All steel conduits shall comply with IEC 60614-2-1.

C1.2.2 Steel Flexible Conduit

Steel flexible conduits and solid type brass adaptors shall comply with IEC 60614-2-5. In addition, the steel conduits shall be of the metallic water tight pattern and PVC oversheathed. PVC oversheath shall not be required for installations within ventilated ceiling void.

The flexible conduit adaptor shall comprise two parts, an inner core and an outer ferrule. The inner core screws into the bore of the conduit together with an outer ferrule which caps off the end of the conduit, so that the adaptor can provide an extremely strong joint. The core shall lock against the outer ferrule and isolate any sharp cut edges in the conduit.

C1.2.3 Steel Conduit Fitting

All steel conduit fittings shall comply with IEC 61035.

Adaptable boxes complete with covers shall be of cast iron or galvanized steel. Boxes of the preferred sizes as given in IEC 60670 shall be used.

Circular boxes, dome covers and hook covers shall be of galvanized malleable cast iron. Ceiling mounted boxes shall be of deep pattern type having an internal depth of not less than 60 mm.

Bushes and tube ends shall be of brass.

Distance (spacing) saddles shall be of galvanized cast iron. The screws for tightening and fixing the saddles shall be of brass.

Solid or inspection tee-pieces, couplers or elbows shall NOT be used on any conduit installation.

C1.2.4 Metal Boxes for Electrical Accessories

Metal boxes complete with covers for enclosure of electrical accessories in conduit installation shall comply with IEC 60670/BS 4662. Boxes used to house accessories such as domestic switches, socket outlets, spur units, etc. shall be 35 mm and 47 mm deep. The depth chosen shall be suitable for the accessories to be housed.

C1.2.5 Class of Protection against Corrosion

Steel conduits and couplers shall be hot-dip zinc coated or sheradized both inside and outside against corrosion and shall be tested to comply Clause 13.4.5 of IEC 60614-1.

Steel or ferrous conduit fittings and adaptable boxes complete with covers shall be hot-dip zinc coated or sheradized both inside and outside against corrosion and shall be tested to comply Clause 13.4.5 of IEC 60614-1.

Metal boxes complete with covers for the enclosure of electrical accessories shall have heavy protection both inside and outside in accordance with IEC 60670/BS 4662 (e.g. hot-dip galvanized coating or sheradizing).

C1.2.6 Screw

Screws used for fixing boxes and spacing saddle, and for tightening covers and spacing saddles shall have ISO metric threads. They shall be of brass or steel and if of steel they shall be protected against corrosion by a finish at least equal to the zinc coating specified in BS 3382: Part 2. Electro-brass plated screws or self tapping screws shall NOT be used.

C1.3 PLASTIC OR PVC CONDUIT AND ACCESSORIES

C1.3.1 Rigid Conduit and Conduit Fittings

Rigid plain PVC conduits shall comply with IEC 60614-2-2 and rigid plain PVC conduit fittings shall comply with IEC 61035. Conduits shall have classification as below:

- (a) According to mechanical properties - for heavy mechanical stress.

- (b) According to temperature - with a permanent application temperature range of -5°C to +60°C.

C1.3.2 Pliable Conduit

Pliable conduits shall be formed of self-extinguishing plastic materials and shall comply with IEC 60614-2-3 and pliable conduit fittings shall comply with IEC 61035. Conduits shall be suitable for installation, storage or transport at temperature range of -5°C to +60°C.

C1.3.3 Plastic or PVC Conduit Boxes

Plastic or PVC adaptable boxes and plastic or PVC boxes for enclosure of electrical accessories shall be of heavy duty having dimensions complying with IEC 60670/BS 4662 respectively. They shall be interchangeable with the steel boxes complying with the same IEC standard. The minimum wall thickness of boxes shall be 2 mm.

C1.3.4 Plastic Couplers

Plain, moulded slip-type couplers and expansion type couplers to IEC 61035-1 shall be used in the jointing of conduits. Adhesive/jointing cement for jointing shall be the type recommended by the manufacturer.

C1.4 STEEL TRUNKING AND ACCESSORIES

C1.4.1 Steel Trunking

Steel surface trunking and fittings shall be compatible to the requirements laid down in IEC 61084-1 and shall be fabricated with sheet steel having a nominal thickness as indicated in Table C1.4.4-1.

Steel underfloor (duct) trunking shall be compatible to the requirements laid down in IEC 61084-1 and shall be fabricated with sheet steel having a nominal thickness as indicated in Table C1.4.4-3.

Manufacturer's standard fittings such as tee or angle pieces, connectors, etc. shall be used throughout unless prior approval has been obtained from the Architect.

C1.4.2 Class of Protection against Corrosion

Steel surface trunking and steel underfloor (duct) trunking and associated fittings shall have class 3 protection against corrosion in accordance with BS 4678: Part 1, i.e. Hot-dip zinc coating to BS 2989 with a minimum coating designation of G275.

C1.4.3 Construction

Steel surface trunking shall be of square or rectangular cross section. One side of the trunking shall be removable or hinged. No projection from screw or other sharp object will be allowed inside the trunking.

Steel underfloor (duct) trunking shall be so designed and constructed as to permit the laying of the trunking on a structural floor without ingress of water or cement whilst the floor is screeded.

C1.4.4 Dimension

The sizes, body and cover thickness, and preferred length of steel surface trunking, are given in Table C1.4.4-1. The tolerances on external dimensions shall be as indicated in Table C1.4.4-2.

TABLE C1.4.4-1

**Size , Body and Cover thickness, and
Preferred Length of Surface Steel Trunking**

Trunking external dimension (mm)	Minimum thickness of body with return flange (mm)	Minimum thickness of body without return flange (mm)	Minimum thickness of cover (mm)
50 x 37.5	1.0	1.0	1.0
50 x 50	1.0	1.0	1.0
75 x 50	1.2	1.2	1.2
75 x 75	1.2	1.2	1.2
100 x 50	1.2	1.2	1.2
100 x 75	1.2	1.2	1.2
100 x 100	1.2	1.4	1.2
150 x 50	1.2	1.4	1.2
150 x 75	1.2	1.4	1.2
150 x 100	1.2	1.4	1.2
150 x 150	1.4	1.6	1.2
200 x 100	1.6	--	1.4
225 x 50	1.6	--	1.4
225 x 75	1.6	--	1.4
225 x 100	1.6	--	1.4
225 x 150	1.6	--	1.4
225 x 225	1.6	--	1.4
300 x 50	1.6	--	1.6
300 x 75	1.6	--	1.6
300 x 100	1.6	--	1.6
300 x 150	1.6	--	1.6
300 x 300	2.0	--	1.6
Preferred lengths: 3 m, minimum: 2 m, maximum: 3 m Nominal thickness of partitions or dividers: 1.0 mm.			

Table C1.4.4-2**Tolerance of Trunking Dimension**

Dimension (mm)	37.5	50	75	100	150	200	225	300
Tolerance (mm)	+5	+5	+5	+6	+7	+8	+9	+10

The sizes, thickness and preferred lengths for steel underfloor (duct) trunking shall be as given in Table C1.4.4-3.

The dimensions of the trunking for the installation shall be the same throughout.

TABLE C1.4.4-3**Size, Thickness and Preferred Lengths
Of Steel Underfloor (Duct) Trunking**

External dimension (excluding flange projections) width (mm) by depth (mm)	Compartments	Nominal thickness of body with compartment width (mm)		Nominal thickness of partitions/ connector material (mm)
		Not exceeding 100 mm	Not exceeding 150 mm	
75 ± 4 x 25 ± 1.2	One	1.2	--	1.0
75 ± 4 x 37.5 ± 2	One	1.2	--	1.0
100 ± 5 x 25 ± 1.2	One or Two	1.2	--	1.0
100 ± 5 x 37.5 ± 2	One or Two	1.2	--	1.0
150 ± 7.5 x 25 ± 1.2	Two or Three	1.2	1.6	1.0
150 ± 7.5 x 37.5 ± 2	Two or Three	1.2	1.6	1.0
150 ± 7.5 x 25 ± 1.2	One	--	1.6	1.0
150 ± 7.5 x 37.5 ± 2	One	--	1.6	1.0
225 ± 11.2 x 25 ± 1.2	Two	1.2	1.6	1.0
225 ± 11.2 x 37.5 ± 2	Two	1.2	1.6	1.0
225 ± 11.2 x 25 ± 1.2	Three	1.2	1.6	1.0
225 ± 11.2 x 37.5 ± 2	Three	1.2	1.6	1.0
Preferred lengths: 3 m, minimum: 2 m, maximum: 3 m				

- Notes:**
- (1) The thickness of the base may be reduced to a minimum of 1.0 mm if desired.
 - (2) Where a body has more than one compartment and is not made up from smaller sizes, the nominal thickness shall be that specified for the largest compartment.
 - (3) Trunking to special order having dimensions differing from the Table may be used, provided that they meet all the requirements as stated in this Specification.

C1.4.5 Connection between Lengths of Trunking

Connection between adjacent lengths of surface trunking, tee or angle pieces, accessories, etc. shall be made by means of butt joints. The two adjacent ends of trunking shall be fixed so that no relative movement can occur between them.

Connectors for underfloor (duct) trunking shall also provide adequate mechanical strength. One connector shall be provided per length of trunking.

Electrical continuity shall be achieved by means of connecting a copper continuity connector of adequate size across the two adjacent ends of the surface trunking.

For underfloor (duct) trunking, such continuity bonding links shall be of such materials so as to prevent electrolytic corrosion.

C1.4.6 Steel Surface Trunking Cover

Trunking and fittings shall have removable or hinged covers extending over the entire length. The covers shall be of the same material and finish as those of the trunking body.

Removable covers shall be held in position on the trunking either by the natural elasticity of the material of the cover (e.g. spring capped trunking) or by other approved means which hold the covers tightly onto the trunking body and cause no damage to the cables inside.

Bends, tee junctions, etc. shall also be fitted with removable or hinged covers of the same construction as that of the trunking.

C1.4.7 Screw

Screws used for securing a cover or connector and for fixing a trunking shall have ISO metric threads. They shall be of brass or steel. Steel screws shall be protected against corrosion by a finish at least equal to the zinc coating specified in BS 3382: Part 2. Electro-brass plated screws or self tapping screws shall NOT be used. Projection of screws inside a trunking or a trunking fitting will not be allowed.

C1.5 PLASTIC OR PVC TRUNKING AND ACCESSORIES

PVC trunking and fittings shall comply with IEC 61084-1. The nominal dimensions of PVC cable trunking shall be selected from any of the following numbers in mm:

12.5, 16.0, 20.0, 25.0, 32.0, 37.5, 40.0, 50.0, 75.0, 100.0 and 150.0

Trunking shall have covers secured by purpose-made rivets. Covers of the clip-on type will be acceptable for trunking sizes up to 100 x 100 mm.

SECTION C2

POWER CABLES AND ASSOCIATED CABLING FACILITIES

C2.1 GENERAL

Power cables are mainly for electricity supply and distribution. They shall be manufactured under British Approvals Service for Cables (BASEC) licence or an equivalent quality surveillance scheme (e.g. European Committee for Electrotechnical Standardization (CENELEC) Harmonization Scheme) and bear BASEC marking or the appropriate marking of the equivalent quality surveillance scheme (e.g. CENELEC HAR).

Power cables shall have grading as specified in Sub-section C2.2 below.

Cabling facilities will include cable ducts, cable trays and cable ladder.

C2.2 TYPES OF POWER CABLES

Power cables for supply and distribution shall be one or a combination of the following types as specified in the Particular Specification or on the Drawings:

- (a) 600/1000V cross-linked polyethylene (XLPE) insulated, PVC sheathed copper cables with armour, single-core, two-core, three-core or four-core, suitable for conductor operating temperature not exceeding 90°C – IEC 60502-1, or
- (b) 600/1000V low emission of smoke and corrosive gases cross-linked polyethylene (XLPE) insulated and sheathed copper cable with armour, single-core, two-core, three-core or four-core, suitable for conductor operating temperature not exceeding 90°C – BS 6724, or
- (c) 600/1000V fire resistant, low emission of smoke and corrosive gases cross-linked polyethylene (XLPE) insulated and sheathed copper cable with armour, two-core, three-core or four-core, suitable for conductor operating temperature not exceeding 90°C - Category F2 of BS 7846, or
- (d) 500V (light duty grade) mineral insulated, copper sheathed copper cable with single-core, two-core, three-core or four-core – IEC 60702-1 and IEC 60702-2, or
- (e) 750V (heavy duty grade) mineral insulated, copper sheathed copper cable with single-core, two-core, three-core or four-core – IEC 60702-1 and IEC 60702-2, or
- (f) 600/1000V PVC insulated, PVC sheathed copper cables with armour, single-core, two-core, three-core or four-core, suitable for conductor operating temperature not exceeding 70°C – IEC 60502-1, or

- (g) 600/1000V paper insulated, lead sheathed copper cables with armour, single-core, two-core, three-core or four-core, suitable for conductor operating temperature not exceeding 80°C – IEC 60055-1 and IEC 60055-2.

C2.3 CONDUCTOR

Conductors of power cables shall be of high-conductivity copper and all meet the requirements of IEC 60228, IEC 60228A. Copper conductors shall be circular stranded.

The CSA of the neutral conductor shall not be less than that of the phase conductors, unless otherwise specified.

C2.4 ARMOUR

The armour shall be of galvanised steel single wire for multi-core cables. Single core cables shall be provided with non-ferrous sheathing and shall be without steel armour.

C2.5 OUTER COVERING

The armour of the cable shall be covered with extruded PVC oversheath.

In the range of fire performance cables to BS 6724, the compound for the oversheath shall be free from halogens and when tested to IEC 60754-1, the acidic gas evolved during combustion shall be less than 0.5% by weight of material and when tested in accordance with BS 2782 Method 141D, the oxygen index of both bedding and sheath shall be less than 30.

C2.6 IDENTIFICATION OF CORE

Each core of a PVC or XLPE power cable shall be identified continuously throughout its entire length.

For a mineral-insulated cable each core shall be identifiable at its termination by the application of sleeves or discs of appropriate colours as prescribed below. Identification sleeves shall comply with BS 3858, Type 3, where appropriate and shall have temperature rating similar to that of the sealant.

The identification shall take the form of appropriate colour or number codes in accordance with Table C2.6, or the relevant Specifications.

Table C2.6

Core Identification of Power Cables

Function of core	Colour code	Number code
Phase conductor of a single phase circuit	Red (or yellow* or blue*)	1
Phase conductor of a three-phase circuit	Red or yellow or blue according to phase concerned	1 or 2 or 3 according to phase concerned
Neutral conductor	Black	0
* In large installations, the colour yellow or blue may be used on the supply side of the final distribution board to denote the appropriate phase. Core used as protective conductors shall have an exclusive colour identification of green-and-yellow.		

C2.7 SPECIAL REQUIREMENTS FOR MINERAL INSULATED (MI) CABLE

C2.7.1 Outer Covering

MI cables shall have plastic outer covering when installed under the following conditions where:

- (a) the cables are exposed to weather;
- (b) the atmosphere is likely to cause corrosion;
- (c) the cables are laid upon or fixed direct to a concrete or stone surface subject to dampness;
- (d) the cables are laid upon or fixed to a zinc coated surface, e.g. a galvanised cable tray or corrugated sheeting, subject to dampness; and
- (e) the cables are buried direct in the ground.

MI cables buried in concrete brick or other building structure, installed in refrigerated space or areas where the temperature is persistently below 0°C shall be without plastic outer covering.

The outer covering shall be of low smoke halogen free, or low smoke zero halogen, i.e. evolving very low content of smoke or corrosive gases during combustion when tested to IEC 60754.

C2.7.2 Restriction of Use

MI cables shall not be used in discharged lighting circuits unless suitable precautions, approved by the Architect, have been taken to avoid excessive voltage. MI cables shall also not be used for earthed concentric wiring system.

C2.7.3 Cable Saddle and Clip

Saddles and clips for fixing MI cables shall be purpose-made by the cable manufacturer for this purpose. Cables with plastic outer covering shall be fixed by saddles or clips having also plastic covering.

C2.8 CABLE DUCT

Cable ducts shall be formed from concrete, PVC, metal or such other materials as may be specified by the Architect relating to a particular job.

Metallic ducting shall comply with the same requirement as metal trunking.

Ducts cast in-situ in concrete shall be so formed that the radial thickness of the concrete or screed surrounding the cross-section of the complete ducting shall not be less than 15 mm at every point.

C2.9 METAL CABLE TRAY

C2.9.1 Material

Metal cable trays shall be perforated, formed from plain steel sheet complying with BS 1449: Part 1, and shall be hot-dipped galvanised to ISO 1459, ISO 1460, ISO 1461 after perforation.

C2.9.2 Dimensions of Tray

Cable trays shall have typical dimensions as shown on Table C2.9.2.

Table C2.9.2

Typical Dimensions of Cable Trays

Nominal Width (mm)	Minimum height of upstand (mm)	Thickness of steel sheet (mm)	Minimum height of return flange (mm)
100 and 150	12	1.2	--
225 and 250	12	1.5	--
300 and 350	20	1.5	12
400 and 450	20	1.5	12
500 and 550	20	2.0	12
600 and 700	20	2.0	12
800 and 1000	20	2.0	12
1200	20	2.0	12

C2.9.3 Bend Piece

Bend pieces shall be of the same material, thickness and finish as the main body of the cable tray and shall have an inner radius of 50mm and a straight length of 100mm at each end.

C2.9.4 Perforation on Bend

No perforation shall be made in the circular portion of all bend pieces having a nominal width of 150mm or 100mm. Perforation may be allowed in bend pieces having a nominal width of 225mm or above provided that the perforation is made along a line passing through the centre of curvature of the bend pieces and set at an angle θ to the normal of the axis of the cable tray. The values of θ are shown in Table C2.9.4.

Table C2.9.4

Location of Perforation in Bend Piece of Cable Tray

Nominal width of cable tray	Value of θ
225 mm to 350 mm	45°
400 mm and above	30° and 60°

C2.9.5 Tee Piece

Tee pieces shall be of the same material, thickness and finish as the main body of the cable tray. The distance measured between the point of inter-section and the end of the tee piece shall not be less than 100mm.

C2.9.6 Cable Tray Accessory

Manufacturer's standard items of accessories shall be used. Site fabrication of accessories will only be allowed upon approval of the Architect and shall be kept to a minimum.

Where special sections are required, the material, thickness and finish shall be as specified for the standard items.

C2.10 CABLE LADDER

C2.10.1 Material

Generally, all cable ladder fittings and accessories mentioned below shall be manufactured from hot rolled steel to BS 1449: Part 1 and then hot dipped galvanised to ISO 1459, ISO 1460, ISO 1461 after fabrication.

For heavily corrosive environments where specified in the Contract, Specification or on the Drawings, cable ladder fittings and accessories shall be manufactured from stainless steel 316S31 to ISO 683/13.

C2.10.2 Fittings and Accessories

All fittings and accessories applied to the same cable ladder system shall be supplied by the same manufacturer to the same finish. In addition to straight ladders, the standard product range of the same cable ladder system shall at least include 90° bends, equal tees, four-way crossovers, 45° internal risers, 45° external risers, 90° internal risers, 90° external risers, straight reducers, left-hand offset reducers, right-hand offset reducers, various jointing couplers, various supporting brackets and hangers, various connectors, and various bolt and nuts.

C2.10.3 Construction of Cable Ladder

Cable ladder shall be of "heavy duty" type. The two rails shall be 90mm minimum in height with top and bottom flanges of sufficient strength. The rungs shall be spaced at 300mm centers maximum and shall have slots for cable fixing. The working depth (depth between top edge of rail and top surface of rung) shall be 60mm minimum.

SECTION C3

WIRING ACCESSORIES AND MEASURING INSTRUMENTS

C3.1 WIRING ACCESSORIES - GENERAL

Wiring accessories shall meet the general requirements of BS 5733. They shall be white or ivory in colour, uniform in colour and appearance throughout an installation.

Moulded box or pattress and steel or cast iron box for the enclosure of wiring accessories shall comply with IEC 60670 and shall meet the requirements specified in this Section and Sections B1, B3 & C1 of this Specification where appropriate.

C3.2 DOMESTIC SWITCHES

C3.2.1 General

Switch for domestic and similar purposes shall comply with IEC 60669-1.

Switch mounted outdoor, or in positions where it may be exposed to rain or water, shall be of watertight construction with minimum IP 54 protection in accordance with BS EN 60529.

C3.2.2 Lighting Switch

Lighting switch shall be of the microgap type suitable for use in a.c. circuits, and shall be of the quick make-and-break type when used in d.c. circuits. The front plate shall be of plastic insulating material. Suspension pear type switches shall not be used.

Lighting switch shall be single pole rated at 5A or 10A as specified in the Particular Specification or Drawings.

C3.2.3 Double Pole Switch for Appliance

Double pole switch shall be integrated with a pilot light formed by a neon lamp with a resistor and a red coloured lens.

C3.2.4 Sparkless Switch

Sparkless switch shall be of the tilting mercury type. The contacts of a sparkless switch shall be contained in a sealed glass capsule.

C3.2.5 Time Switch

Time switch shall be designed for outdoor operation with 24-hour dial inscribed with 15-minutes divisions. It shall be driven by a quartz oscillator synchronous motor or an electronic operated clock. Time setting shall be accomplished by plugging in setting pins and a minimum setting period of 15 minutes shall be achievable. All component parts shall be of robust design, constructed from durable materials and capable of maintaining proper functions and high accuracy and not subject to easy wear and tear during normal operation. The whole unit shall be encompassed in a metal or moulded box with ingress protection not less than IP53 to BS EN 60529. The box shall be suitable for wall mounting and entry of a 20 mm conduit. An inspection glass window and quick action fastener shall be fitted on the front lid of the box.

Time switch shall incorporate the following features:

- (a) The clock shall be of direct reading type with minute adjustable knob to set time precisely to the minute. Accuracy of the clock shall be within ± 15 sec per month.
- (b) A “long life” cassette type alkaline battery back-up device shall be incorporated to provide 360 hours continuous operation upon power failure.
- (c) The switch shall consists of single pole, single throw silver contacts capable of accommodating a minimum load of 20A at 250V a.c. resistive, 7.5A inductive at 0.7 power factor or 10A incandescent lamps. The contacts shall be capable of being isolated for external circuit connection.
- (d) A changeover switch shall be provided for selecting the ON/AUTO/OFF mode of operation.
- (e) Rated power consumption of the whole unit shall not exceed 2.5W.

C3.3 SOCKET OUTLETS

C3.3.1 General

Socket outlet and plug rated at 5A or 15A for general application shall comply with BS 546. Socket outlet and plug rated at 13A shall comply with BS 1363. All socket outlets shall be of 3-pin and shall be of the shuttered type. 5A socket outlets may be unshuttered provided they are installed on ceiling or at high level and are not normally accessible.

Socket outlet used for supplying appliance mounted at high level shall be unswitched, otherwise it shall be fitted with an integral switch. The integral switch shall be of single pole, forming part of the same front plate as the socket outlet, and with clear indication of the ON/OFF switching position.

Weatherproof type socket outlet shall comply with IEC 60309-2 and be provided with a push-on cap and cap retaining ring or a screw-on cap with rubber gasket. The socket outlet shall have ingress protection of at least IPX4 to BS EN 60529.

C3.3.2 Shaver Supply Unit

Electric shaver supply unit shall comply with EN 60742 and shall be all insulated, suitable for both flush and surface mounting. Each unit shall comprise two outlets, one for 110V and the other for 220V, obtained from tappings of a double wound transformer to BS 3535 and with unearthed secondary windings.

C3.3.3 Plug

Unless otherwise specified, plug for 13A socket outlet shall be fitted with a fuse to IEC 60269-1, rated at 13A.

Each plug shall be fitted with a cord grip which is so designed that no stress will be exerted on the conductors of the flexible cable connected to it at the terminals.

C3.4 CONNECTION UNITS

C3.4.1 Fused Clock Connector

Fused clock connector is used for connecting clock, fixed domestic fan, etc. of a rating not exceeding 3A. It shall be of two-pole type with earthing facilities. It shall incorporate a cartridge fuse link in the pole connecting to the phase conductor. The fuse shall comply with BS 646. The fuse carrier shall only be removable by the use of a tool.

C3.4.2 Switched or Unswitched Fused Connection Unit

The connection unit is intended for final connection to a fixed equipment or appliance which has a full load current not exceeding 13A. It shall be of double pole type with neon indicator meeting the requirements of BS 5733. It shall incorporate a fuse link to IEC 60269-1 rated to suit the appliance to be connected in the pole connecting to the phase conductor. An earth terminal shall also be provided for the connection of the circuit protective conductor to the appliance.

C3.5 INSULATED TERMINAL BLOCK

The rated voltage of a terminal block shall not be less than 435V between terminals and 250V to earth.

Terminal block shall comprise copper connectors with screw connections, all contained within a moulded block suitable for working temperature up to 100°C. Terminals shall be designed to clamp the conductors to the metal surface with sufficient contact pressure but without damaging the conductors. With the largest recommended conductor in position, and tightly clamped, there shall be at least two full threads of the screw engaging in the connector.

C3.6 LIGHTING SYSTEM

C3.6.1 Luminaire Track System

Luminaire track system shall comply with EN 60570: Part 2. It shall be designed for ordinary interior use for mounting on, or suspended from wall or ceiling. The track shall be of two or four-pole with provision for earthing, with a rated voltage not exceeding 250V a.c. to earth and a rated current not exceeding 32A per conductor for distribution to luminaires.

C3.6.2 Photocell Device

Photocell device shall comply with BS 667 and shall have good tolerances in physical dimensions and with no moving parts. An additional circuitry shall be provided to achieve a delay of at least 30 seconds so as to eliminate switching due to lightning or other short period changes in illumination.

C3.6.3 Ceiling Rose

Ceiling rose of maximum rating of 6A at 250V shall comply with BS 67 and shall be ivory or white moulding with outside diameter not less than 63mm and 50.8mm fixing centres, 3-plate pillar type with earth terminal and with integral cord-grip.

C3.6.4 Lampholder

Batten lampholder shall comply with BS EN 61184, of all-insulated bayonet socket pattern manufactured from moulded hard white or ivory colour plastic material which shall be unaffected by the heat from the lamp. It shall be fitted with a shade-carrier ring, a ventilated shield or a white plastic cone as required. White moulded plastic break joint rings shall be used.

Cord grip lampholder shall comply with BS EN 61184 and shall be white or ivory in colour, fitted with cord grip so designed that no stress shall be taken by the conductors or terminals. Lampholder shall be of all-insulated bayonet socket pattern fitted with shade carrier ring, a ventilated shield or a moulded white plastic cone as required. It shall be suitable for PVC insulated and sheathed, circular flexible cable of not less than 0.75 mm² size. White moulded plastic break joint rings shall be used.

Lampholder for weatherproof luminaire shall be porcelain and comply with BS EN 61184.

Lampholder for use with tubular fluorescent lamp shall be of bi-pin type, complying with EN 61184, EN 60061-1 and EN 60061. It shall be made of moulded white plastic material and designed to hold the tube in position without the need for additional clip.

C3.7 MEASURING INSTRUMENT

C3.7.1 Watt-hour Meter

Watt-hour meter shall comply with EN 60521. The register shall be of drum type and the principal unit in which the register records shall be in kilowatt-hours (kWh). The casing shall be of black phenolic moulding with an inspection glass window.

Watt-hour meter shall have Class 2 accuracy calibrated at the normal working voltage and frequency.

C3.7.2 Ammeter and Voltmeter

Ammeter and voltmeter shall be of moving iron type, moving magnet type or moving coil with transducer type complying with IEC 60051-1 to IEC 60051-9. The accuracy class shall be "2.5" or better in accordance with IEC 60051-1 to IEC 60051-9. The dial shall have a nominal diameter of 100 mm and shall have a total scale deflection of 240° for ammeter and 120° for voltmeter.

An ammeter for any circuit of rating up to 60A may be connected directly in series with the circuit, so that the full circuit current passes through the instrument. For a circuit of rating exceeding 60A, the ammeter shall be fed through the secondary winding of a current transformer, and shall give a full scale deflection with a secondary current of 5A.

C3.7.3 Current Transformer

Current transformer for use with measuring instrument shall comply with BS EN 60044-1 or EN 60044-1 having rated secondary current of 5A and rated output suitably matched with the loading of the measuring instrument. The accuracy class shall be "1" in accordance with BS EN60044-1 or EN 60044-1.

C3.7.4 Selector Switch for Ammeter

Where a single ammeter is used to measure the current in each phase or the neutral of a three phase circuit, the ammeter shall be connected to a selector switch which shall enable the ammeter to be inserted in series with each phase and the neutral in turn. When the ammeter is connected to the secondary windings of the measuring current transformers, the selector switch shall have facilities to prevent the current transformers from being open circuited during change-over and at "OFF" position.

C3.7.5 Selector Switch for Voltmeter

In a three phase circuit in which a single voltmeter is used to measure the various voltages, the voltmeter shall be provided with a selector switch to enable the following voltages to be measured:

- (a) voltage between each phase to neutral
- (b) voltage between any two phases

The selector switch shall also have an "OFF" position.

C3.7.6 Meter Chamber

Meter chamber for housing watt-hour meter shall be made from galvanized steel of not less than 1.6 mm thick and shall be of ample size to accommodate the required number of watt-hour meters and meter cables. Provision shall be made to enable the watt-hour meters to be fixed inside the chamber without removing the chamber from the wall or other supports. Meter fixing screws shall not project through the back of the chamber.

When a meter chamber is installed indoor, it shall be fitted with a hinged metal front cover. Meter chamber installed outdoor shall be waterproof, with screw-on type front cover. The ingress protection for the outdoor type shall be at least IP 54 in accordance with BS EN60529.

A glass window of adequate size shall be provided on the front cover of the meter chamber to enable the registers and serial numbers of the watt-hour meters to be read easily.

SECTION C4

SWITCHGEAR AND ASSOCIATED EQUIPMENT

C4.1 GENERAL

C4.1.1 Scope

This Section specifies the general requirements of switchgear and associated equipment operating at low voltages, which may be assembled on site from individual items of components. The switchgear and associated equipment shall be manufactured to the relevant current International Electrotechnical Commission (IEC) Standards as indicated below:

IEC 60947 : Low voltage switchgear and control gear

IEC 60947-1 : General rules

IEC 60439-1 : Type-tested and partially type-tested assemblies

Other requirements as specified in Sub-sections C4.1.2 to C4.1.8, both inclusive, shall also apply to all items of switchgear and associated equipment where applicable unless explicitly mentioned elsewhere.

Additional and specific requirements for type-tested low-voltage switchgear and controlgear assemblies (TTA) as described in IEC60439-1 shall be given in Annex A to this Specification, the Particular Specifications, the Drawings and other documents issued by the Architect.

The component equipment covered in this Section shall include the following:

- (a) Switches, disconnectors (isolators), fuse-switches and switch-fuses
- (b) Circuit-breakers comprising air circuit-breakers (ACB), moulded case circuit-breakers (MCCB), miniature circuit-breakers (MCB), residual current-operated circuit breakers without integral overcurrent protection (RCCB) and residual current-operated circuit breakers with integral overcurrent protection (RCBO)
- (c) Fuses
- (d) Busbar chambers and distribution boards including fuseboards
- (e) Electromechanical contactors, motor starters and automatic changeover switches

C4.1.2 Service Condition

The following service conditions shall apply:

- (a) Ambient temperature - peak from minus 5°C to plus 40°C for 4-hours continuously with an average from 0°C to plus 35°C over only 24 hours period
- (b) Altitude - up to 2000 m above sea level
- (c) Relative humidity - up to 0.99 saturation
- (d) Pollution Degree 3 - Conductive pollution occurs, or dry, non-conductive pollution occurs which becomes conductive due to condensation.

C4.1.3 Short-circuit Rating and Continuous Current Rating

Switchgear shall be suitably rated for the specified prospective short-circuit current which can occur at the point of its installation. It shall also be rated for uninterrupted duty when carrying continuously the specified full load current. For non-automatic switching devices, the rated short-time withstanding current shall be at least 12 times of the maximum rated operational current for 1 second.

Where equipment components are installed in enclosures, they shall be suitable for operation at the actual maximum temperatures which will be reached within the enclosures under normal loaded conditions when the ambient temperature is 40°C.

C4.1.4 Voltage Rating

Same as specified in Sub-section A1.3 above.

C4.1.5 Degree of Protection for Enclosure

Enclosures for switchgear and associated equipment shall be of totally enclosed type. For indoor applications, the enclosure shall have an ingress protection (IP), in accordance with IEC 60529, of at least IP 41 for the top surface and IP 31 for the other surfaces of the enclosure. For outdoor applications, the enclosure shall be of at least IP 54.

C4.1.6 Material

Unless otherwise specified, switchgear and associated equipment except MCCB and MCB shall be of metalclad. All ferrous metal parts shall be galvanised or chrome plated unless the final finish has been painted or enamelled in the manufacturer's factory.

All extraneous conductive parts shall be electrically continuous.

C4.1.7 ON and OFF Indication

The design of a switching device shall incorporate positive means to indicate clearly and reliably the ON (or CLOSE) and the OFF (or OPEN) positions of the contacts. Indication of either position shall only occur when the ON or OFF position on every pole has been attained. Such indication shall be provided on the outside of the device and shall be prominently visible to an operator when the device is installed in the normal manner.

When the switching device is also used for isolation purpose, then an indication of the OFF position shall occur only when all contacts are also in the OFF position and the isolating distance between contacts in every pole has attained a clearance not less than those specified for disconnectors according to IEC 60947-3.

C4.1.8 Identification of Circuit

Labels or other means of identification shall be provided for every item of switchgear and associated equipment to indicate the purpose of the item. The labels shall either be fixed at the front cover of the equipment or at the inside surface of the hinged front cover.

C4.2 SWITCH, DISCONNECTOR, FUSE-SWITCH AND SWITCH-FUSE

C4.2.1 Scope of Switch

All reference to switches in this and subsequent Sub-sections shall include also fuse-switches or switch-fuses.

C4.2.2 General

Switches, disconnectors, fuse-switches and switch-fuses shall comply with and be tested to IEC 60947-3 and shall have air-break type contacts which are designed for uninterrupted duties. They shall be either three pole with switched neutral (four-pole), triple-pole with neutral link, double-pole, or single pole with neutral link as specified, and shall each be fitted with earthing facilities. All live parts shall be efficiently shrouded with insulating materials. Cam switches or disconnectors shall not be used for circuits of 50A or above.

Each switch shall be supplied in complete unit consisting of a basic unit contained within an enclosure. Adequate space shall be provided in the enclosure for proper cable termination, otherwise cable boxes shall be provided. Fuse carriers, when required, shall be included.

C4.2.3 Operating Mechanism

Switches and disconnectors shall be of the quick-make and quick break type. The switching mechanism shall be of independent manual operation with suitable means such as accelerating springs.

For switches and isolators with switched neutral, the neutral pole shall open after the phase pole contacts and shall close before or at the same time as the phase pole contacts.

C4.2.4 Construction

The enclosure shall be of totally enclosed type, made up of heavy gauge sheet metal, adequately rust and dust protected, and finished in enamel. An earthing terminal shall be provided. The enclosure shall be suitable for conduit, trunking and armoured cable entries and also for connection to busbar chamber from top or bottom. Frame sizes for the range of switches shall be kept to a minimum.

Switches and isolators shall be constructed with an interlocked front cover to prevent access to the interior parts of the equipment when the contacts are in the CLOSE position, and to prevent the contacts from being switched to close when the front cover is opened. However, facilities shall be provided to allow the checking of the contact alignments. The fastening devices for the front cover shall be of captive type.

Insulation material used shall be of non-hygroscopic and non-ignitable type. The contacts shall be self-aligning so that contact pressure can be maintained at all times. All live parts shall be adequately shielded from the front of the unit but easily accessible for maintenance by using a tool.

C4.2.5 Operating Performance

The operating performance of the switches and disconnectors shall be tested in accordance with IEC 60947-3. The number of operating cycles corresponding to the rated operational current shall not be less than the values given in Table IV of IEC 60947-3.

C4.2.6 Utilization Category

Switches shall be to utilization categories of AC-22A or AC-22B for general applications and AC-23A or AC-23B for electrical motor circuits; unless otherwise specified.

C4.2.7 Padlocking Facility

Switches and disconnectors shall be fitted with padlocking facilities so that they can be padlocked in either ON or OFF position.

C4.3 CIRCUIT BREAKER - GENERAL

C4.3.1 Scope of Circuit Breaker

This Sub-section covers the general requirements of ACB, MCCB, MCB, and RCCB and RCBO. Additional requirements relevant to a particular type of circuit breakers shall be given in Sub-sections C4.4 to C4.7, both inclusive.

C4.3.2 Number of Poles

Circuit breakers shall be of triple-pole with switch neutral (four-pole), three-pole, double-pole or single-pole, as specified, and shall have air-break contacts. All poles, except the neutral poles, shall be designed to have their contacts open or close simultaneously.

C4.3.3 Operating Mechanism

The operating mechanism of a circuit breaker shall be trip-free.

When a MCCB, MCB, RCCB or RCBO trips and opens its contacts, the operating toggle shall automatically resume the OFF or TRIPPED position.

C4.3.4 Casing

The casing of an ACB shall be metalclad.

The casing of a MCCB, MCB, RCCB or RCBO shall be formed from insulating material. The construction shall be capable of withstanding the appropriate rated short circuit current and reasonably rough use without fracture or distortion.

C4.3.5 Current Rating

The rated current of a circuit breaker shall be taken as that rated continuous current when the circuit breaker is installed in the enclosure together with other equipment if any under normal operating conditions as specified in the Particular Specification.

C4.4 AIR CIRCUIT BREAKER (ACB)

C4.4.1 General

All circuit breakers shall not be of moulded case type. The neutral pole shall have cross-sectional areas not less than that of respective phase pole.

ACB shall be of triple-pole with switch neutral (four pole) or triple-pole with bolted neutral, as specified, fully metalclad with earth terminals. It shall be of horizontally withdrawable type having spring assisted closing and, where specified, motorised spring charger and push-button electrical control.

ACB shall comply with and be type tested to IEC 60947-2.

Unless otherwise specified, ACB shall have built-in overload protection with IDMT characteristics and instantaneous short circuit interruption. Where an ACB is used as the main incomer, the IDMT characteristics shall be compatible with those of the Electricity Supplier.

C4.4.2 Performance Characteristic

ACB shall be certified, in accordance with IEC 60947-2, to have the following performance characteristics:

- (a) Rated short-circuit breaking capacity - not less than 50 kA
- (b) Rated short-circuit making capacity - not less than 105 kA
- (c) Rated short-time withstanding current - not less than 50 kA for 1 second

C4.4.3 Closing and Tripping Operation

Unless otherwise specified, ACB shall be suitable for independent manual operation utilizing energy stored in a spring. For automatic closing ACB, the spring mechanism shall be wound by a universal motor fitted with limiting switches. In addition, the spring mechanism shall have manual charging facilities for emergency use. All ACBs shall have slow closing mechanism for contact checking.

Unless otherwise specified, trip coil of 30V d.c. shall be fitted for local, remote or relay tripping.

"Trip" push buttons shall be provided on the front plate of each ACB. These buttons shall be direct acting mechanically.

When automatic closing is specified, the control circuit of the ACB shall be fitted with suitable anti-pumping devices.

C4.4.4 Racking Gear

The enclosure shall be fitted with a set of racking gear which shall lock the ACB to the runner rails in three distinct positions, i.e. CONNECTED, TEST and ISOLATED. The ACB can only be closed fully when it is in the CONNECTED position. In the TEST position, it shall be possible to operate the ACB (for ACB with motorised charging spring only) to close and test the secondary and auxiliary contacts, but not the main isolating contacts.

The racking gear shall consist of rollers fitted to the ACB frame. All parts shall be accurately aligned and adjusted so that the ACB can be moved freely along the runner rails within the enclosure between the two extreme positions, i.e. CONNECTED and ISOLATED. Facilities shall be provided to padlock the ACB in its CONNECTED, TEST or ISOLATED position.

Position indicators and breaker-condition indicators shall be provided. These indicators shall be arranged so as to be prominently visible when the ACB is in its normally installed position.

C4.4.5 Interlocking Facility

Suitable interlocking facilities shall be provided such that:

- (a) the ACB cannot be plugged in or withdrawn when it has been closed;
- (b) the ACB cannot be closed until it is fully engaged in either the CONNECTED or the TEST position;
- (c) the ACB cannot be slowly closed except in the TEST or ISOLATED position;
- (d) it shall not be possible to initiate the closing action of the energy stored spring mechanism until the spring has been fully charged.
- (e) Where key interlocking is employed, tripping of a closed ACB shall occur if an attempt is made to remove the trapped key from the mechanism.

C4.4.6 Main Isolating Contacts and Safety Shutter

The main isolating contacts shall be self-aligning and shall be protected by insulated barriers forming the safety shutter.

Two sets of safety shutters shall be provided for every ACB, one for the incoming terminals of the main isolating contacts and the other for the outgoing terminals. Each set shall be capable of being operated individually.

When the ACB is not in the CONNECTED position, the safety shutters shall close automatically, screening off the main isolating contacts. When the ACB is being racked into the CONNECTED position, the safety shutters shall automatically open the insulating barrier, thereby allowing the entry of the movable isolating contacts but without lowering the degree of protection.

Safety shutters shall be fitted with properly designed and securely fixed warning labels. In addition, facilities shall be provided to padlock the safety shutters after the ACB has been withdrawn from the enclosure.

C4.4.7 Contact

All contacts shall be self-aligning, provided with spring accelerated opening mechanism.

Main contacts shall be fitted with detachable arc chutes for each pole. Sufficient auxiliary contacts shall be provided for connection of secondary wiring. These auxiliary contacts shall remain engaged when the ACB is in the TEST or CONNECTED position and shall be disengaged when the ACB is in the ISOLATED position.

All ACB shall be fitted with the maximum number of auxiliary contacts as the manufacturer's standard provision. In any event, not less than two pairs of normally-closed auxiliary switches and two pairs of normally-open auxiliary switches shall be provided. All auxiliary contacts and switches shall be wired to an easily accessible terminal strip for external connection.

Terminals for external connections of the secondary/auxiliary contacts and switches shall be of clamping yoke type for wires of minimum CSA of 1.0mm². All terminals shall be clearly labelled to identify the function of the circuits connected to the terminals.

Terminals for each ACB for secondary/auxiliary contacts shall be separated from all other terminals by means of a spacer of 20 mm width.

C4.5 MOULDED CASE CIRCUIT BREAKER (MCCB)

C4.5.1 General

MCCB shall be of four-pole, triple-pole or double-pole as specified. It shall comply with and be type-tested to IEC 60947-2. It shall be totally enclosed in a moulded casing formed from an insulating material. The construction of the casing shall be capable of withstanding the appropriate rated short circuit current and reasonably rough use without fracture or distortion. The moulded casing shall have an ingress of protection not less than IP 30. Utilization category for those MCCB with built-in protection shall be class B, unless otherwise specified in the Particular Specification or on Drawings.

MCCB shall either be an individual isolating unit or incorporate overcurrent and earth fault protection as specified with shunt trip coil operated by protection relays.

C4.5.2 Operating Characteristic

MCCB with built-in protection shall have thermal-magnetic, hydraulic magnetic or solid state tripping device which features a fixed, stable,

inverse time-current characteristic. The operating characteristic shall be such that:

- (a) the time delay on overload tripping shall be inversely proportional to the overcurrents up to a threshold value of approximately 7 times the rated current;
- (b) there shall be no intentional time-delay on overcurrent tripping due to short-circuit or heavy overcurrent exceeding the threshold value (i.e. approximately 7 times the rated current).

The operating characteristics shall be calibrated at 40°C.

When MCCB is specified to be completed with earth leakage tripping device, the tripping current shall be as specified in the Particular Specification or on the Drawings. The earth leakage relay and the zero-sequence current transformer, if any, shall comply with the relevant IEC Standards.

C4.5.3 Performance Characteristic

MCCB shall be certified, according to IEC 60947-2, to have the following performance characteristics:

Rated short circuit breaking capacity - not less than the values given in the Table C4.5.3.

Table C4.5.3

Rated Short Circuit Breaking Capacity of MCCB

Frame size	Tested short-circuit breaking capacity	Tested at power factor of:
100A	23 kA	not exceeding 0.30 lagging
225A	23 kA	not exceeding 0.25 lagging
400A	23 kA	not exceeding 0.25 lagging
> 400A	40 kA	not exceeding 0.25 lagging

C4.5.4 Shunt Trip Release

Where shunt trip release is specified, this shall operate correctly at all values of supply voltage between 70% and 110% of the nominal supply voltage under all operating conditions of the MCCB up to the rated short-circuit breaking capacity of this MCCB. MCCB incorporating shunt release shall be provided with block terminals and shunt release lead cables.

C4.5.5 Locking Facility

MCCB shall be provided with facility for padlocking in either the "ON" or "OFF" position.

C4.6 MINIATURE CIRCUIT BREAKER (MCB)

C4.6.1 General

MCB shall be of four-pole, triple-pole, double-pole or single-pole as specified. It shall comply with and be type tested to IEC 60898. It shall be totally enclosed in a moulded insulating case for safe use by unskilled people and also designed to be maintenance free. Overall dimensions and fixing centres for the same range of MCB shall be identical and suitable for fixing individually to a metal back plate or directly mounted inside a manufacturer's designed distribution metal box.

Cable terminals of the MCB shall be at top and bottom of the units with access from front, and suitable for terminating the size of solid or stranded conductor in accordance with Table 4 of IEC 60898.

MCB with current carrying contacts of plug-in type shall not be accepted.

Contacts of the MCB shall be of non-weld type.

C4.6.2 Operating Characteristic

The operating mechanism of a MCB shall be thermal-magnetic, designed to give a fixed, stable, inverse time-current characteristic in accordance with Table 6 of IEC 60898. The calibration temperature shall be 30°C. The classification according to rated instantaneous tripping current shall be Type B, except for motor circuit application where Type C shall be provided and 6A circuits in which either Type B or Type C may be acceptable.

C4.6.3 Short Circuit Breaking Capacity

The rated short circuit breaking capacity shall be certified, in accordance with IEC 60898, to have at least 6000A of rated short circuit capacity. In addition, energy limiting class of MCB shall be of class 3 in accordance with table ZA1 and ZA2 of IEC 60898 or BS EN 60898. MCB shall be capable of being connected in cascade with fuse to IEC 60269 or BS 88 up to a rating of 160A in situation where the prospective short circuit current at the supply side is up to 22 kA.

C4.7 Residual Current-operated Circuit Breaker without Integral Overcurrent Protection (RCCB) and Residual Current-operated Circuit Breaker with Integral Overcurrent Protection (RCBO)

C4.7.1 RCCB - General

Residual Current-operated Circuit Breaker without Integral Overcurrent Protection (RCCB) shall be double-pole or four-pole as specified, type tested to BS EN 61008 or IEC 61008. The casing of RCCB shall be constructed of totally enclosed moulded-case insulating material to withstand the fault level as certified to BS EN 61008.

The RCCB shall be suitable for use at ambient temperature between -5°C and +40°C. It shall be designed to the rail mounting method inside the distribution board with the other protective devices side by side.

C4.7.2 RCCB - Electrical and Operating Characteristics

The rated current of RCCB shall be 10A, 13A, 16A, 20A, 25A, 32A, 40A, 63A and 80A as shown on the Particular Specification or Drawings. Unless otherwise specified, the rated residual operating current shall be 30mA.

RCCB shall have minimum short circuit making and breaking capacity of 3000A with rated residual making and breaking capacity to be ten (10) times the rated current of RCCB or 500A, whichever is the greater.

Tripping operation of RCCB shall not involve amplification of operating residual current and shall be independent of the line voltage.

Operating characteristic of RCCB shall be of type a.c. as specified in BS EN 61008 for which tripping is ensured for residual sinusoidal alternating current, whether suddenly applied or slowly rising. Type A RCCB shall be provided as specified in case of residual currents with d.c. components.

RCCB shall be instantaneous tripping type without time delay function.

Multi-pole RCCB shall be interlocked internally such that an earth leakage current through any one phase shall trip all the poles of the RCCB simultaneously.

C4.7.3 RCCB - Test Device

An integral test device shall be provided on the front of every RCCB to enable automatic tripping operation be tested. Operation of the test device shall create “out-of- balance” condition simulating an earth fault.

C4.7.4 RCBO – General

Residual current operated circuit-breaker with integral overcurrent protection (RCBO) shall be double-pole or four-pole current operated circuit breaker as specified and housed in a totally enclosed moulded-case type tested to BS EN 61009 or IEC 61009. The RCBO shall be suitable for use at ambient temperature between -5°C and +40°C. It shall be designed to the rail mounting method inside the distribution board.

C4.7.5 RCBO – Electrical and Operating Characteristics

Technical requirement of RCBO shall refer to Sub-section C4.7.2 “RCCB – Electrical and Operating Characteristic”, in addition to the overcurrent requirement as detailed in this Sub-section.

RCBO shall have minimum short circuit making and breaking capacity of 6000A with rated residual making and breaking capacity to be ten (10) times the rated current of RCBO or 500A, whichever is the greater. In addition, energy limiting class shall be of class 3 in accordance with table ZD1 and ZD2 of IEC 61009 or BS EN 61009.

Unless otherwise specified, RCBO shall have instantaneous tripping characteristic of type B, except for application of motor circuit or high inrush current situation where type C shall be provided. The calibration temperature shall be 30°C.

Multi-pole RCBO shall be interlocked internally such that an earth leakage current through any one phase shall trip all the poles of the RCBO simultaneously.

C4.7.6 RCBO - Test Device

An integral test device shall be provided on the front of every RCBO to enable automatic tripping operation be tested. Operation of the test device shall create “out-of- balance” condition simulating an earth fault.

C4.8 FUSE

C4.8.1 Scope of Fuse

All references to fuses shall include fuses forming part of a fuse-switch, a switch-fuse or a fuseboard.

C4.8.2 General

Fuse shall comply with, and be type tested to, the following IEC and British Standard Specifications, where appropriate:

- (a) IEC 60269 or BS 88 - Low-voltage fuses.

- (b) BS 3036 - Semi-enclosed electric fuses (ratings up to 100A and 240V to earth)

C4.8.3 Fuse Carrier and Holder

Fuse carrier and fuse holder shall be constructed of ceramic porcelain or thermoplastic. Plastic units shall be unaffected by heat generated by an overloaded fuse or by a blown fuse. Fuse carrier shall be so designed that there is no risk of touching live parts when the fuse is being withdrawn.

The maximum rating of a fuse inserted in a fuse holder shall not be greater than the rating for which the holder is designed.

C4.8.4 Semi-enclosed Fuse

Semi-enclosed fuse shall not be used unless specified by the Architect. In any case, a semi-enclosed fuse shall not be rated in excess of 30A.

Element of a semi-enclosed fuse shall be provided in accordance with the manufacturer's instructions. In the absence of such instructions, the element shall be of plain or tinned copper wires having appropriate diameters as specified in Table C4.8.4.

Table C4.8.4

Sizes of Tinned Copper Wire for Use in Semi-enclosed Fuses

Nominal current of fuse element (A)	Nominal diameter of wire (mm)
3	0.15
5	0.2
10	0.35
15	0.5
20	0.6
25	0.75
30	0.85
45	1.25
60	1.53
80	1.8
100	2.0

C4.8.5 Cartridge Fuse to IEC 60269 or BS 88

Cartridge fuses to IEC 60269 or BS 88 shall have a rated breaking capacity of 50kA at rated voltage and the Utilisation Category shall be of "gG" unless otherwise specified. All dimensions shall be standardized in accordance with Figure 1 of IEC 60269-2-1 or Section 2.1 of BS 88.

C4.9 BUSBAR CHAMBER

C4.9.1 General

Busbar chambers shall comply with, and be type tested to IEC 60439-1 and IEC 60439-2.

Busbar chambers with rated operational currents above 400A shall be typed tested to a short time current capacity equivalent at least to that of the incoming switchgear and type tested to the rated operational current.

C4.9.2 Construction

A busbar chamber shall contain 4 sets of fully sized, hard drawn, high conductivity, solid electro-tinned copper busbars and supported on epoxy resin or other approved insulators. The busbar chamber shall be totally enclosed and manufactured from sheet steel suitably rust-proofed and painted or hot-dip galvanised. The thickness of sheet steel shall not be less than 1.5 mm for current rating not exceeding 500A, and not less than 2 mm for current rating of 500A and above. The front cover and end plates shall be removable and normally held in position by non-ferrous metal screws.

C4.9.3 Colour Identification of Busbar

Each busbar shall be coloured to indicate the phase to which it is connected. Colouring shall comprise a band of paint on the busbar at intervals of not more than 600 mm, but the busbar shall not be painted throughout its length.

C4.9.4 Interconnection to Other Equipment

Items of switchgear or associated equipment shall be connected or jointed to a busbar chamber by means of properly designed connection flanges having similar material and finish of the busbar chamber, or by means of conduit couplers and bushes complying with Section B1.

Interconnection cables between a busbar chamber and other items of switchgear or associated equipment shall be of copper conductors and shall be sized in accordance with IEC 60439-1 and IEC 60439-2 or IEC 60364.

C4.10 DISTRIBUTION BOARD - GENERAL

C4.10.1 Scope of Distribution Board

This Sub-section covers the general requirements of MCCB distribution boards, MCB distribution board and fuseboards. Additional requirements relevant to a particular type of distribution board shall be given in Sub-sections C4.11 to C4.13 inclusive.

C4.10.2 Construction of Enclosure

The enclosure of a distribution board shall be constructed from sheet steel, rust proofed and epoxy powder painted or baked enamelled finish to a colour approved by the Architect. Conduit knock-outs shall be provided on the top and bottom.

The construction shall be of robust design, capable of withstanding the mechanical, electrical and thermal stresses under all working conditions, including fault conditions.

C4.10.3 Arrangement of Component Parts

Distribution board shall include all necessary components and accessories to form a complete assembly. Components and accessories shall be firmly fixed in position in the distribution board, and shall be assembled in such a way that it shall be possible to remove or replace any component parts and to carry out cable connection from the front. Ample space shall be allowed for cabling. MCCB, MCB or fuses shall be arranged neatly in a row or rows. All components shall be totally concealed. Only the toggles of the MCCB, MCB, RCCB or RCBO shall protrude through the cover plate of the distribution board.

C4.10.4 Busbar

All busbar shall be of hard drawn copper having ratings as specified, and shall be electro-tinned. Neutral busbars shall have CSA not smaller than that of the phase busbars, and shall have adequate number of terminals for all outgoing circuits including spare ways.

C4.10.5 Earthing Terminal

Every distribution board shall be provided with an external earthing terminal. In addition, a multi-terminal connector shall be provided within the distribution board for connection of protective conductors of all outgoing circuits including spare ways.

Both the external earthing terminal and the multi-terminal connector for protective conductor shall be of hard drawn, electro-tinned copper and shall be labelled in accordance with the requirement of IEC 60439-1.

C4.10.6 Provision of Spare Ways

Each distribution board shall be provided with spare ways for future expansion. For new installations, the number of spare ways shall not be less than 20% of the total number of outgoing ways in the distribution boards. Each spare way shall be blanked off with a suitable blanking plate having a finish comparable to that of the distribution board.

C4.10.7 Shrouding of Live Part

All conductive parts shall be properly shrouded against accidental contact by means of rigid barriers, partitions of insulating materials such that accidental contact can be prevented during operation of component replacement or cable connection.

All conductive structural parts of the distribution boards shall comply with the protective circuit requirements of IEC 60439-1.

C4.11 MCCB DISTRIBUTION BOARD

C4.11.1 General

The enclosure of an MCCB distribution board shall be constructed from sheet steel having a thickness of not less than 1.5 mm, and shall be designed for general commercial and light industrial applications. The enclosure shall be designed with ingress protection not less than IP 41.

The design, construction and testing specifications of the distribution board shall comply with IEC 60439-1.

C4.11.2 Type of MCCB Distribution Board

MCCB distribution board shall be of two types, viz. Type A and Type B. Type A MCCB distribution board shall be suitable for accommodating, in any combination, the double-pole and triple-pole MCCB of 100A and 250A frame size respectively. Type B MCCB distribution board shall be suitable for accommodating triple-pole MCCB of 250A frame size.

MCCB distribution board shall each be provided with a moulded-case isolating switch having a current rating not less than that of the supply side protective device. Moulded-case isolating switch shall meet the relevant requirements of Sub-sections C4.1 and C4.2.

C4.11.3 Busbar

MCCB distribution board shall be provided with vertical triple-pole and neutral copper busbars of rating not less than that of the supply side protective device subject to a minimum of 250A. The configuration of the busbars, busbar supports and busbar mounting arrangement shall be type tested to a short-time withstand current in accordance with Table C4.11.3 at a voltage of not less than 380V.

Table C4.11.3
Busbar Short-time Withstand Current for MCCB Distribution Board

Type of board	No. of outgoing circuits	Busbar rated current	Busbar rated S.C. withstand current
A	up to 12	250 A	23 kA for 0.2s
A	up to 36	400 A	23 kA for 0.2s
B	up to 12	400 A	23 kA for 0.2s
B	up to 36	630 A	43 kA for 0.2s

Outgoing MCCB shall be mounted horizontally on both sides of the vertical busbars. The connection between the MCCB and the phase busbars shall be by means of copper tapes and bolted joints.

C4.12 MCB DISTRIBUTION BOARD

C4.12.1 General

The enclosure of a MCB distribution board shall be constructed from sheet steel having a thickness of not less than 1.2 mm, and shall be designed for general commercial and light industrial applications. The ingress protection for the enclosure with the functional units and blanking plates fitted shall be at least IP 41.

The design and construction of MCB distribution boards shall comply with and be type tested to IEC 60439: Part 3.

C4.12.2 Construction

The moulded back plate assembly shall be of substantial thickness and attached to the back of the enclosure for mounting of MCB, RCCB, RCBO and double pole or triple pole all insulated switch as specified.

MCB distribution board shall be provided with a moulded-case, all-insulated, double-pole or three-pole incoming switch-disconnector (isolating switch) having a current rating of not less than that of the supply side protective device. This incoming switch-disconnector shall meet the relevant requirements of Sub-section C4.1 and C4.2 with a Utilization Category of AC-22A. However, switch-disconnector of Category AC23A shall be provided in event of any one of the outgoing circuits being fed for motor circuit.

Ferrules shall be provided for wires, including earthing, phase and neutral conductors, throughout the distribution board internally for circuit identification.

The metal front plate shall be screwed onto the metal box, making the assembly suitable for surface or flush mounting, and shall be supplied with a hinged cover to conceal all operating handles of the circuit breakers and isolating switch. The front plate shall be affixed with phase colour labels and circuit identification chart, and shall be supplied with moulded single way blanking plates.

MCB distribution board shall be provided with phase, neutral and earthing terminals for the incoming cables. There shall be one neutral and one earthing terminal for each outgoing MCB circuit and spare ways.

C4.12.3 Method of Mounting

MCB distribution board shall be suitable for flush or surface mounting as specified. Flush mounting shall be so arranged that the assembly is flush with the surface of the wall and shall not cause any adverse effect to the heat dissipation of internal devices.

C4.13 FUSEBOARD

C4.13.1 General

Fuseboard shall utilise cartridge fuses to IEC 60269 or BS 88. The use of semi-enclosed fuses shall not be permitted.

Fuseboard shall comply with BS EN 60439-3 and shall be type tested and certified to have a fused short circuit current of not less than 16.5kA at a power factor of not exceeding 0.3 lagging.

Individual outgoing circuits shall have rated currents not exceeding 200A.

C4.13.2 Construction

Fuseboard shall be totally enclosed, constructed from sheet steel having a thickness of not less than 1.5 mm. The front cover shall be hinged or screwed-on, and access to the fuses for replacement shall only be possible after the front cover is opened or removed.

C4.13.3 Shrouding of Live Part

Fuseboard shall be fully shrouded so that:

- (a) additional circuits can be wired and connected in safety whilst the existing circuits remain alive and on load;
- (b) when the door of the fuseboard enclosure is open, there will be no possibility of accidental contact with any live parts whilst fuse carriers, etc. are fitted into their bases and whilst any insulation barriers, etc. are correctly fitted;
- (c) fixed contacts of the fuse bases are screened to satisfy the ingress protection of IP20 of IEC 60529 even when the fuse carriers are removed from their bases.

C4.14 ELECTROMECHANICAL CONTACTORS AND MOTOR STARTERS

C4.14.1 General

Electromechanical contactor and motor starter shall comply with and be type tested to IEC 60947-4-1. Each shall be of double air-break type with four pole, triple-pole, double-pole or single pole contacts as specified.

Motor starter shall be of air-break triple-pole electromagnetic type. Unless otherwise specified, each starter shall comprise an isolating device, a thermal overload protective device, main and auxiliary contacts, on/off controls and indications.

Both the main and auxiliary contacts shall be rated for uninterrupted and intermittent duty. The main contact of a contactor or starter shall be silver or silver-faced.

Contactor and starter shall each have utilization category suitable for the particular application as shown in Table I of IEC 60947-4-1.

C4.14.2 Performance Requirements

Contactor and starter shall each be capable of making and breaking currents without failure under the conditions stated in Table VII and VIII of IEC 60947-4-1 for the required Utilization Categories and the number of operation cycle indicated.

C4.14.3 Co-ordination with Short-circuit Protective Devices

Contactor and starter shall comply with the requirements for performance under short-circuit conditions stipulated in IEC 60947-4-1. Type of co-ordination shall be Type “1” unless otherwise specified.

C4.14.4 Control Circuit

Rated control circuit voltage of a contactor shall be the same as that of the main circuit; otherwise, it shall be 24V, 30V or 110V d.c. as specified.

C4.14.5 Overload Relay

Overload relay for a starter shall be of thermal type unless otherwise specified. The trip class of starters shall be according to the classification in Table II of IEC 60947-4-1. Overload relay shall be able to operate at an ambient air temperature of 40°C and have a setting range of 50%-150% rated operational current.

C4.14.6 Auxiliaries

For an assisted start starter, timer shall be of solid state plug-in type with 0 -15 seconds setting. For star/delta and reversing starter, mechanical and electrical interlocks shall be fitted with the contactor.

C4.15 AUTOMATIC CHANGEOVER SWITCH

Changeover switch shall be electromagnetically controlled at mains voltage, double air-break, four-pole type and tested to IEC 60947-4-1.

Changeover switch shall be rated in Utilization Categories AC-3 and capable of making, breaking and carrying continuously the rated current and making on fault without overheating, damage or deterioration.

Changeover switch shall be electrically and mechanically interlocked in operation. Unless specified otherwise, the changeover action shall be automatic in response to the failure or resumption of supply mains.

Illuminated indicator for “Mains On” and “Essential Supply On” shall be provided at the cover of the compartment housing a changeover switch.

C4.16 ACTIVE HARMONIC FILTER

C4.16.1 General Requirements

- (a) Active harmonic filter (hereinafter referred to as “AHF”) shall be used to eliminate harmonic currents circulating across the installation so that the Total Harmonic Distortion (THD) may be limited to a given percentage as specified in the Particular Specification. (Note: For precise definition of this percentage, reference shall be made to sensitive equipment specifications regarding the acceptable THD for trouble-free operation or to the applicable standards at the point of common coupling.)
- (b) Active harmonic filter shall be installed in parallel with the distribution system, i.e. shunt connected, wherever attenuation of harmonic current is needed. Preferably, active harmonic filter shall be located close to those loads generating harmonic currents in order to avoid circulation of the harmonic currents along the cables.
- (c) AHF shall conform to IEC 61000 or other similar recognised international standards on Electromagnetic Compatibility (EMC) compliance for industrial or commercial applications and shall be manufactured to ISO 9001. Certificate of compliance shall be issued for each standard rating of AHF after being fully tested at the manufacturing facility.
- (d) AHF shall be manufactured by a reputable manufacturer which has continuously manufactured AHF for at least 3 years and their manufacturing facility shall have a local agent to provide full technical support which includes adequate spares holding and technical expertise in testing, commissioning and trouble-shooting. Training shall be provided by the manufacturer’s representatives for government staff on operation and maintenance aspects including essential trouble-shooting techniques.
- (e) Full technical details of the AHF as submitted by the manufacturer shall be provided for the Architect’s approval and shall cover the following:
 - (i) technical guide on its applications,
 - (ii) schematic and wiring drawings down to circuit board level released by the manufacturer,
 - (iii) shop drawings and as-fitted drawings,
 - (iv) operation manuals with commissioning guide,
 - (v) maintenance manuals with trouble-shooting guide, and
 - (vi) parts list and recommended spare parts with price.

- (f) The following technical requirements shall apply:
- (i) Input voltage : 380 V a.c. $\pm 6\%$, 3 phases
 - (ii) Frequency : 50 Hz $\pm 2\%$
 - (iii) No. of phases : 3-phase without/with neutral, 3/4 wires as specified in the Particular Specification
 - (vi) Unit capacity : as specified in the Particular Specification but up to 150kVA for any single AHF
 - (v) Harmonic orders : 2nd order to 25th order or more compensation
 - (vi) Filtering efficiency : 85% or more
 - (vii) Power factor correction: up to 0.98 lagging
 - (viii) Response time : 40 ms or less
 - (ix) Ventilation : Forced air cooled
 - (x) Noise level : 65 dBA or less
 - (xi) Heat losses : 8% of rated capacity or less
 - (xii) Service condition : Ambient temperature - 0 to 40°C
Relative humidity - up to 85%
Operating altitude - 1000 m or less

C4.16.2 Performance Requirements

- (a) The operating principle of AHF shall be based upon the injection of a harmonic current with appropriate phase shift corresponding to the harmonic current drawn by the load which shall be analysed by the AHF continuously. Consequently, the current supplied by the source shall remain sinusoidal under the effective operating range of the AHF.
- (b) AHF shall be compatible with any type of load, and shall guarantee efficient compensation, even when changes are made to the installation. The AHF shall also be capable of delivering its rated output harmonic current to the point of connection irrespective of load condition.
- (c) If the compensation of neutral harmonic current is required, in the neutral conductor, the AHF shall be capable of compensating the harmonic current three times greater than the phase current, particularly to compensate harmonic current of order 3 and its multiples.
- (d) Start-up and shut down of AHF shall be initiated by control push buttons or remote control. After a main power break-down, start-up of AHF shall be automatic.

- (e) Should the AHF be overloaded during transient operation of certain loads or permanently, this should not affect the reliability of its operation. Under such circumstance, the AHF shall operate in a current limiting mode and still deliver to the network its rated harmonic current.
- (f) For better adaptation to any installation, AHF shall be capable of operating in association with other harmonic reduction systems. It shall also be possible to associate 2 or more AHF's in parallel to increase the compensation capacity, or to enhance dependability, i.e. redundant operation.
- (g) To compensate the harmonics at different levels in the distribution network, it shall be possible to connect the AHF at any point in the distribution network, or to connect several AHF's at different points in the installation for maximum effectiveness.

C4.16.3 Construction

- (a) AHF shall use an isolated gate bipolar transistor (IGBT), bridge or other similar technique to inject the proper harmonic current on the network, and will be controlled by a microprocessor based system.
- (b) AHF shall be housed in an industrial grade cabinet constructed from high quality steel sheet of minimum 1.2 mm thick side and back plate and 1.5 mm thick hinged front door with key lock. Protection class of the cabinet shall be not less than IP44 for indoor and IP55 for outdoor application. The entire surface shall be applied with chemical rust inhibitor, rust resisting primer coat and topcoat to give maximum corrosion protection.
- (c) The dimension of AHF shall be as small as possible. Particularly, it will be preferable to have the AHF fitted in low voltage cubicle switchboard or in motor control centre.
- (d) AHF shall include the following kinds of protection:
 - (i) thermal overload protection,
 - (ii) internal short circuit protection, and
 - (iii) inverter bridge abnormal operation protection.

A three or four poles circuit breaker shall be installed close to the point of the connection to the system to protect the connection cables. It shall be selected according to general selection practice for circuit breakers and the manufacturer recommendation.

- (e) As a minimum the AHF shall include the following read-out:
 - (i) an indicator for each phase of the incoming power supply,
 - (ii) an indicator for normal operating condition,
 - (iii) an indicator for AHF shut down, and
 - (iv) an indicator for fault condition.

Also a diagnostics panel shall be accessible from the front of the unit to help the operator to identify the origin of abnormal situation and control push buttons will be provided for ON/OFF operation and alarm reset.

- (f) AHF shall be equipped with built-in RS 485/232 serial communication ports for control, programming and monitoring of the AHF by PC or other user interface.

C4.17 SURGE PROTECTION DEVICE

C4.17.1 General Requirements

- (a) Surge protection device shall be suitable for application in electrical installation operating at 380V 3-phase /220V 1-phase and at frequency 50 Hz.
- (b) The operation of surge protection device shall base on the use of metal oxide varistor or other similar technique to effectively limit over-voltage under surge conditions and to safely divert the excessive surge energy to ground.
- (c) Surge protection device shall be manufactured by a reputable manufacturer which has been continuously manufacturing surge protection products preferably for at least 5 years and the manufacturer shall have a local agent to provide full technical support and after sales services.
- (d) Type test certificate for the surge protection device shall be submitted for approval by the Architect. The certificate shall, unless otherwise specified, demonstrate that the equipment can fulfill the requirements stipulated in IEC 61024-1 'Protection of structures against lightning', for use in Location Category C, B and A - High Exposure Level, or IEEE C62.41-1991 'Recommended Practice on Surge Voltages in Low-Voltage a.c. Power Circuits' with the following performance:
 - (i) Surge protection device at the main LV switchboard shall be able to perform under a standard test wave of 20kV 1.2/50µs voltage impulse and 10 kA 8/20µs current impulse.

- (ii) Surge protection device at the electrical distribution system shall be able to perform under a standard test wave of 6kV 1.2/50 μ s voltage impulse and 3kA 8/20 μ s current impulse. It shall limit the transient voltage to below equipment susceptibility levels. The peak 'let-through' voltage shall not exceed (600V), unless otherwise specified.
- (iii) Surge protection device at sub-main distribution board shall be able to perform under a standard test wave of 6kV 1.2/50 μ s voltage impulse and 0.5kA 8/20 μ s current impulse.
- (e) Surge protection device shall be shunt or series connected to the concerned electrical installation to achieve maximum protection as recommended by the manufacturer. It shall be installed in strict compliance with manufacturer's installation instructions and relevant safety standards and regulations.
- (f) All components and circuits of the surge protection device shall be contained in a metal enclosure suitable for wall mounting. The enclosure shall be electrically earthed. In case of floor mounting is required because of its size and weight, the device shall be installed and mounted on concrete plinth provided for this purpose.
- (g) Detailed installation instructions and manuals from the surge protection device manufacturer shall be submitted to the Architect for approval.

C4.17.2 Performance Requirements

- (a) The device shall be able to give protective performance in all modes, including Phase and Neutral, Phase and Earth, and Neutral and Earth.
- (b) The device shall be designed in such a way that its performance shall not be easily affected by field wiring practice.
- (c) The let-through voltage, i.e. the transient overvoltage which is allowed through a surge protection device, shall be clearly specified for the acceptance by the Architect. Unless otherwise specified, the let through voltage shall not be greater than 600V under the standard test waves. The reaction time between the start of the surge and the time the surge protection device initiates the protective action shall be less than 1 nanosecond.
- (d) Surge protection device shall be able to withstand repeated electrical surges appeared in the electrical system without undue degradation of its surge protection performance under healthy condition.

C4.17.3 Construction

- (a) Surge protection device shall incorporate both high energy clamping devices and special filtering circuitry to reduce any electrical surge appearing in the connected electrical system to an acceptable level without causing any damage to the connected electrical and electronic equipment.
- (b) Surge protection device shall be housed in an industrial grade cabinet with hinged and lockable front door made of high quality 1.5 mm thick steel sheet. The device and the enclosure shall be electrically earthed. The entire cabinet shall also conform to the requirement of the manufacturer of the surge protection device.
- (c) Surge protection device shall be equipped with monitoring facilities so that whenever its surge protection performance is reduced to a pre-determined level below its original rating after a number of incident surges it has been subjected to, an audible and visual alarm shall be given off to indicate that the device requires servicing or replacement. The audible and visual alarm may be given through a build-in facility inside the device or by activating an electrical dry contact to which an indicator and an alarm bell are connected.

C4.18 SOLID STATE SOFT MOTOR STARTER

C4.18.1 General Requirements

- (a) The solid state soft motor starter (hereinafter referred to as “softstarter”) shall be a power electronic type motor starting device. It shall control the voltage applied to the motor smoothly by varying the conduction angle of the solid stage a.c. switches which can be triacs, reverse parallel connected SCR-diode circuit or reverse parallel connected SCR-SCR circuit, etc. or using other similar technique.
- (b) UNDER NO CIRCUMSTANCES shall the power factor correction equipment be connected between the softstarter and the motor. If power factor correction equipment is employed, it shall be connected to the supply side of the softstarter.
- (c) Softstarter shall be manufactured to conform to the currently-in-force editions of the following relevant standards or other similar recognized international standards:
 - (i) BS EN 60068-2-6 for vibration resistance,
 - (ii) BS EN 60068-2-27 for shock resistance,
 - (iii) BS EN 61000-4-3 for radio-frequency electromagnetic field interference immunity,
and

- (iv) BS EN 50081 for electromagnetic compatibility.
- (d) The softstarter shall be manufactured by a reputable manufacturer which has continuously manufactured softstarter for at least 5 years and their manufacturing facility shall have a local agent to provide full technical support, including adequate spares holding and technical expertise in testing, commissioning and trouble-shooting. Training shall be provided by the manufacturer's representatives for government staff on operational and maintenance aspects including essential trouble-shooting techniques.
- (e) Full technical details of the softstarter provided by the manufacturer shall be submitted and shall cover at least the following:
 - (i) technical guide on its applications,
 - (ii) schematic and wiring drawings down to circuit board level,
 - (iii) shop drawings and as-fitted drawings,
 - (iv) operation manuals with commissioning guide,
 - (v) Maintenance manuals with trouble-shooting guide, and
 - (vi) parts list and recommended spare parts with price.
- (f) Unless other specified, the rated operational voltage shall be 380 Volt $\pm 6\%$, 3-phase, 50 Hz $\pm 2\%$. The rated power and quantities of the softstarters shall be as specified in the Particular Specification.

C4.18.2 Performance Requirements

- (a) Softstarter shall provide the following modes of operation and shall be transitionless without causing any current inrush and torque surges during operation:
 - (i) Voltage ramp: The motor voltage shall begin initially at a preset 'start voltage' and increase to line voltage at a preset 'ramp rate'. The acceleration ramp time shall be adjustable up to 30 seconds.
 - (ii) Current limitation: It shall be capable of limiting the maximum starting current. The maximum starting current shall be adjustable to at least 4 times of rated current.
 - (iii) Soft stop: A deceleration voltage ramp shall be applied to the motor for applications which require an extended coast to rest. The voltage ramp down time shall be adjustable to 30 seconds or above.

- (iv) Kickstart: If specified in the Particular Specification, a current pulse shall be provided to develop additional torque at start for loads which may need a boost to get started.
- (v) Energy saving: If specified in the Particular Specification, when the motor is lightly loaded or unloaded for long periods of time, it shall automatically decrease motor power losses by controlling the motor terminal voltage.
- (vi) Apart from the above, other modes of operation such as voltage pedestal starting, full voltage starting, d.c. injection braking, etc. can also be required if specified by the Architect.

C4.18.3 Construction

- (a) Enclosure of softstarter shall be protected to at least IP44 for indoor and IP55 for outdoor application by a single front-access enclosure and shall be suitable for operation without derating under ambient temperature of up to 50°C and relative humidity of up to 95%.
- (b) Softstarter shall have either external or internal protection to the motor and softstarter and LED diagnostics to aid in set-up and troubleshooting. The protection shall include:
 - (i) thermal overload protection of the motor and softstarter,
 - (ii) mains supply protection for phase failure and phase unbalance,
 - (iii) internal fault protection and
 - (iv) stalled motor protection.
- (c) The heat sink of the softstarter shall be of good quality aluminium construction and shall provide sufficient thermal inertia to permit successful starting of the motor without exceeding the solid state a.c. switches permitted junction temperature.
- (d) Softstarter shall provide auxiliary contacts for end of starting (by-pass) and fault condition. The output relay contact shall be suitable for 220V a.c. operation in category AC11 and d.c. operation in category DC11.
- (e) Softstarter shall have the possibility to accept d.c. input from external device such as PLC for controlling the start and stop of the unit.

- (f) Semiconductor fuses shall be available as an option and have the characteristics suitable to protect the softstarter.
- (g) The solid stage a.c. switches shall have a blocking voltage of at least 1400V for 415V system with a rate of rise of reapplied voltage tolerance of at least 1000V per microsecond. However, an isolation contactor or isolator shall be available as an option to isolate the supply in the 'Off' stage to the softstarter for the safety of the operator.

C4.18.4 Selection of Softstarter and Operating Precautions

- (a) The starting current-speed transition curve of the selected softstarter shall closely match with the starting torque-speed characteristics of the motor and loading. The ratings of the softstarter shall base on 'hot start' operation i.e. the motor is re-started immediately after operating at maximum rating for a period of time.
- (b) The motor associated with the softstarter shall be capable of starting the drive load when is supplied at reduced voltage and current. In case of severe duty, it shall check with the motor manufacturer that its derating is compatible with the operating cycle and the starting times.
- (c) The softstarter shall be capable of continuously delivering rated output voltage or reduced output voltage under energy saving mode (as specified in the Particular Specification) with power factor of not less than 0.9 lagging without external chokes or power factor correction capacitors at any load. When using a by-pass contactor, the order to close and open the contactor shall be controlled by the built-in signal of the softstarter.

C4.19 VARIABLE SPEED DRIVES FOR CENTRIFUGAL FANS AND PUMPS WITH THROUGHPUT POWER UP TO 150 kVA

C4.19.1 General Requirements

- (a) Variable speed drive (hereinafter referred to as "VSD") shall be a solid-state converter to convert three phase mains supply of $380V \pm 6\%$ and $50Hz \pm 1Hz$ to an adjustable voltage and frequency output at its rated throughout power. VSD shall conform to BS EN50081 or other similar recognised international standards on Electromagnetic Compatibility (EMC) compliance for industrial or commercial applications and shall be manufactured to ISO 9001. Certificate of compliance shall be issued for each standard rating of VSD used in the Contract after being fully tested at the manufacturing facility.

- (b) VSD shall be manufactured by a reputable manufacturer which has continuously manufactured VSD's for at least 5 years and their manufacturing facility shall have a local agent to provide full technical support which includes adequate spares holding and technical expertise in testing, commissioning and trouble-shooting. Training shall be provided by the manufacturer's representatives for government staff on operational and maintenance aspects including essential trouble-shooting techniques.
- (c) Full technical details of the VSD shall be submitted by the manufacturer through the Contactor and shall cover the following:
 - (i) technical guide on its applications,
 - (ii) schematic and wiring drawings down to circuit board level,
 - (iii) shop drawings and as-fitted drawings,
 - (vi) operation manuals with commissioning guide,
 - (v) maintenance manuals with trouble-shooting guide, and
 - (vi) parts list and recommended spare parts with price.
- (d) VSD shall be capable of continuously delivering rated output voltage even when the mains supply voltage is down to 6% of its nominal value and shall be able to control a standard BS 5000 3-phase squirrel cage induction motor of class B insulation over a speed range of 20% to 100% continuously and smoothly without the need to derate the motor kW rating and to provide total power factor of not less than 0.9 lagging, without external chokes or power factor correction capacitors, at all loads within the speed range. The inrush current shall be zero and during starting, the current shall start from zero and rises as the load accelerates with no danger of exceeding full load current.
- (e) VSD shall allow up to 100 meters of cables to be used between the VSD and the motor.
- (f) VSD shall allow unlimited switching of the motor circuit, at any load and within the controlled speed range without damage and without the need of auxiliary control switching. The VSD shall be capable of automatically reconnecting to a spinning fan and run without tripping, following mains interruption and on transfer from backup source. The VSD shall be capable of running with no motor connected during functional testing. The VSD shall have voltage/frequency (V/f) ratio suitable for centrifugal pumps and fans control. Selectable V/f ratios shall be provided and it shall not be possible to set a constant V/f ratio, to prevent damage to connected equipment and to optimise energy usage.

C4.19.2 Performance Requirements

- (a) VSD shall be fully rated to provide the performance as follows:
 - (i) minimum efficiency of 95% at 100% load and not less than 90% at any other operating loads,
 - (ii) output torque shall be limited to 105% of full load torque,
 - (iii) no facility for reversing the motor rotation shall be incorporated,
 - (iv) the VSD shall have a maximum capacity of 150 kVA as recommended by the Engineering Recommendation G5/3 titled "Limits for Harmonics in the United Kingdom Electricity Supply System" published by the Electricity Council, 1976,
 - (v) the maximum allowable fifth harmonic current distortion expressed in percent of the fundamental input current at the VSD input terminals during operation within the variable speed range shall be preferably less than 35%, and
 - (vi) the electromagnetic compatibility shall be to BS EN50081 or similar inter-national standards.
- (b) The following minimum features shall be incorporated in the VSD unit complete with an integral control panel:
 - (i) it shall accept digital and analogue 0-10V, 4-20mA control signals,
 - (ii) integral measurement and selectable alpha-numeric display of:
 - output current,
 - output voltage,
 - output frequency,
 - output speed,
 - output power,
 - output torque,
 - motor temperature, and
 - inverter temperature,
 - (iii) alpha-numeric display in English for warning/fault/alarm status,
 - (iv) information can be transmitted on the RS485/232 output for remote interrogating and reprogramming,
 - (v) it shall have 1 programmable relay output (250V 2A) and 1 programmable analogue output of 4-20mA or 0-10V d.c.,
 - (vi) 10 programmable preset speeds (including at least 2 skip frequencies of adjustable bandwidth to overcome mechanical or air system resonance),
 - (vii) selectable local or remote control,
 - (viii) hardware lock to prevent unauthorised parameter adjustment,

- (ix) it shall have the following integral protection against:
 - loss of mains and motor phase,
 - motor short circuit,
 - motor circuit earth fault,
 - motor overheat (without the use of motor winding thermistors),
 - overvoltage,
 - VSD overheat,
 - under voltage,
 - input transients,
 - VSD and motor overload, and
 - mains input accidentally couples to motor output terminals,
- (x) it shall have a digital electronic equivalent of a motor operated potentiometer control or similar device for open loop operation,
- (xi) it shall have an integral full 3-term PID control to provide close loop control direct from a signal transmitter without need for external signal conditioning, and
- (xii) it shall have a facility for controlling motor anti-condensation heater for heater operation when the motor is idle.

C4.19.3 Construction

- (a) VSD shall incorporate a 6-pulse full-wave uncontrolled diode bridge, fixed voltage-fed d.c. link with inductors and capacitors to form a filter, a mains filter for EMC compliance, a pulse width modulation (PWM) inverter bridge utilising insulated gate bipolar transistors (IGBTs) and output inductors in the motor lines. The inverter bridge shall be controlled by a microprocessor to produce a pulse width modulation (PWM) waveform or similar technique which would result in full motor voltage and sinusoidal current mains supply in the motor circuit. The VSD shall be equipped with built-in RS485/232 serial communication ports.
- (b) The complete VSD unit shall be housed in a single front-access enclosure designed and built as an integral part of the VSD. The VSD shall be protected to at least IP44 for indoor and IP55 for outdoor application, without having to use a secondary enclosure. Unless otherwise specified, it shall be suitable for continuous operation without derating under ambient temperature of up to 40°C and relative humidity of up to 95%. The equipment shall be fully tested including motor loading at manufacturer's facility or by an approved testing authority to certify that the equipment conforms to the aforesaid standard. Certificate of compliance shall be issued for each standard rating of VSD used after being fully tested at the manufacturing facility or by the testing authority.

C4.20 DIGITAL MULTIFUNCTION POWER METER

C4.20.1 General Requirements

- (a) The microprocessor based Digital Multifunction Power Meter shall measure the electrical parameters including current, voltage, power factor, active and reactive power and frequency by means of microprocessor technology. The meter shall be able to communicate with PC-based Building Management System via a common network protocol (e.g. RS232/RS485) by means of plugging in communication module and without further modification of the basic unit.
- (b) Digital Multifunction Power Meter shall be housed in a single front access industrial grade enclosure designed and built as an integral part of the meter by the original manufacturer. The meter shall then be panel mounted in the L.V. switchboard cubicles. Alternatively, the meter can be configured for DIN rail mounting. In either case, the front face shall be protected to not less than IP54. The display shall either be L.E.D. or L.C.D. back light, with auto blinking function for prolonging the life of the display.
- (c) The meter shall be so arranged that the replacement of meter shall not require the switching off of the respective switchgear. All wiring shall be routed to allow easy removal of the cable connectors in the event that the meter requires replacement. Current transformers shorting block shall be provided such that current inputs can be disconnected without open circuiting the current transformers. The shorting block shall be wired so as not to affect the operation of protective relays.
- (d) Manufacturer's calibration certificate shall be issued for every meter.

C4.20.2 Technical Requirements

- (a) Digital Multifunction Power Meter shall comply with the following technical requirements:
 - (i) Voltage input
 - Maximum : 600V a.c. between phase direct voltage
 - Other : through potential transformers voltages
 - (ii) Current input (In) : On current transformers, In / 5A (secondary)

- (iii) Measurement :
 - True RMS value of line current for each phase and neutral current
 - True RMS value of phase-neutral voltage for each phase
 - True RMS value of line voltage for each phase
 - Active power, kW
 - Reactive power, kVAr
 - Apparent power, kVA
 - Frequency, Hz
 - Power factor
 - Energy, kWh
- (iv) Accuracy
 - Voltage : $\pm 0.5\%$
 - Current : $\pm 0.5\%$
 - Power : $\pm 1\%$
 - Power factor : $\pm 2\%$
 - Frequency : $\pm 1\%$
 - Energy : $\pm 1\%$
- (v) Service condition
 - Temperature : 0° to 50°C
 - Relative humidity : Up to 80%
- (vi) Communication
 - Numeric : Series link RS-232 or RS-485
 - Analog : 4-20 mA output
- (b) Digital Multifunction Power Meter shall store in memory the maximum and minimum values of the each parameter measured by the unit. The values in memory shall be recalled and displayed upon pressing of a switch on the meter. Memory shall be backup by Lithium battery of battery life not less than 7 years.

C4.21 CHARGER AND BATTERY SET

C4.21.1 General Requirements

- (a) Battery charger set shall be a solid state secondary d.c. power supply unit operating in parallel with a battery bank. The maximum rated capacity referred to herein this specification shall be 3kVA. The exact rated capacity shall be designed by the Contractor to supply a constant voltage current for the combined standing load and alarm / switch tripping load , if applicable, or not less than 15 Amperes or as specified in the Particular Specification, as well as recharging and restoring the battery bank back to its constant potential voltage setting within the specified time limit after fully discharge.
- (b) The charger unit shall consist of a rectifier bridge which has the a.c. mains input supplied via the isolation transformer and has the ripples of its d.c. output smoothed by a d.c. filter before supplying connected load under normal operation or the battery after discharging in a.c. mains failure. The rectifier shall be equipped with two voltage levels output, trickle charge and high rate charge (hereinafter called boost charge) which shall be fully automatically controlled and switched by a control logic unit comprising the printed circuit boards (hereinafter called PCB).
- (c) Battery charger set shall be manufactured to conform to the currently-in-forced editions of the relevant standards as indicated below:

BS EN 61204		Specification for Performance Characteristics and Safety Requirements of Low-voltage Power Supply Devices, d.c. Output,
BS 5654	(=IEC 60478)	Specification for Stabilized Power Supplies, d.c.110 Output, Part 1: Terms and Definition Part 2: Rating and Performance Part 3: References levels and Measurement of Conducted EMI Part 4: Tests other than RFI Part 5: Measurement of the Magnetic Component of the Reactive Near Field
BS 6115	(=IEC 60622)	Specification for Sealed Nickel-Cadmium Prismatic Rechargeable Single Cells,
BS 7430		Code of Practice for Earthing,

- (d) The battery bank shall have sufficient voltage and rated capacity in ampere-hour rating to maintain the connected load at the rated output capacity for the duration specified below. The ampere-hour rating shall be at least 10 ampere-hour if it is not specified in the Particular Specification. The battery shall be sealed, high rate maintenance free nickel-cadmium type and shall have a proven life expectancy of at least 7 years.
- (e) Battery charger set shall be designed and manufactured by a reputable manufacturer which has continuously manufactured battery set to work in conjunction with a wide range of applications for at least 5 years and their manufacturing facility shall have a local agent to provide full technical support which includes adequate spare holding and technical expertise in testing, commissioning and trouble-shooting.
- (f) The following technical information shall be submitted to the Architect for approval prior to ordering of equipment:
 - (i) Technical catalogues and specification, calculation sheet for charger and battery capacity
 - (ii) Power supply unit circuit diagram
 - (iii) Circuit diagram of control and battery disconnected
 - (vi) Printed circuit board diagram
 - (v) Power supply unit front plate layout
 - (vi) Power supply unit console detail

C4.21.2 Technical Requirements

The following technical requirements shall apply:

- (a) Input voltage : 220V a.c. $\pm 10\%$
- (b) Frequency : 50 Hz $\pm 5\%$
- (c) Output ripple voltage : $\pm 5\%$ of d.c. output
- (d) Output voltage ($\pm 1\%$) : 12V / 24V / 30V / 48V
- (e) Output current : 15A / as specified in the Particular Specification
- (f) Re-charge time : As specified in the Particular Specification
- (g) Battery type : Sealed, high rate maintenance free Nickel-cadmium, life time at least 7 years under normal usage
- (h) Overcurrent protection : Mains fuse, charger fuse, battery fuse against overload and short circuit conditions

- (i) Control : Manual boost charge, automatic trickle charge and boost charge
- (j) Audible noise : less than 55 dBA
- (k) Service condition : Temperature -10°C / +40°C; derated to 80% rated output current at +50°C;
Relative humidity 95% max.;
Altitude 1000 m above sea level; derated to 90% rated output current at 2000 m altitude
- (l) Instrument : d.c. output voltmeter, d.c. output ammeter (1.5% accuracy)
- (m) Indication : Mains and charger healthy,
Charger short-circuit,
Battery connected,
Battery low-volt,
Boost charge
- (n) Voltage-free contact : Voltage-free contacts for “load on battery” and “battery low voltage” should be provided if specified in Particular Specification for remote monitoring
- (o) Input connection : 13 A fused a.c. supply

C4.21.3 Construction

- (a) The charger and battery set shall be housed in a industrial grade cabinet constructed from high quality steel sheet of minimum 1.2mm thick side and back plate and 1.5mm thick hinged front door with key lock. Protection class of the cabinet shall be not less than IP31 for indoor and IP55 for outdoor application as specified in BS EN 60529. The entire enclosure surface shall be applied with chemical rust inhibitor, rust resisting primer coat and top coat to give maximum corrosion protection.
- (b) The logic PCB, together with the isolation transformer and fused mains input terminals, shall be factory assembled on a plate located at the rear of the case. The power transistors are mounted on heatsinks, separately from the PCB, on the back plate. The instruments and LED indicators are mounted on the front door of the cabinet. A lower ventilated compartment inside the cabinet provides adequate space for accommodation of the storage battery bank and ventilation.
- (c) The cabinet shall be suitable for wall-mount or installation inside a switch cubicle where appropriate.

C4.21.4 Selection Criteria

- (a) The rated kVA capacity, voltage, current of the rectifier charger and the storage capacity, terminal voltage, ampere-hour rating of the battery bank shall be designed by the manufacturer and selected by the Contractor that it is suitable to work in conjunction with a range of application in switch tripping / fire alarm and protection system / gas detection system / security system / PA and audio system.
- (b) For the switch tripping of cubicle switchboards, the selected charger and battery set shall satisfy the following criteria:
 - (i) Output voltage : 24V, 30V, 48V or operating voltage of tripping coil as specified in the Particular Specification.
 - (ii) Output current and re-charge time : 15A or 20 times tripping current of air circuit breaker and upon mains restoration, adequate to re-charge the battery from fully discharge to fully charge within 8 hours as specified in the Particular Specification.
 - (iii) Ampere-hour rating : 10 Amp-hour or Upon mains failure, adequate to discharge the tripping current of the associated air circuit breaker(s) consecutively at least 20 times or up to twenty air circuit breaker(s) simultaneously as specified in the Particular Specification.
- (c) When used in conjunction with in fire alarm and protection system / gas detection system, the selected charger and battery set shall satisfy the following criteria:
 - (i) Output voltage : 24V
 - (ii) Output current and re-charge time : 15A or output current for combined standing load at normal condition and alarm load at maximum alarm condition and upon mains restoration, adequate to re-charge the battery from discharge to fully charge within 24 hours as specified in the Particular Specification.

- (iii) Ampere-hour rating : 10 Amp-hour or Upon mains failure, adequate to discharge the operating current for the connected standing load at normal condition for 24 hours and then the connected alarm load at maximum alarm condition for at least 60 minutes as specified in the Particular Specification.
- (d) When used in conjunction with in security system / PA and audio system, the selected charger and battery set shall satisfy the following criteria:
 - (i) Output voltage : 12V or 24V as specified in the Particular Specification.
 - (ii) Output current and re-charge time : 15A or output current for combined standing load at normal condition and alarm load at maximum alarm condition and upon mains restoration, adequate to re-charge the battery from discharge to fully charge within 24 hours as specified in the Particular Specification.
 - (iii) Ampere-hour rating : 10 Amp-hour or Upon mains failure, adequate to discharge the operating current for the connected standing load at normal condition for 24 hours and then the connected alarm load at maximum alarm condition for at least 60 minutes as specified in the Particular Specification.

C4.22 POWER FACTOR CORRECTION EQUIPMENT

C4.22.1 General Requirements

- (a) The power factor correction equipment (hereafter referred to as “the equipment”) shall include capacitors, protective devices, contactors, control relays, current transformers, cabinet, cables, cable glands, trunkings, control wirings, necessary accessories, etc. Blocking filter shall also be included to suppress harmonic and inrush currents.

Additional and specific requirements for the equipment shall be given in the Particular Specifications, the Drawings or other documents issued by the Architect.

(b) Service Condition

The following service conditions shall apply:

- (i) Altitude – up to 2000 m above sea level
- (ii) Ambient air temperature – peak from minus 5 °C to plus 40°C for 4 hours continuously with an average from 0 °C to plus 35 °C over only 24 hours period

C4.22.2 Requirements of the Components

(a) Capacitor Units

The capacitors shall be of low loss dry-type, metallized polypropylene (MPP) film type with self-healing properties and fitted in a sheet steel plate enclosure filled with non-inflammable medium. The capacitor units shall be hermetically sealed and manufactured from continuous metal foil and low loss high quality dielectric material. The total capacitor losses shall not exceed 0.5 Watt per kVAr. The capacitors shall comply with the requirement of IEC 60831 and IEC 60070.

The capacitors shall be provided with directly connected discharge resistors which shall reduce the residual voltage from the rated peak alternating voltage to 75V or less measured at the capacitor bank terminals within 3 minutes after disconnection from the source of supply. The discharge resistors shall be protected by an insulating cover.

The capacitor shall have the following characteristics: -

- (i) Rated voltage : 380 V
- (ii) Frequency : 50 Hz
- (iii) Insulation level : 3 kV rms/15 kV crest
- (iv) Dielectric : Polypropylene
- (v) Discharge resistors : Fitted
- (vi) Total capacitor losses : < 0.5 W/kVAr
- (vii) Maximum voltage : 1.1 times rated voltage
- Overload
- (viii) Maximum current : 1.3 times rated current
- Overload
- (iv) Power tolerance : - 5/+10 %
- (x) Ambient temperature : - 5 °C to + 40 °C
- range
- (xi) Residual voltage at : < 10% of rated voltage
- Energization

(b) Protection Units

The capacitor units shall be fed by fuse-switch or MCCB for protection against high fault currents. Besides, an overpressure disconnection device for protection against low fault currents shall be provided. H.R.C fuses and MCCB shall comply with the requirement of IEC 60269 and IEC 60947-2 respectively.

(c) Control Relays

The capacitors in each bank shall be controlled by an automatic multi-step capacitor control relay capable of switching the appropriate amount of capacitors “IN” or “OUT” so as to achieve the best average power factor. A no-volt resetting feature shall be incorporated to ensure that, in the event of power interruption lasting for a period over 50ms, all capacitors involved shall be disconnected from the L.V. installation and re-connected in accordance with the aforementioned arrangement upon supply resumption.

The relay shall be commanded by a microprocessor which measures the reactive power of an installation and gives the necessary instructions to the relay for connecting or disconnecting the capacitors in order to maintain the desired power factor. The microprocessor shall be capable to ensure an uniform aging of contactors and capacitors by using a circular connection sequence which takes into account the time that each capacitor has been switched on (First-In-First-Out (FIFO) System). The control relay shall include a fully operational alarm system which shall operate in case the equipment cannot reach the required power factor. LED/LCD indicator shall be provided to show which step the capacitors are connected.

The control relay shall have the following characteristics:

(i)	Dual voltage	:	220 or 380 V
(ii)	Control current	:	Can be connected without any additional adaptor to C.T. 2500/5A burden 5VA min. Class 1
(iii)	Contacts for contactor : switching	:	Control relay capable of withstanding 2500V a.c., 5 A and 1200VA

(iv)	Test voltage	:	Supply connecting cable and contactor connecting cable: 1500V, 50 Hz; C.T. Contactor: 500V 50Hz
(v)	Harmonics filtering	:	A filter shall be incorporated to avoid falsified measuring results. Not to be confused with the filter circuits for the equipment
(vi)	Response current (C/K setting range)	:	Adjustable from 0.05 to 1A
(vii)	C/K setting	:	Manual or Automatic
(viii)	Power factor reversal point	:	Adjustable from 0.85 lagging to 1 and prevent leading P.F. during light load condition
(ix)	Power factor setting	:	0.85 inductance to 0.95 capacitance
(x)	Switching time from one step to another	:	Adjustable from 10s to 3 minutes according to reactive load
(xi)	Ambient temperature Range	:	- 5 °C to + 40 °C
(xii)	Indicator for operating and steps	:	LED/LCD
(xiii)	No-voltage release	:	If voltage fails, the no-voltage release operates automatically due to drop-out of control relay
(xiv)	Alarm relay	:	Yes

(xv)	Manual switching	:	Two push-buttons for manual operation, suitable to check functioning of relay
(xvi)	Connection	:	Plug-in connector
(xvii)	Mounting	:	With angle brackets and threaded bolts
(xviii)	Degree of protection	:	IP 31

(d) Contactors

The equipment shall be equipped with special contactor for limiting over-current on itself from high inrush current at capacitor switching. The contactors are characterized for having auxiliary contacts equipped with pre-charge resistors. These auxiliary contacts shall be closed before the power contacts such that the connection peak is strongly limited by the effect of the resistors.

Contactors shall be adequately rated to make and break the capacitive current at low power factor. This current limitation increases the life of all the components of the equipment, in particular that of the protective devices and capacitors. The contactors shall comply with the requirement of IEC 60947-4-1.

The contactor shall have the following characteristics:

(i)	Prospective peak current at Switch-on	:	100 times rated current
(ii)	Maximum operating rate	:	150 operations/hour
(iii)	Electrical life at rated load	:	100,000 – 200,000 operations
(iv)	Utilization category	:	AC6b

(e) Cabinet

The equipment shall be of cabinet type of at least IP31 (Indoor) and contained in a separate cubicle with control switchgear and all other necessary accessories and shall comprise multiple identical capacitor units connected and easily dismountable for its replacement. Integrated cubicle with the LV Switchboard installation is not acceptable. The equipment shall be installed in separate compartment segregated from the rest of the LV Switchboard such that failure of the equipment will not affect the operation of the LV Switchboard. The equipment shall be housed in a front-access industrial grade enclosure with epoxy powder coating.

C4.23 DIGITAL PROTECTION RELAY

C4.23.1 General Requirements

- (a) The microprocessor-based digital protection relay shall accept three-phase inputs from industrial standard current transformers with nominal secondary current of 1 or 5 Amperes and shall sense the true RMS current values.
- (b) The digital relay shall provide time delayed three-phase overcurrent protection and earth fault protection and shall allow a variety of selectable time-current IDMT characteristic curves according to IEC 60255.
- (c) The digital relay shall have remote operation feature and shall be able to communicate with PC-based Building Management System via a common network protocol such as Modbus/Lonworks via RS232/RS485/Ethernet communication link by means of plugging in communication module and without further modification of the basic unit.
- (d) The digital relay shall be suitable for protection at main incoming circuit breaker in low voltage electrical system and the tripping characteristics of the relay shall match with the power supply companies' breaker/fuse tripping characteristics for discrimination. The protection scheme and tripping characteristics of the digital relay shall be approved by the power supply companies in Hong Kong.
- (e) The digital relay shall have continuous self-supervision feature to monitor the control circuit. Fault recording function shall be triggered upon fault detection or tripping operation for diagnostic use. The monitoring information and relay setting shall be recallable and programmable by means of front panel keypad or remote access by software. The digital relay shall have security password feature to protect access to relay parameter settings and remote tripping.

- (f) The digital relay shall be type tested for Electromagnetic Compatibility (EMC) and other relevant requirements in accordance with the following international standards:

IEC 61000-4-2	Electrostatic discharge immunity test
IEC 61000-4-3	Radiated, radio-frequency, electromagnetic field immunity test
IEC 61000-4-4	Electrical fast transient/burst immunity test
IEC 61000-4-5	Surge immunity test
IEC 60255-25	Electromagnetic emission tests
IEC 60255-21-1	Vibration test
IEC 60255-21-2	Shock and bump test

Manufacturer's calibration certificate shall be issued for every digital relay.

C4.23.2 Technical Requirements

- (a) The digital protection relay shall comply with the following technical requirements:
- (i) Current input - 1A or 5A via standard protection current transformer
 - (ii) Overcurrent setting - 50% to 200% in step of 5% of nominal current I_n
 - (iii) Earth fault setting - 10% to 40% in step of 5% of I_n
 - (iv) Time multiple setting - 0.1 to 1.0 in step of 0.05
 - (v) AC burden (maximum) - 0.25VA at $I_n = 1A$
- 0.50VA at $I_n = 5A$
 - (vi) Service condition - Temperature range: 0° to 40°C
- Relative humidity: Up to 95%

- (b) The monitoring and fault records of the digital relay shall be stored in nonvolatile memory and retained in the event of control power interruption. The memory shall be backup by Lithium battery with battery life not less than 7 years. Each fault/event record shall include at least the type of faults/alarms, current values, date & time of tripping, etc. The memory shall be capable of storing minimum 5 fault records.
- (c) The digital relay shall be accommodated in a dust-proof case to IP51 and shall be draw-out type flush mounted on the front panel of switchboard cubicle. Facility shall be provided for automatic short-circuiting the associated current transformers upon withdrawal of the module.
- (d) The digital relay shall be able to receive auxiliary d.c. power supply at 30V or 48V for control operation. A battery set and charger shall be provided for digital relay operation.
- (e) The digital relay shall provide at least 4 auxiliary contacts for the input/output of other functions such as remote tripping, alarms, blocking logic, watchdog, etc.
- (f) Trip indicators shall be provided for identification of the type of fault condition.

C4.24 DIGITAL POWER ANALYZER

C4.24.1 General Requirements

- (a) The microprocessor based digital power analyzer shall measure and monitor the electrical parameters including current, voltage, power factor, energy, frequency and power quality parameters by means of microprocessor technology. The digital power analyzer shall be able to communicate with PC-based Building Management System via a common network protocol such as Modbus/Lonworks via RS232/RS485/Ethernet communication link by means of plugging in communication module and without further modification of the basic unit.
- (b) The digital power analyzer shall continuously monitor the power system and trigger alarm/event logging for power monitoring and analysis. The stored and instantaneous measurement data shall be recalled and displayed on the front panel upon pressing of keypad on the digital power analyzer and alternatively monitored by PC-based application software supplied together with the analyzer.

- (c) The digital power analyzer shall have waveform capture capability which shall be either initiated from the software or by the power analyzer as a user defined response to an alarm condition. The captured waveform samples shall be able to transmit over the network to PC-based workstation for display, archival and analysis.
- (d) The digital power analyzer shall comply with the Electromagnetic Compatibility (EMC) requirements in accordance with the following international standards:
- | | |
|---------------|--|
| IEC 61000-4-2 | Electrostatic discharge immunity test |
| IEC 61000-4-3 | Radiated, radio-frequency, electromagnetic field Immunity test |
| IEC 61000-4-4 | Electrical fast transient/burst immunity test |
| IEC 61000-4-5 | Surge immunity test |
| IEC 61000-3-2 | Limits for harmonic current emissions |

Manufacturer's calibration certificate shall be issued for every digital power analyzer.

C4.24.2 Technical Requirements

- (a) The digital power analyzer shall comply with the following technical requirements:
- (i) Voltage input
 - Maximum : 600V a.c. between phase direct voltage
 - Other voltages : Through potential transformers
 - (ii) Current input (In) : On current transformer, In / 5A (secondary)
 - (iii) Measurement :
 - True RMS value of line current for each phase
 - Neutral current
 - % current unbalance
 - True RMS value of phase-neutral voltage for each phase
 - True RMS value of line voltage for each phase
 - % voltage unbalance
 - Active power, kW for each phase and three-phase total

- Reactive power, kVAr for each phase and three-phase total
- Apparent power, kVA for each phase and three-phase total
- Frequency, Hz
- Power factor
- Active energy, kWh for three-phase total with instantaneous and accumulated values
- Demand current for each phase and three-phase average
- Demand active power, three-phase total
- Demand apparent power, three-phase total
- Harmonic distortion for voltage and current, up to 30th harmonic orders
- Total harmonic distortion for voltage and current

(iv) Accuracy

- Voltage : $\pm 0.5\%$
- Current : $\pm 0.5\%$
- Power : $\pm 0.5\%$
- Power factor : $\pm 0.5\%$
- Frequency : $\pm 0.5\%$
- Energy : $\pm 0.5\%$
- Harmonic : $\pm 1.0\%$

(v) Service condition

- Temperature : 0° to 40°C
- Relative humidity : Up to 95%

- (vi) Communication
 - Digital : Serial link RS-232 or RS-485
 - Analog : 4 – 20mA output

- (b) The digital power analyzer shall provide date and time stamped event log. The type of alarm events and size of the event log shall be user definable. The following classes of events shall be available as alarm events:
 - (i) Over /under voltage
 - (ii) Over /under current
 - (iii) Current or voltage unbalance
 - (iv) Phase loss, voltage or current
 - (v) Over /under frequency
 - (vi) Over kVA, kW or kVAr into /out of load
 - (vii) Under power factor, true or displacement
 - (viii) Over THD
 - (ix) Over demand, current or power
 - (x) Phase reversal
 - (xi) Voltage or current sag /swell

- (c) All setup parameters required by the digital power analyzer shall be stored in nonvolatile memory and retained in the event of control power interruption. The memory shall maintain the maximum and minimum values of each parameter measured by the unit and shall be backup by Lithium battery with battery life not less than 7 years.

- (d) The digital power analyzer shall be able to receive d.c. power supply at 30V or 48V for operation. A battery set and charger shall be provided.

SECTION C5

BUSBAR TRUNKING SYSTEM

C5.1 GENERAL

Busbar trunking system shall be designed to operate on 220/380V 3 phase 4 busbar at 50 Hz system and shall be manufactured and type tested to IEC 60439-2. Busbar trunking systems manufactured to other standards (such as National Electrical Manufacturers Association (NEMA) of USA and UL listed) with insulation voltage of 415V may be considered as acceptable provided that the standard of manufacture is not inferior to the relevant IEC standard and that the busbar trunking system meets all the requirements of this Section. All material, components and accessories (such as bends, joints, tees, feeder units, tap-off units, etc.) used for the busbar trunking shall be of the same origin of manufacture. Busbar trunking system shall be certified by testing laboratories or organizations as stated in the Code of Practice for the Electricity (Wiring) Regulations.

In case where busbar trunkings are manufactured under license from the Principal Company, a letter shall be produced by the Principal Company to guarantee that the products manufactured by the licensee will be equivalent in every respect to the type-tested standard products.

C5.2 BUSBAR TRUNKING CONSTRUCTION

The busbar trunking system shall be of the totally enclosed type with ingress of protection not less than IP54 of IEC 60529 for indoor erection in non-sprinklered areas, IP55 of IEC 60529 for indoor erection in sprinklered areas and mechanical plantrooms and IP66 of IEC 60529 for outdoor erection. It shall be constructed to withstand heavy mechanical loads as stated in IEC 60439-2. The casing shall be finished in enamel paint to a grey colour or the nearest manufacturer's colour of standard production.

Adjacent lengths of the busbar casing shall be butt-jointed and the joint shall be mechanically and electrically continuous. The mechanical strength of the joint shall not be less than that of the busbar casing.

Colour circles indicating the phasal arrangement of the busbars shall be painted on the casing of the terminal units and at any physical compartment. Removal of the cover for access facility shall necessitate the use of tools.

For long busbar run, phase transposition of busbar shall be incorporated in accordance with manufacturer's recommendation.

C5.3 BUSBAR INSULATION

The busbars shall be insulated from the busbar casing to maintain a clearance and creepage distance as specified in Sub-section 7.1.2.3.5 of IEC 60439-1 with Pollution Degree 3. The insulation material shall be of heat resistant, self-extinguishing, non-hygroscopic, high electrical and mechanical strength to withstand the stresses under all normal and short-circuit conditions.

C5.4 BUSBAR

Busbars shall be three phase and full rated neutral made of hard drawn, high conductivity solid copper bars to BS 1432 or BS 1433.

The busbar including all electrical contact surfaces shall be silver or tin plated. The busbars shall be of adequate size to carry the rated current continuously at ambient temperature of 40°C without exceeding the temperature rise in accordance with Clause 7.3 of IEC 60439-1.

Each bar shall be painted to indicate the phase to which it is connected. Painting shall comprise a band of colour at each accessible position to the busbars.

C5.5 FEEDER UNIT

Feeder unit shall be of manufacturer's proprietary product. The rated current and rated short-time withstand current of the feeder unit shall not be less than that of the busbar trunking system to which it is connected.

C5.6 TAP-OFF UNITS

Tap-off units shall be used for branch circuits taken off from the busbars. MCCB to IEC 60947-2 or H.R.C. fuses to IEC 60269 of appropriate current ratings and short-circuit breaking capacities shall be provided as near as practically possible to the tapping position for protection of the branch circuits.

Plug-in tap-off units shall be attached on the busbar casing and held in position by means of wing nuts or other quick fastening and quick releasing device.

Tap-off units shall make positive earth connection and shall be equipped with internal barriers to prevent direct contact.

Mechanical interlock shall be incorporated such that the tap-off unit cannot be inserted or removed from the busbar trunking unless it is in the switch OFF position.

C5.7 BUSBAR EXPANSION UNIT

The busbar expansion unit shall be of a single pole laminated copper strip design of appropriate current rating and shall be arranged to take up the axial expansion or contraction of the busbar trunking system under normal service conditions. The expansion unit shall be prevented from short-circuit from adjacent bar either by ample space between phases or alternatively by segregation between phases.

C5.8 FIRE BARRIER IN BUSBAR TRUNKING SYSTEM

Fire barrier shall be made of non-hygroscopic material having a fire-resistant period of not less than that of the corresponding compartmentation wall or slab at where it is installed. Factory fabricated internal barrier shall be used.

C5.9 BUSBAR TRUNKING ACCESSORIES

Bends, tees and intersection units shall be specifically designed and manufactured for the particular type of busbar system with which it is to be used. The casing of the accessories shall be of same material and finish as the busbar casing and shall have a cross-sectional area not less than that of the busbar casing. No loss in mechanical strength, electrical continuity, rated current and rated short-circuit capacity shall be incurred due to insertion of bends or tees.

C5.10 REQUIREMENT FOR AIR-INSULATED BUSBAR TRUNKING SYSTEM

C5.10.1 Busbar Enclosure

Enclosure of the busway shall be of steel construction, made of sheet steel of not less than 1.2 mm thick for busways width or height of casing not exceeding 100 mm and not less than 1.5 mm thick for a width or height exceeding 100 mm, formed in such a way as to give a rigid structure of sufficient strength. Both the main portion of the enclosure and cover shall be flanged at the side edges.

The cover shall be fixed onto the body of the busway at the front by means of heavily electroplated hexagonal head screws and nuts, one of which shall be firmly fixed onto the trunking assembly. The cover shall be removable except where the busway passes through the floor slab.

Steel work shall be treated to prohibit corrosion by hot-dip galvanizing or electrolytically coated with zinc. The inside and outside surfaces of the enclosure shall then be coated with two layers of stoved enamel finish paint with contrasting colours or one layer of stoved epoxy powder paint.

C5.10.2 Busbar Supports

Busbars shall be supported on insulated racks or blocks to IEC 60667 and shall comply with clause 7.1.2.3 of IEC 60439-1.

- (a) At each location of the busbar support insulator, the busbar shall be insulated with self-extinguishing heat shrinkable insulating sleeve of suitable operating temperature extended to 50 mm on each side of the busbar support insulator.
- (b) The busbar supports shall be mechanically strong enough to withstand the force between busbars produced by a short circuit of negligible impedance between two or more busbars.

C5.10.3 Busbar Jointing

Jointing of sections of busbars shall be made by clamps tightened by bolts and nuts. Soldered, welded or riveted joints shall not be used.

Bolts for jointing busbars shall be of steel either hot dip galvanized or heavily electroplated with zinc or cadmium to guard against corrosion.

C5.10.4 Suspension Unit, Flexible Joint and Stop-end Unit

Suspension unit and flexible joint shall be capable of taking up the busbar movements due to axial expansion and contraction. The flexible joint shall be insulated with self-extinguishing heat shrinkable insulating sleeves of suitable operation temperature.

Stop-end unit and built-in thrust block shall be of the same material and finish as the busbar casing. The unit shall contain an insulated support to enable the ends of the busbars to be properly supported.

C5.10.5 Tap-off Unit

Proper tap off devices in the form of tap-off clamps and cable lugs where necessary shall be provided for tap-off cables and such devices shall not reduce the effective size or rating of the busbars. Slots through enclosures for tap-off cables shall be sealed with phenolic resin bonded paper laminated sheet.

C5.10.6 Testing and Certification

Busway shall be type tested in accordance with Clause 8.1.1 of IEC60439-2. The verification of short-circuit strength shall be carried out by an Independent Short Circuit Testing Organization.

Short-circuit test on the phase and neutral busbars shall be carried out in accordance with Clause 8.2.3 of IEC 60439-1 to the value of short-circuit current specified below:

<u>Busbar Rating</u>	<u>Test Current</u>
(a) Under 800A	: Fused* short-time withstand current of 40kA minimum.
(b) 800A to 1600A inclusive	: Short-time withstand current of 40kA minimum for one second.
(c) Above 1600A	: Short-time withstand current of 50kA for one second.

* IEC 60269

The busbar insulation shall be tested in accordance with Clause 8.2.2 of IEC 60439-1. All test certificates shall be submitted for endorsement prior to ordering.

C5.11 REQUIREMENT FOR ALL INSULATED BUSBAR TRUNKING SYSTEM

C5.11.1 Busbar Enclosure

The enclosure of the busway shall be rigidly constructed from galvanized sheet steel of not less than 1.5 mm thick or aluminium of minimum 2.5mm thick clamped on rigid casing side steel channels. Where a combination of sheets of these two materials is used as the assembly, no apparent visible stress shall be observed during operation when the busways are properly supported. However, the thickness of the metal sheets employed shall, in no cases, be less than 1.5 mm each.

Steel work shall be treated to prohibit from rusting and corrosion by hot-dip galvanizing or electrolytically coated with zinc. The inside and outside surfaces of the enclosure shall then be coated with two layers of stoved enamel finish paint, or one layer of stoved epoxy powder paint.

Sheet metal shield or appropriate protective cover with neoprene gasket shall be provided to prevent contamination of busbar trunking if it is for outdoor use or it is running near any services water pipe.

C5.11.2 Busbar Insulation

Busbar shall be insulated over their entire length except at joints and plug-in contact surfaces and the insulation material shall be of at least Class B (130°C) rating.

The temperature rise at any point in the busbar trunking shall not exceed 55°C rise above ambient temperature when operating at rated load current.

C5.11.3 Tap-off Units

Tap-off unit shall be equipped with internal barriers to prevent accidental contact of fish tapes and conductors with the live parts at the terminals of the outgoing protective device during the time of conductor fixing.

Bolt-in tap-off unit enclosure shall be provided with sufficient spacing for cable connection to other sub-circuit devices.

Plug-in tap-off shall be polarized to prevent incorrect insertion and be mechanically interlocked with the busway housing to prevent insertion or removal of the plug-in unit while the protective device is in the ON position and shall be equipped with an operating handle which always remains in control of the switching mechanism. The protective device shall be fusible switch type with visible blade quick-make and break mechanism unless otherwise specified. Plug-in unit enclosures shall make positive ground connection with the earthing conductors before the jaws make contact with the phase busbars.

C5.11.4 Joint in Busbar Trunking System

Joints shall be of removable type with through-bolts that can be checked for tightness without de-energizing the system. It shall be possible to make up a joint from one side in the event the busway is installed against a wall or ceiling. The joint shall be so designed as to allow removal of any length without disturbing adjacent lengths. All bolts shall be tightened up either by means of a torque wrench to a strength figure as recommended by the manufacturer, or in accordance with the manufacturer's provision of special torque-indicating tightening device.

C5.11.5 Testing and Certification

Busway shall be type tested or individually tested to the satisfaction of the Architect by the verification of short-circuit strength carried out by Short Circuit Testing authorities internationally recognized as having equal standing as ASTA.

Short-circuit test on the phase and neutral busbar shall be carried out in accordance with Sub-section 8.2.3 of IEC 60439-1 to the value of short-circuit current specified below:

<u>Busbar Rating</u>	<u>Test Current</u>
(a) Under 500A	: Fused* short-time withstand current of 40 kA minimum.
(b) 500A to 1600A inclusive	: Short-time withstand current of 40 kA minimum for one second.
(c) Above 1600A	: Short-time withstand current of 50 kA for one second.

* IEC 60269

The busbar insulation shall be tested in accordance with Sub-section 8.2.2 of IEC 60439-1. All test certificates shall be submitted for endorsement prior to ordering.

SECTION C6
FLUORESCENT LUMINAIRE AND LAMP

C6.1 GENERAL

C6.1.1 The luminaires, including the control gear, shall be suitable for operation at 220V $\pm 6\%$, 50 Hz $\pm 2\%$, single phase, a.c. supply.

C6.1.2 The luminaires shall comply both in manufacturing and testing with the following international standards and their manufacturing process shall conform to the relevant quality standard of ISO 9000:

Luminaires	:	IEC 60598-2
Ballast	:	IEC 60920 and/or IEC 60921 as applicable
Electronic ballast	:	IEC 60928 and/or IEC 60929 as applicable
Capacitor	:	IEC 61048 and/or 61049 as applicable
Starter, glow type	:	IEC 60155
Starter, electronic type	:	IEC 60926 and/or IEC 60927 as applicable
Lampholder	:	IEC 60400
Lamp	:	IEC 60081 and/or IEC 60901 as applicable
Internal cable	:	IEC 60245-7 450/750V heat resistant rubber insulated cable, suitable for conductor operating temperature not exceeding 110°C

Test certificate shall be provided and the luminaires shall be marked in accordance with the requirements of IEC 60598-2.

C6.1.3 The luminaires excluding the fluorescent lamp shall be supplied in complete set comprising control gear, lampholders, cable terminal block, etc., interconnected with cables of appropriate colour codes.

C6.1.4 The lamp circuit power factor shall not be less than 0.85.

C6.1.5 Low loss ballast or electronic ballast shall be used. The low loss ballast shall not give wattage losses exceeding:

6 watts for 18 and 36 watt units

8 watts for 58 watt units.

and the noise generated by the ballast shall not exceed 24 dBA when measured in a noiseless room.

Electronic ballast shall be preheat start design.

C6.2. TYPE OF LUMINAIRES

Group 1

This group includes batten luminaires and the combination of different reflectors or diffusers with the basic battens.

Group 2

This group covers special luminaires including glass fibre, garage pit and flame-proof luminaires.

Group 3

This group covers self-contained emergency fluorescent luminaire.

Group 4

Wall-mounted fluorescent luminaire complete with shaver socket.

C6.3 GROUP 1 LUMINAIRES

(Batten luminaires and the combination of different reflectors or diffusers with the basic battens)

C6.3.1 The starting circuit for these luminaires shall be of switch start or electronic start, and the position of the starter shall be readily accessible.

C6.3.2 The basic batten shall be made of sheet steel of minimum 0.5 mm thickness and finished in white stove enamel/stove miracryl enamel/stove miracoat enamel to IEC 60598-1, Class I. The ingress protection shall be at least IP2X to IEC 60529.

- C6.3.3 The basic batten shall be suitable for 20 mm diameter conduit suspension and/or direct-on-ceiling mounting. Two 20 mm diameter clearance holes shall be provided at 610 mm fixing centres on 1200 and 1500 mm luminaires, but only one clearance hole at central position on 600 mm luminaire. All clearance holes shall be surrounded by four number 50.8 mm Pitch Circle Diameter (P.C.D.) holes for circular conduit box fixing.
- C6.3.4 The basic batten shall have a 20 mm diameter knockout at the centre (except for 600 mm luminaire) and in each end face for back or end cable entry. Where the end face of the basic batten is made of non-metallic material, additional means shall be provided to ensure the continuity of earthing when the luminaire is used for surface conduit installation.
- C6.3.5 For back entry installation, if the basic batten cannot fully cover the circular conduit box, a pattress block cover made of 0.5 mm thick mild steel, finished in white stoved enamel shall be supplied with each basic batten to shield the conduit box outlet.
- C6.3.6 The basic batten shall be capable to accept the metal cover plate and different reflectors or diffusers.
- C6.3.7 The metal cover plate, open-end metal angle reflector, and open-end metal trough reflector shall be manufactured and finished to the same specification as the basic batten, and shall be suitable for direct fixing to a basic batten of the appropriate length. The luminaires of this group shall be categorized as follows:

Cat. A: Batten luminaire with metal cover plate

Luminaire composed of basic batten and metal cover plate.

Cat. B: Batten luminaire with metal angle reflector

Luminaire composed of basic batten and open-end metal angle reflector.

Cat. C: Batten luminaire with metal trough reflector

Luminaire composed of basic batten and open-end metal trough reflector.

Cat. D: Batten luminaire with plastic diffuser

Luminaire composed of basic batten, metal cover plate and plastic prismatic diffuser.

C6.3.8 The plastic prismatic diffuser with clip-on-end-plates shall be manufactured from extruded plastics with external reeding suitable for fixing to a basic batten with metal cover plate. The plastic clip-on-end-plate shall be simply fitted to the basic batten thus enabling the diffuser to be quickly and easily removed for cleaning and general maintenance.

C6.4 GROUP 2 - SPECIAL LUMINAIRES

C6.4.1 Luminaires of this group are categorized as follows:

Cat. A: Glass-fibre luminaires

Cat. B: Garage pit luminaires

Cat. C: Flameproof luminaires

C6.4.2 Cat. A: Glass-fibre luminaires

- (a) The starting circuit shall be either of switch start or electronic start, and the control gear components shall be fixed in a removable tray. The construction of the luminaire shall be suitable for chemically corrosive atmosphere and complying with BS 4533: Part 101 (BS EN 60598-1), Class I or II, but preference will be given to Class II. The ingress protection shall be at least IP55 to IEC 60529.
- (b) The luminaire shall comprise glass fibre reinforced polyester base canopy and high impact resistant polycarbonate diffuser with internal prisms held together by corrosion resistant clips. Wide seamless polyurethane gasket shall be fitted between diffuser and canopy. The exterior of the fitting shall be of white acrylic finish. The luminaire shall maintain a maximum light output ratio not less than 73%.
- (c) The luminaire shall be suitable for 20 mm diameter conduit suspension and direct-on-ceiling mounting. Two 20 mm diameter clearance holes shall be provided at 610 mm centres, surrounded by four number 50.8 mm C.P.D. holes for circular conduit box fixing. One number. 20 mm diameter knockout shall also be provided in one end face of the fitting.

C6.4.3 Cat. B: Garage pit luminaires

- (a) The starting circuit shall be of electronic start. The construction of the luminaire shall comply with IEC 60598-1, Class II and suitable for use in Zone 2 hazardous area as defined by IEC60079-10. The ingress protection shall be at least IP65 to IEC 60529.

- (b) The luminaire shall be made of sheet steel and finished in white stove enamel internally and grey externally. The luminaire shall have a removable opal polycarbonate front cover which shall be clamped securely into a soft rubber gasket by means of quick release fasteners. Fixing holes shall be provided in the front flange together with 20 mm diameter knockout at each end.

C6.4.4 Cat. C: Flameproof luminaires

- (a) The luminaires shall be designed and constructed in accordance with IEC 60079-1, flameproof enclosure Ex 'd' and certified flameproof by an approved independent testing authorities, such as the British Approval Services for Electrical Equipment in Flammable Atmospheres (BASEEFA). The luminaire shall be suitable for installation in Zone 1 hazardous area as classified in IEC 60079-10. The enclosure of the luminaire shall comply with the requirements for temperature classification T6, i.e. maximum surface temperature does not exceed 85°C, as stated in IEC 60079-0 and Gas Group IIB as stated in IEC 60079-12. The ingress protection shall be at least IP66 to IEC 60529.
- (b) The body casting, control gear housing and end covers shall be constructed with cast aluminium at least to ISO 3522 Al-Si5Cu3 or grade LM4 of BS 1490 and with suitable coating for increased protection against corrosion. The fluorescent lamp shall be housed in a cylinder of borosilicate glass and flamesealed at the end of the casing.
- (c) The starting circuit shall be electronic start and the control gear components shall be installed on a removable metal tray enclosed in a separate housing which shall be provided with at least 20 mm E.T. entries for through connections.
- (d) The luminaire shall be suitable for either 20 mm diameter conduit suspension or direct-on-ceiling mounting by hook brackets with locking screw which mates with catch bracket. The luminaire shall also be suitable for wall mounting without diminution of performance.
- (e) The incoming terminal chamber shall be an integral part of the body casting complete with two phase and earth terminal block. The cover of chamber shall be provided with weatherproof gasket and with at least 20 mm entries fitted with hexagonal headed flameproof plug.

C6.5 GROUP 3 - SELF-CONTAINED EMERGENCY FLUORESCENT LUMINAIRES

C6.5.1 General

The specified type of self-contained emergency fluorescent luminaires shall be of the following types:

Type I : 18W, 600 mm long, single fluorescent lamp

Type II : 36W, 1200 mm long, single fluorescent lamp

Type III : 58W, 1500 mm long, single fluorescent lamp

All fluorescent lamps shall not be larger than 26 mm diameter.

C6.5.2 Standards

In addition to Clause C6.1.2, the luminaire shall comply with the following standards:

Luminaire : IEC 60598-2-22

Inverter assembly : IEC 60924

Isolating transformer : IEC 60742

C6.5.3 Functional Requirements

- (a) Emergency luminaire shall be of maintained type. Under normal supply, a sealed nickel-metal hydride battery unit complying to BS EN 61436 and BS EN 61951-2 where applicable shall be charged to maintain in a fully charged state ready to supply power as required and lamp should be operated by the mains supply through a separate circuit. When a failure of mains supply occurs, the unit shall switch instantaneously to battery-powered operation. Upon restoration of the mains supply, the lamp should be switched back to mains supply operation and the batteries shall be re-charged again. The whole operation shall be performed automatically.
- (b) Battery cells shall be capable of continuous operation at cell wall temperature of 60°C. The battery shall have ample capacity to maintain the output of the fluorescent lamp upon mains supply failure as specified below for up to a period of 2 hours. The life time of the battery cells shall be not less than 4 years.
- (c) Charging system shall be capable of recharging the battery to full capacity in 24 hours after a total discharge of the battery. Facilities shall be provided to prevent the battery from over-charging.

- (d) Circuit of the fitting shall be so designed such that a lighting switch can be installed to control the lamp in the ON or OFF position under the mains-powered operation. Upon mains supply failure, the lamp shall be switched on under battery power irrespective of whether the lighting switch is in the ON or OFF position.
- (e) Light output throughout the average mid-tube life when using “daylight” 4500°K tube shall be as follow:
 - (i) When in maintained mode

Type I	:	1,050 lumens
Type II	:	2,650 lumens
Type III	:	4,110 lumens
 - (ii) Throughout the 2-hour discharging period when mains fails

Light output shall not be less than 50% of the nominal light output under the maintained mode.

C6.5.4 Construction

- (a) The luminaire shall be supplied complete with the following component parts integrated in the interior of the fitting:
 - (i) A battery charger unit
 - (ii) A sealed, rechargeable, maintenance free, nickel-metal hydride battery
 - (iii) A mains power failure detector
 - (iv) An automatic change-over switch, capable of changing over within 8 ms from mains supply to battery supply
 - (v) Inverter/ballast to operate fluorescent tubes
 - (vi) Capacitors and radio interference suppressors
 - (vii) Indications that the mains supply is normal or that the battery is discharging
 - (viii) A test button for checking battery condition
 - (ix) Fluorescent tube
 - (x) A low voltage “cut-out” battery protective device
 - (xi) A battery over-charging protective device.

- (b) The basic spine of the fitting shall be manufactured from sheet steel to form a complete enclosure, and finished in white stoved enamel.
- (c) The luminaire shall be suitable for conduit, rod chain or conduit box mounting at normal suspension centres. Alternative mains entry shall also be provided in the centre back of the spines or by a knock-out in each end plate.
- (d) A fused terminal block fitted with cartridge fuses of appropriate rating shall be provided separately for both the charger and the maintained circuit.
- (e) The luminaire shall be provided with a clear acrylic diffuser.

C6.6 GROUP 4 - WALL-MOUNTED FLUORESCENT LUMINAIRE COMPLETE WITH SHAVER SOCKET

C6.6.1 Construction

The luminaire shall be of wall-mounted type and suitable for use in bathroom. It shall be supplied in a complete set including body, diffuser, end caps, control gear, lampholders, shaver socket, fluorescent lamp, mounting accessories, etc.

The luminaire shall be constructed with the following components:

- (a) An extruded aluminium or steel body with silver anodized finish or finished to the nearest manufacturer's standard colour.
- (b) An opal acrylic or equal and approved diffuser fitted between two end caps. The diffuser shall be arranged for easy removal, cleaning and general maintenance.
- (c) Sufficient numbers of two-way terminal blocks suitable for terminating 1.5 mm² P.V.C. insulated cables and a separate earth terminal.
- (d) A control gear tray cum reflector made of anodized aluminium or steel with white finish.
- (e) Low power factor switch start control gear comprising ballast, capacitor, starter, lampholders, etc. for a 13W, 525mm fluorescent lamp. The overall power factor of the lamp circuit shall not be less than 0.85 lagging.
- (f) A shaver supply unit complying with BS EN 60742.

- (g) An on/off pull cord switch controlling both the fluorescent tube and the shaver socket.
- (h) A rocker switch controlling the shaver socket.

C6.6.2 The luminaire shall be suitable for back entry through a conduit box complying with IEC 60670.

C6.6.3 The luminaire shall be supplied with a 13W, 525 mm approximately warm white fluorescent lamp to IEC 60081.

C6.7 FLUORESCENT LAMPS

C6.7.1 Lamp Features

Lamps shall have, but not limited to, the following features:

- (a) Superb colour rendering (Ra) property with values not less than:

Areas served	Values of R _a
Car parking spaces or similar	50
Office areas or similar	80
Hospitals or other clinical functional areas	90

- (b) Energy saving
- (c) Compatible to the type of lamp circuit, and
- (d) Tubular shape with preheated cathode and suitable for operation in ambient temperature up to 40°C and 100% relative humidity.

C6.7.2 All fluorescent lamps shall have lumen output not less than those listed in Tables C6.7.2-1 to C6.7.2-10 .

Table C6.7.2 – 1

Lumen Output for 26 mm Diameter (T8) Tubular Fluorescent Lamps

Rated power of lamp	Min. Lumen output				
	2700°K	3000°K	3800°K	5400°K	6500°K
18	1350	1350	1350	1300	1000
36	3350	3350	3350	3250	2300
58	5200	5200	5200	5000	3700

Table C6.7.2 – 2

Lumen Output for Circular Fluorescent Lamps

Rated power of lamp	Min. Lumen output				
	2700°K	3000°K	3800°K	5400°K	6500°K
22	1350	--	1000	--	1050
32	2050	2000	2000	--	1750
40	2900	2800	2300	--	2500

Table C6.7.2 – 3

**Lumen Output for 38 mm Diameter U-tube Fluorescent
Lamps**

Rated power of lamp (W)	Min. Lumen output		
	2700°K	3000°K	3800°K
20	--	1150	950
40	--	2700	2400
65	--	4500	3900

Table C6.7.2 – 4

**Lumen Output for 16 mm Diameter (T5) Tubular
Fluorescent Lamps**

Rated power of lamp (W)	Min. Lumen output		
	3000°K	4000°K	6000°K
14	1350	1350	1300
21	2100	2100	2000
28	2900	2900	2750
35	3650	3650	3500
24	2000	2000	1900
39	3500	3500	3325
54	5000	5000	4750
49	4900	4900	4650
80	7000	7000	6650

Table C6.7.2 – 5

**Lumen Output for Compact Fluorescent, Single-ended,
4 Pin Base Lamps**

Rated power of lamp (W)	Min. Lumen output			
	2700°K	3000°K	3800°K	5400°K
5	250	--	250	--
7	400	400	400	--
9	600	600	600	--
11	900	900	900	--
18	1200	1200	1200	750
24	1800	1800	1800	1200
36	2900	2900	2900	2400
40	3500	3500	3500	2200
55	4800	4800	4800	3000

Table C6.7.2 – 6

**Lumen Output for Compact Fluorescent, Single-ended,
2 Pin Base With Built-in Starter Lamps**

Rated power of lamp (W)	Min. Lumen output			
	2700°K	3000°K	3800°K	5400°K
5	250	250	250	--
7	400	400	400	375
9	600	600	600	565
11	900	900	900	850

Table C6.7.2 – 7

**Lumen Output for Compact Fluorescent, Twin Independent
Single-ended, 2 Pin Base With Built-in Starter Lamps**

Rated power of lamp (W)	Min. Lumen output		
	2700°K	3000°K	3800°K
10	600	600	600
13	900	900	900
18	1200	1200	1200
26	1800	1800	1800

Table C6.7.2 – 8

**Lumen Output for Compact Fluorescent, Triple Independent
Single-ended, 2 Pin Base With Built-in Starter Lamps**

Rated power of lamp (W)	Min. Lumen output		
	2700°K	3000°K	3800°K
13	900	900	900
18	1200	1200	1200
26	1800	1800	1800

Table C6.7.2 – 9

**Lumen Output for Compact Fluorescent, Triple
Independent Single-ended, 4 Pin Base Lamps**

Rated power of lamp (W)	Min. Lumen output		
	2700°K	3000°K	3800°K
13	900	900	900
18	1200	1200	1200
26	1800	1800	1800
32	2400	2400	2400
42	3200	3200	3200

Table C6.7.2 – 10

**Lumen Output for Compact Fluorescent, Four Independent
Single-ended, 2 Pin Base With Built-in Starter Lamps**

Rated power of lamp (W)	Min. Lumen output		
	2700°K	3000°K	3800°K
8	350	--	--
10	600	600	--
13	900	900	900
18	1200	1200	1200
26	1800	1800	1800

- C6.7.3 All fluorescent lamps shall have average rated life not less than those listed below at 50% failure:

Table C6.7.3

Average Rate Life for Fluorescent Lamp

Fluorescent Lamp Type	Average Rated Life (Hour)
T8 fluorescent lamp	12000
T5 fluorescent lamp	20000
Circular fluorescent lamp	12000
U-tube fluorescent lamp	8000
Compact fluorescent lamp	8000

C6.8 ELECTRONIC BALLASTS

C6.8.1 General

The electronic ballast shall be a solid-state converter to convert single phase mains supply of 220V $\pm$ 6% and 50Hz $\pm$ 1Hz to a high frequency voltage output at its rated throughout power to suit the lamp(s) connected. The electronic ballast shall conform to the following international standards:

- (a) IEC 60928/EN 60928/GB 15143-94:
AC-supplied electronic ballasts for tubular fluorescent lamps -
General & safety requirements
- (b) IEC 60929/EN 60929/GB 15144-94:
AC-supplied electronic ballasts for tubular fluorescent lamps -
Performance requirements
- (c) IEC 61000-3-2/EN 61000-3-2:
Limits for harmonic current emission
(equipment input current $\leq$ 16A per phase)
- (d) EN 55015:
Limit and method of measurement of radio disturbance
characteristics of lighting and similar equipment
- (e) EN 61547:
Equipment for general lighting purposes - EMC immunity
requirements

Certificates of compliance with the above standards shall be issued by a recognised test laboratory for each standard rating of electronic ballast to be used in the Contract.

C6.8.2 Construction

The electronic ballast shall incorporate a low-pass filter for limitation of harmonic distortion, radio interference, inrush current and high mains voltage peak, a full diode bridge rectifier, a power factor correction part, a high frequency oscillator and an internal control circuit.

C6.8.3 Performance Requirements

The minimum efficiency of the electronic ballast shall be 90%. In case of dimmable electronic ballast, the minimum efficiency shall not be less than 85% at its lowest dimmable range.

For the fluorescent lamp(s) operated by electronic ballast, the regulated light output shall be less than $\pm 2\%$ over a supply voltage range of 220V $\pm 10\%$ to the electronic ballast.

The Ballast Lumen Factor of the electronic ballast shall not be lower than 0.95 or higher than 1.05 with reference to a standard conventional ballast.

The electronic ballast shall be rapid or instant start and the lamp operating frequency shall be above 30kHz.

The Total Power Factor (TPF) of the electronic ballast shall be higher than 0.95 and its maximum Total Harmonic Distortion (THD) shall be less than 20% when tested on a pure sinusoidal mains supply.

The complete electronic ballast shall be housed in a single front-access enclosure with appropriate terminal blocks for easy connection of wiring. The electronic ballast shall be suitable to operate at an ambient temperature range from 0°C to 50°C and at a maximum relative humidity of 95%. The maximum case temperature of the electronic ballast shall be 70°C.

The electronic ballast shall go into a shutdown or low power stand-by state when defective lamps are connected or when overload occurs in the lamp circuit.

The maximum inrush current of the electronic ballast shall not exceed 15A peak at starting and shall not last longer than 0.5 ms.

The rated life of the electronic ballast shall not be less than 50,000 hours at the test point of 70°C.

The failure rate of the electronic ballast shall be less than 1% per 4000 hours operation at the maximum case temperature.

SECTION C7

HIGH PRESSURE DISCHARGE LAMP AND LUMINAIRE

C7.1 GENERAL

This section covers the requirements for the following high pressure discharge lamps.

Tubular sodium vapour discharge lamps (SON-T)

Elliptical sodium vapour discharge lamps (SON-E)

Elliptical mercury vapour discharge lamp (MBF)

Floodlight luminaire accepting linear metal halide / linear high pressure sodium lamp

The lamp, in connection with the control gear, shall be suitable for operation at $220V \pm 6\%$, $50Hz \pm 2\%$, single phase, a.c. supply.

The lamp shall be compatible with the luminaire and the control gear of the luminaires.

C7.2 HIGH PRESSURE SODIUM VAPOUR DISCHARGE LAMP (SON-T AND SON-E)

The lamp shall be manufactured and tested in accordance with BS EN 60662 or the equivalent BS 6193. The manufacturing process shall comply with the quality standard of BS EN ISO 9000-4 or the equivalent BS 5750.

The lamp shall consist of a high pressure sodium discharge operating within a sintered alumina arc tube. The arc tube shall be mounted in a clear glass bulb complete with an E40 (GES) cap.

The lamp shall have a universal operating position and shall be suitable for use with external ignitor.

The correlated colour temperature of the lamp shall be in the order of $2000^{\circ}K$. The light output of the lamp shall be constant and shall not be less than the following figures for the respective wattage type in the initial 2000 hours:

Nominal Lamp Wattage	Initial Light Output
150W	16000 lumens
250W	28000 lumens
400W	48000 lumens

The rated average life of the lamp shall not be less than 24000 hours at 50% failure.

C7.3 ELLIPTICAL HIGH PRESSURE MERCURY VAPOUR DISCHARGE LAMP (MBF)

The lamp shall be manufactured and tested in accordance with BS EN 60188 or the equivalent BS 3677. The manufacturing process shall comply with the quality standard of BS EN ISO 9000-4 or the equivalent BS 5750.

The lamp shall consist of a high pressure mercury discharge operating within a quartz arc tube. The arc tube shall be mounted in an elliptical glass bulb coated with a fluorescent phosphor and complete with a cap of the type compatible with the respective lamp wattage type.

The correlated colour temperature of the lamp shall be in the range of 3400°K to 4000°K with respect to the selected nominal lamp wattage.

The lamp shall have a universal operation position.

The light output of the lamp shall be constant and shall not be less than the following figures for the respective wattage type in the initial 2000 hours:

Nominal Lamp Wattage	Initial Light Output
50W	1800 lumens
80W	3700 lumens
125W	6500 lumens
250W	13000 lumens
400W	22000 lumens

The rated average life of the lamp shall not be less than 16000 hours or 24000 hours with respect to the selected nominal lamp wattage at 50% failure.

C7.4 FLOODLIGHT ACCEPTING LINEAR METAL HALIDE/LINEAR HIGH PRESSURE SODIUM LAMP

C7.4.1 General

This Sub-section covers floodlight luminaires to accept either of the following lamps:

- (a) 750W/1500W linear metal halide (MBIL)
- (b) 400W linear high pressure sodium (SON-TD)

The floodlighting luminaires shall be manufactured and tested in accordance with BS 4533 or the equivalent BS EN 60598. The

manufacturing process shall conform to the relevant quality standard of ISO 9000-4 or the equivalent BS 5750.

The floodlighting luminaires shall have a degree of protection of not less than IP54 to BS EN 60529 and they shall be constructed from corrosion resistant materials.

The floodlighting luminaires shall be suitable for continuous outdoor operation at an ambient temperature of 35°C without unduly affecting the life and performance of the floodlighting luminaires, the control gear and the lamps.

The floodlighting luminaires shall be supplied in complete set including the main body, reflectors, front glass, lampholder assemblies, terminal box, internal wings, control gear, control gear box and mounting facilities as specified and as required.

C7.4.2 Construction

The main body shall be manufactured from highly specular aluminium reflector, which is fixed to two aluminium alloy end castings. The luminaire should also incorporate removable drain plugs for use in humid conditions.

Internal reflectors consisting of the main body and two end cheeks and the two optional reflectors, baffled and faceted, are to be constructed from highly specular aluminium. The metal reflector shall be polished, anodized and shall be designed to give an asymmetrical light distribution of beam angle to 1/10 peak to approximately the following requirements:

- (a) for 750/1500W MBIL lamp
 - Horizontal 90°
 - Vertical 9° above peak, 41° below peak
- (b) for 400W SON-TD lamp
 - Horizontal 84°
 - Vertical 4° above peak, 19° below peak

The heat resistant toughened glass shall be fitted to a non-ferrous metal front frame with corrosion resistant hinges and four swivel bolts (stainless steel) for securing to the main body and provided with weatherproofing silicon rubber gasket between the main body and toughened front glass.

The lampholder assembly shall be suitable for accepting the lamp as specified. They shall be incorporated with appropriate heat sinks if necessary to avoid overheating.

Weatherproof wiring terminal box shall be mounted at the rear side of the main body suitable for housing a two-way terminal block, each

terminal suitable for 1x10 mm² cable. Cable entry is provided via a combined cable gland/cord grip. Earthing stud/terminal shall be provided.

Internal wiring shall be of heat resistant type to the appropriate IEC standard or British Standard.

The control gear shall be suitable for operation of the lamp as specified, and shall consist of a ballast, ignitor, transformer and power factor correction capacitor(s) as appropriate, to enable the whole assembly to operate at the specified voltage with an overall power factor not less than 0.85.

Control gear shall be provided with facilities for easy and securely fixing to a metal back plate or gear box. Control gear shall be suitable for continuous operation under an ambient temperature of 35°C.

The floodlighting luminaires shall be complete with the stirrup arrangement which permits the floodlighting luminaires to be rotated in azimuth and adjusted in elevation. An aiming stop shall be provided on the floodlighting luminaires to ensure that the aiming angle remains undisturbed even if the floodlighting luminaires are removed from the stirrup for servicing.

C7.4.3 Lamps

All types of lamps suitable for fixing to the specified luminaire shall have a high efficiency and a fairly constant output and be constructed with standard Rx7s ceramic caps.

MBIL linear metal halide lamp shall consist of an arc burning between tungsten electrodes in an atmosphere of mercury and additional metal halides enclosed in a double-ended quartz arc tube. The halides shall be chosen to have a high efficiency light output of good colour rendering and correlated colour temperature of 5200°K. The lamp shall be 750/1500W as specified. The rated average life of the lamp shall not be less than 6000 hours at 50% failure.

SON-TD linear high pressure sodium lamp shall be tubular, double ended in construction and shall consist of an arc tube made of sintered aluminium oxide and mounted in a clear tubular quartz outer bulb having a single contact ceramic cap at each end. The lamp shall be rated at 400W and have a correlated colour temperature of 2100°K. The rated average life of the lamp shall not be less than 24000 hours at 50% failure.

SECTION C8
TUNGSTEN HALOGEN LAMP

C8.1 GENERAL

Tungsten lamps shall meet the safety requirements as specified in BS EN 60423. The manufacturing process shall comply with the relevant quality standard of ISO 9000 series standards.

The colour temperature of the lamp shall be within the range between 2800°K and 3200°K. The colour rendering index shall not be less than 90.

The rated average life of the lamp shall not be less than 2000 hours at 10% failure. The light output of the lamp shall not be diminished by more than 5% throughout the guaranteed life.

C8.2 SPECIAL REQUIREMENTS FOR MAINS VOLTAGE (220V) LAMP

The lamps shall comply with EN 60357 or other equivalent international standards suitable for operation at 220V $\pm$ 6% and 50 Hz $\pm$ 2%, single phase a.c.

The luminous efficacy shall not be less than 13 lumens/lamp watt.

C8.3 SPECIAL REQUIREMENTS FOR EXTRA-LOW VOLTAGE (ELV) LAMP

C8.3.1 General

The lamp shall be suitable for operation at 12V single phase a.c. through a compact electronic step-down transformer suitable for operation at an input supply of 220V $\pm$ 6%, 50 Hz $\pm$ 2%, single phase a.c. The output shall be 12V a.c.

C8.3.2 The Transformer

The transformer shall be supplied together with the 12V lamp as an integral package by the same manufacturer or supplier.

The general and safety requirements shall comply with IEC 61046 or other equivalent international standards which shall at least cover:

(a) General requirements:

- (i) tests
- (ii) classification
- (iii) marking

(b) Safety requirements:

- (i) terminals
- (ii) earthing
- (iii) construction
- (iv) creepage distances and clearances
- (v) protection against contact with live parts
- (vi) moisture resistance and insulation
- (vii) electric strength
- (viii) transformer heating
- (ix) abnormal conditions (such as, but not limited to, no lamp inserted, lamp resistance reduced, output terminals short-circuited, etc.)
- (x) fault conditions
- (xi) screws, current-carrying parts and connections
- (xii) resistance to heat and fire
- (xiii) resistance to corrosion

The performance requirements shall comply with IEC 61047 or other equivalent international standards which shall at least cover:

- (i) tests
- (ii) classification
- (iii) marking
- (iv) output voltage and current
- (v) total circuit power
- (vi) circuit power factor
- (vii) supply current
- (viii) impedance at audio-frequencies
- (ix) mains transient over voltages
- (x) abnormal conditions (such as, but not limited to, no lamp inserted, lamp resistance reduced, output terminals short-circuited, etc.)
- (xi) endurance

The harmonics of the output current shall comply with IEC 60555-2 as stipulated in IEC 61047.

The radio interference suppression shall comply with EN 55015/A1 or other equivalent international standards.

The transformer shall be suitable for use with dimmers so that the illuminance of the lamp can be adjusted if required. In addition, the transformer shall be able to be used with d.c. supplies for emergency lighting purpose.

SECTION C9

DOMESTIC APPLIANCES

C9.1 GENERAL

C9.1.1 Compliance with Regulation

Domestic appliances together with their electric components and cabling shall comply with the currently-in-force edition of

- (a) Electrical Products (Safety) Regulation, CAP 406G of Laws of Hong Kong, and
- (b) the specified or relevant IEC or equivalent standards

C9.1.2 General Requirements

- (a) Unless otherwise specified, the domestic appliances shall be designed for operation on 220 V $\pm 6\%$, 50 Hz $\pm 2\%$, single phase, a.c. supply.
- (b) Unless otherwise specified, the domestic appliances shall be suitable in all respects for operation in ambient air condition of temperature range between 0° and 40°C, and relative humidity range between 0% and 99% with condensation due to temperature changes.
- (c) Unless otherwise classified as Class II appliances under the specified IEC or equivalent standards, all accessible metal parts of the domestic appliances that may become live in the event of electric fault shall be effectively and suitably bonded to earth via to a common earthing terminal provided within the domestic appliances.
- (d) Where specified, 3-core flexible cord connected to the domestic appliances shall conform to BS 6500 or equivalent standard. The size of the cable shall not be less than that specified and shall be compatible with the rating of the respective domestic appliance.
- (e) Where specified, 13A plug connected to the flexible cord shall conform to BS 1363 or equivalent standard. The fuse of the plug shall be of a rating compatible with the rating of the respective domestic appliance.

C9.1.3 Technical Literature

The following technical literatures in Chinese and/or English shall be provided, where applicable:

- (a) Certificate of Safety Compliance
- (b) Product catalogue
- (c) Assembly drawings with dimensions
- (d) Electrical circuit diagram
- (e) Installation, operation and service manuals

- (f) Trouble-shooting guide
- (g) Spare part list with itemised price

C9.2 900 mm, 1200 mm and 1400 mm CEILING FAN

C9.2.1 General Requirements

- (a) The fan shall be fully balanced after assembly to ensure that the fan shall not oscillate/vibrate due to out-of-balance forces or whatsoever during operation.
- (b) The fan shall conform to the latest edition of the following standards:
 - (i) IEC 60879: "Performance and construction of electric circulating fans and regulators", BS 5060 or equivalent standards; and
 - (ii) IEC 60335-2-80: "Safety of household and similar electrical appliances-Part 2: Particular requirements for fans" or equivalent standards.

C9.2.2 Performance Requirements

- (a) The sweep diameter of the fans shall be:

Size of Fan	Sweep Diameter
900 mm	900 mm $\pm$ 5%
1200 mm	1200 mm $\pm$ 5%
1400 mm	1400 mm $\pm$ 5%

- (b) The air delivery rate of the fans shall be:

Size of Fan	Air Delivery Rate
900 mm	2.2 m ³ /s
1200 mm	4.0 m ³ /s
1400 mm	4.5 m ³ /s

- (c) The power factors of the fans shall not be less than 0.85 at any speed.

C9.2.3 Construction

- (a) Fan unit

- (i) Fan motor

- The motor shall be a totally enclosed, capacitor run induction motor with internal stator and external squirrel-cage rotor.

- The rotor shall be mounted on sealed-for-life grease lubricated ball bearings.

(ii) Fan blades

- The fan shall be fitted with two or more well balanced blades so as to be reasonably free from vibration.
- The blade assemblies shall consist of blades manufactured from heavy gauge aluminium riveted to steel blade carriers.
- The blade carriers shall be manufactured from mild steel plate of not less than 40mm width at the narrowest point, pressed to shape.
- Where the blade carriers are twisted to give the required angle of incidence to the blades, there shall be large radius bends to prevent stress concentrations in the blade carriers.
- The blade carriers shall be securely fastened to the frame of the motor by machine screws and spring washers, the whole designed to ensure that there is no possibility of a blade becoming detached during operation.

(b) Connecting piece (capacitor housing)

- (i) The plastic terminal block and capacitor shall be mounted in a ferrous metal connecting piece located between the fan and the down-rod assembly. The leads from the stator windings shall be connected to the terminal block. An earthing terminal, consisting of a round head brass screw and washer, shall be provided on the connecting piece. All exposed metal parts of the fan shall be connected to this earthing terminal.
- (ii) The bottom portion of the connecting piece shall be screwed on the shaft of the motor. The connecting piece shall be tightened on to a shoulder formed on the motor shaft. An 4 mm minimum thickness steel hexagonal lock-nut with lock bracket underneath shall then be fitted and tightened in position as shown on the BSB Standard Drawings. The connecting piece shall be secured in the fully tightened position by two (2) hardened steel grub screws. These screws shall engage in shallow depressions drilled in the shaft after the connecting piece has been tightened in place to ensure positive locking.

(c) Down-rod assembly

- (i) The down-rod assembly shall consist of a steel down-rod complete with shackle and hard rubber roller for suspension of the fan as generally shown on the BSB Standard Drawings. The down-rod shall be supplied in lengths of 200mm, 300mm, 450mm, 600mm, 750mm, 900mm and 1200mm as specified in the Particular Specification.
- (ii) Cable of such a length as to suit the down-rod shall be provided. The down-rod shall be manufactured from steel tube to BS 1387 or equivalent standards, having an outside diameter of approximately 21 mm, with minimum wall thickness of not less than 3 mm as specified in Table 5 of BS 1387. It shall be accurately threaded at one end and shall be screwed into the top portion of the fan connecting piece (capacitor housing) from which it shall protrude by a minimum of 2 mm. The minimum wall thickness of the threaded portion, measured from the minor diameter of the thread to the internal diameter of the tube, shall be not less than 1.8 mm.
- (iii) The down-rod shall be locked in position by two (2) hexagonal steel lock nuts, having a minimum thickness of 6 mm, tightened on to the upper machined surface of the fan connecting piece.
- (iv) The down-rod shall also be locked to the fan connecting piece by means of a steel split-pin, of not less than 5 mm diameter, passing through both the fan connecting piece and the down-rod.
- (v) The split-pin holes in the fan connecting piece shall be of such diameter that the split-pin is a light push fit there in. The matching split-pin holes in the down-rod shall be just sufficiently large so that the split-pin shall be a light push-fit, when the hole is in its worst position relative to the threading. All burrs and sharp edges shall be removed from the split-pin holes in both the fan connecting piece and the down-rod.
- (vi) The steel suspension shackle shall be welded to the down-rod. Welding shall be of good quality. The rubber roller shall be mounted on an 8 mm diameter steel clevis pin secured by a split-pin.
- (vii) The ends of the down-rod shall be rounded off and free from burrs. There shall be no sharp edges which could cause damage to the insulation of the wiring.
- (viii) Suspension joints and threaded parts:
 - Joints along the suspension rod must be of double-locking design i.e. at least two independent positive locking devices must be employed to prevent a joint from loosening itself.
 - All factory-assembled threaded components which form part of a suspension joint must be bonded with glue as approved by the Architect.

- The maximum clearance between threaded mating parts must not exceed 1% of their mean diameter.
 - The direction of rotation of the fan shall be such that all screwed joints tend to be tightened when the fan is in operation.
- (ix) Two (2) canopies manufactured from plastic or pressed steel sheet and fitted over the upper and lower ends of the down-rod shall be provided. They shall be fixed to the down-rod by grub screws.

(d) Surface finish

The whole fan shall be finished in high quality stove enamel in white or ivory colour.

(e) Speed regulator

- (i) A speed regulator shall be supplied with each fan.
- (ii) The speed regulator shall be of robust construction and built on a flame-retardant moulded plastic or insulated steel base and enclosed by a flame-retardant moulded plastic cover. The cover shall be in white or ivory colour to match the fan.
- (iii) The speed regulator shall be equipped with five (5) speed and an "OFF" position.
- (iv) The rotary switch of the speed regulator shall be designed for smooth and easy movement by hand between different speed positions.
- (v) For choke type regulator, an earth terminal shall be provided on the base with an earth wire permanently connected to the steel core of the choke unit.

C9.3 400 mm SWEEP AUTO CYCLE/OSCILLATING CEILING FAN

C9.3.1 General Requirements

- (a) The fan shall be provided with cable entries, conduit opening or glands for permanent connection to fixed wiring. Connection terminal shall be provided and secured by means of screws, nuts or equally effective devices.
- (b) The power factor of the fan shall not be less than 0.8.
- (c) The fan shall comply with the latest edition of safety standards for household electric fans and regulators as follows:
 - (i) IEC 60342-1, or
 - (ii) IEC 60335-2-80: 1997, or
 - (iii) JIS C 9601 issued by Japan Standards Association, or
 - (iv) BS 3456 Part 101 and Part 102 Section 102.342.

C9.3.2 Performance Requirements

- (a) The fan blades shall have a sweep diameter ranging from 385 to 415mm.
- (b) The air delivery rate of the fan shall be not less than 1 m³/s.
- (c) The noise level of the fan at all operating speeds shall not exceed 58dBA measured at 1 m from the fan.
- (d) The fan shall be provided with double oscillating mounting of not less than 360° (i.e. the direction of the axis of the air flow is changed automatically and continuously in more than one plane.)

C9.3.3 Construction

- (a) The fan shall be designed for ceiling-mounted application.
- (b) The fan motor shall have sealed-for-life roller bearings or bushes.
- (c) The fan shall have adequate mechanical strength and be so constructed as to withstand such rough usage as may be expected in normal use.
- (d) The material of the fan shall be fire-resistant and non-flame propagating.
- (e) The fan shall be of domestic type with smooth, safe edges and 'easy-to-disassemble' design for cleaning.
- (f) The fan blades shall be enclosed by chromed and closely meshed metal guard. The gap of the guard slots shall not be greater than 13 mm.
- (g) The fan shall equip with a thermal cut-out device to protect the fan from abnormal operation.
- (h) The fan shall include a separate fan regulator which shall comprise of three speed settings and a switching-off function.
- (i) The fan shall equip with a control device for adjustment of its angle of oscillation.
- (j) The fan shall be designed with shock-proof device for quiet operation.
- (k) The fan shall be finished to manufacturer's standard light colour to be approved by the Architect.
- (l) The construction of the fan shall be so designed that end-user does not need any tools to assemble/disassemble the fan guard and fan blade for cleaning.
- (m) The fan shall be subject to function test for not less than 72 hours of continuous running and shall show no abnormal conditions such as overheat, failing to oscillate and, etc. during the testing period.

C9.4 400 mm SWEEP WALL FAN

C9.4.1 General Requirements

- (a) The fan shall be fitted with a 0.75 mm² 3-core PVC insulated and sheathed flexible cord of approximately 1.5 m in length; and a suitably fused 13A plug.

- (b) The power factor of the fan shall be not less than 0.8.
- (c) The fan shall comply with the latest edition of safety standards for household electric fans and regulators as follows:
 - (i) IEC 60342-1, or
 - (ii) IEC 60335-2-80: 1997, or
 - (iii) JIS C 9601 issued by Japan Standards Association, or
 - (iv) BS 3456 Part 101 and Part 102 Section 102.342.

C9.4.2 Performance Requirements

- (a) The fan blades of the fan shall have a sweep diameter ranging from 385 to 415 mm.
- (b) The air delivery of the fan shall not be less than 1 m³/s.
- (c) The noise level of the fan at all operating speeds shall not exceed 58 dBA measured at 1 m from the fan.

C9.4.3 Construction

- (a) The fan shall be designed for wall-mounted application. Fans converted from desk type fan will NOT be accepted.
- (b) The fan motor shall have sealed-for-life roller bearings or bushes.
- (c) The fan shall have adequate mechanical strength and be so constructed as to withstand such rough usage as may be expected in normal use.
- (d) The material of the fan shall be fire-resistant and non-flame propagating.
- (e) The fan shall be of domestic type with smooth, safe edges and 'easy-to-disassemble' design for cleaning.
- (f) The fan blades shall be enclosed by chromed and closely meshed metal guard. The gap of the guard slots shall be not greater than 13 mm.
- (g) The fan shall equip with a thermal cut-out device to protect the fan from abnormal operation.
- (h) The fan regulator shall comprise three speed settings and a switching-off function.
 - (i) The fan regulator shall be of pull-cord type.
- (j) The fan shall be provided with oscillating and tilting mechanism for horizontal swing and vertical adjustment respectively.
- (k) The fan head shall be capable of being clamped or locked at any desired position within a range of tilting angle
- (l) The tilting mechanism shall be of robust and durable construction. If plastic stand is used, a U-shape sheet steel of suitable thickness shall be inserted into the pivot spring chamber as a reinforcement of supporting strength of the tilting mechanism, otherwise the design of the tilting mechanism shall be approved by the Architect.
- (m) The oscillating mechanism shall have a reinforced and reliable clutch that will slip or disengage the steering-gear of the oscillating mechanism if the fan meets an obstruction as it swings. The oscillating mechanism shall be easily disengaged when not required.

- (n) An oscillation switch for controlling of 'oscillation' and 'not oscillating', must be provided in a hand-touch position and easily accessible by the operator at floor level.
- (o) The fan shall be finished to manufacturer's standard light colour approved by the Architect.
- (p) The construction of the fan shall be designed that end-user does not need any tools to assemble/disassemble the fan guard and fan blade for cleaning.
- (q) The fan shall be subject to function test conducted not less than 72 hours of continuous running and shall show no abnormal conditions such as overheat, failing to oscillate and, etc. during the testing period.

C9.5 400 mm SWEEP DESK FAN

C9.5.1 General Requirements

- (a) The fan shall be fitted with a 0.75 mm² 3-core PVC insulated and sheathed flexible cord of approximately 1.5 m in length; and a suitably fused 13A plug.
- (b) The power factor of the fan shall be not less than 0.8.
- (c) The fan shall comply with the latest edition of safety standards for household electric fans and regulators as follows:
 - (i) IEC 60342-1, or
 - (ii) IEC 60335-2-80: 1997, or
 - (iii) JIS C 9601 issued by Japan Standards Association, or
 - (iv) BS 3456 Part 101 and Part 102 Section 102.342.

C9.5.2 Performance Requirements

- (a) The fan blades of the fan shall have a sweep diameter ranging from 385 to 415 mm.
- (b) The air delivery of the fan shall not be less than 1 m³/s.
- (c) The noise level of the fan at all operating speeds shall not exceed 58 dBA measured at 1 m from the fan.

C9.5.3 Construction

- (a) The fan shall be free-standing type and portable.
- (b) The fan motor shall have sealed-for-life roller bearings or bushes.
- (c) The fan shall have adequate mechanical strength and be so constructed as to withstand such rough usage as may be expected in normal use.
- (d) The material of the fan shall be fire-resistant and non-flame propagating.
- (e) The fan shall be of domestic type with smooth, safe edges and 'easy-to-disassemble' design for cleaning.
- (f) The fan blades shall be enclosed by chromed and closely meshed metal guard. The gap of the guard slots shall be not greater than 13 mm.

- (g) The fan shall equip with a thermal cut-out device to protect the fan from abnormal operation.
- (h) The fan regulator shall comprise three speed settings and shall provide a switching-off function, complete with a timer switch for controlling of continuous operation and at least providing of time setting of 1 hour.
- (i) The fan shall be provided with oscillating and tilting mechanism for horizontal swing and vertical adjustment respectively.
- (j) The fan head shall be capable of being clamped or locked at any desired position within a range of tilting angle.
- (k) The construction of the tilting mechanism shall be of robust and durable construction.
- (l) The oscillating mechanism shall be easily disengaged when not required.
- (m) The oscillating mechanism shall have a reinforced and reliable clutch which will slip or disengage for avoiding overturning when meeting an obstruction, otherwise a mechanism shall be incorporated into the fan which can automatically swing to opposite direction when the fan meets an obstruction.
- (n) The fan shall have sufficient degree of mechanical stability that it shall not overturn during operation in any normal position on a plane inclined at an angle of 10° to the horizontal.
- (o) The fan shall be finished to manufacturer's standard light colour approved by the Architect.
- (p) The construction of fan shall be so designed that end-user does not need any tools to assemble/disassemble the fan guard and fan blade for cleaning.
- (q) The fan shall be subject to function test conducted not less than 72 hours of continuous running and shall show no abnormal conditions such as overheat, failing to oscillate and, etc. during the testing period.

C9.6 400 mm SWEEP PEDESTAL FAN

C9.6.1 General Requirements

- (a) The fan shall be fitted with a 0.75 mm² 3-core PVC insulated and sheathed flexible cord of approximately 1.5 m in length; and a suitably fused 13A plug.
- (b) The power factor of the fan shall be not less than 0.8.
- (c) The fan shall comply with the latest edition of safety standards for household electric fans and regulators as follows:
 - (i) IEC 60342-1, or
 - (ii) IEC 60335-2-80: 1997, or
 - (iii) JIS C 9601 issued by Japan Standards Association, or
 - (iv) BS 3456 Part 101 and Part 102 Section 102.342.

C9.6.2 Performance Requirements

- (a) The fan blades of the fan shall have a sweep diameter ranging from 385 to 415 mm.
- (b) The air delivery of the fan shall not be less than 1 m³/s.
- (c) The noise level of the fan at all operating speeds shall not exceed 58 dBA measured at 1 m from the fan.

C9.6.3 Construction

- (a) The fan shall be of free-standing type complete with a vertical supporting rod of adjustable working height.
- (b) The maximum working height of the fan shall be 1.5 m $\pm$ 10% above the floor.
- (c) The fan motor shall have sealed-for-life roller bearings or bushes.
- (d) The fan shall be statically and dynamically balanced and shall not have abnormal vibration or creeping on the floor during operation.
- (e) The fan shall have adequate mechanical strength and be so constructed as to withstand such rough usage as may be expected in normal use.
- (f) The material of the fan shall be fire-resistant and non-flame propagating.
- (g) The fan shall be of domestic type with smooth, safe edges and 'easy-to-disassemble' design for cleaning.
- (h) The fan blades shall be enclosed by chromed and closely meshed metal guard. The gap of the guard slots shall be not greater than 13 mm.
- (i) The fan shall equip with a thermal cut-out device to protect the fan from abnormal operation.
- (j) The fan regulator shall comprise three speed settings and shall provide a switching-off function, complete with a timer switch for controlling of continuous operation and at least providing of time setting of 1 hour.
- (k) The fan shall be provided with oscillating and tilting mechanism for horizontal swing and vertical adjustment respectively.
- (l) The fan head shall be capable of being clamped or locked at any desired position within a range of tilting angle.
- (m) The construction of the tilting mechanism shall be of robust and durable construction.
- (n) The oscillating mechanism shall have a reinforced and reliable clutch that will slip or disengage for avoiding overturning when meeting an obstruction, otherwise a mechanism shall be incorporated into the fan which can automatically swing to opposite direction when the fan meets an obstruction.

- (o) The fan shall be fitted with adjustable height pedestal with positive locking arrangement. The extended part of the pedestal shall be chromium-plated and incorporated with a stopper at the end. The base weight shall be sufficiently heavy to hold the fan in a stable manner when the fan is extended to its maximum height of approximately 1.5 m above the floor. At the maximum working height the fan shall not overturn when operated in any normal position on a plane inclined at an angle of 10° to the horizontal.
- (p) The fan shall be finished to manufacturer's standard light colour approved by the Architect.
- (q) The construction of the fan shall be designed that end-user does not need any tools to assemble/disassemble the fan guard and fan blade for cleaning.
- (r) The fan shall be subject to function test conducted not less than 72 hours of continuous running and shall show no abnormal conditions such as overheat, failing to oscillate and, etc. during the testing period.

C9.7 DOMESTIC EXHAUST FAN

C9.7.1 General Requirements

- (a) The design and the construction of the fan shall be manufactured and tested in compliance with the requirements of IEC 60335-2-80 or equivalent standards.
- (b) All electrical components, parts and accessories shall be manufactured conforming to the relevant IEC standards or equivalent standards.
- (c) The fan shall be fitted with a 0.75 mm² 3-core PVC insulated and sheathed flexible cord of approximately 2 m in length.
- (d) The power factor of the fan shall not be less than 0.8.

C9.7.2 Performance Requirements

- (a) The fan diameters of the respectively exhaust fans shall be:

Fan Size (mm)	Fan Diameters (mm)
150	150 ± 5%
230	230 ± 5%
300	300 ± 5%

- (b) The exhaust fans shall be capable of providing the following air extraction rate:

Fan Size (mm)	Air Extraction Rate (m ³ /s)
150	0.08 to 0.1 at 1,250 rpm
230	0.21 to 0.23 at 1,200 rpm
300	0.47 to 0.5 at 1,200 rpm

- (c) The noise level of the fan during operation shall not exceed 65dBA measured at 1 m from the fan.

- (d) Maximum overall height and width:

Fan Size (mm)	Maximum Height (mm)	Maximum Width (mm)
150	232	230
230	323	305
300	413	391

C9.7.3 Construction

- (a) The exhaust fan shall be designed of robust construction. The exhaust fan shall be suitable for mounting on windows and partitions which shall have a opening of the following diameter:

Fan Size (mm)	Diameter of Opening (mm)
150	175 to 185
230	250 to 260
300	315 to 325

- (b) The impeller, fan duct, outlet grille and shutter assembly shall be constructed of high quality flame retardant plastic material.
- (c) The motor winding shall have Class B insulation and protected by a thermal cut-out. The fan motor shall be totally enclosed in an aluminium alloy casing.
- (d) Motor bearings shall be of self-aligning, oil impregnated porous bronze brushes.
- (e) The exhaust fan shall comprise an electrically operated back draught shutter assembly.
- (f) The inner and outer clamp plate/grille assembly shall have rubber gasket.
- (g) The exhaust fan impeller shall be fully balanced to avoid vibration during operation.
- (h) The exhaust fan shall be designed for easy assembling/dismantling to facilitate servicing and maintenance work.

C9.8 PROPELLER FAN - RING MOUNTED TYPE

C9.8.1 General Requirements

- (a) The fan shall be rated for continuous operation under ambient temperature of up to 50°C.
- (b) The motor shall have Class E insulation to IEC 60085, BS 2757 or equivalent standards. The power factor of the fan motor shall not be less than 0.85 under any operating condition.
- (c) The fan shall be fitted with a 0.75 mm² 3-core PVC insulated and sheathed flexible cord of approximately 2 m in length.

C9.8.2 Performance Requirements

- (a) The fan diameters of the respectively propeller fans shall be:

Fan Size (mm)	Fan Diameters (mm)
241	241 ± 5%
305	305 ± 5%
381	381 ± 5%
457	457 ± 5%
610	610 ± 5%

- (b) The air flow rate of the propeller fan of respective sizes shall be as follows:

Fan Diameter	Fan Speed	Air Flow Rate	
(mm)	(rpm)	(m ³ /min)	(cfm)
241	1300	12	440
305	900	19	700
381	900	39	1350
457	900	70	2500
610	700	129	4600

- (c) The sound pressure level emitted by the fan shall not exceed 65dBA measured at 1 m from the fan outlet.

C9.8.3 Construction

- (a) The fan impeller shall be mounted on the same shaft as the driving motor and constructed of heavy gauge pressed steel blades fitted to cast aluminium alloy hubs, fully balanced after assembly.
- (b) The motor shall be of squirrel cage induction type, with capacitor start and run, and of totally enclosed construction with dust seals.
- (c) Ball or roller bearings shall be provided and shall be filled with lithium based grease suitable for operating temperature between -30°C and 120°C.
- (d) The fan and motor assembly shall have heavy duty and robust steel mounting arms.

- (e) The mounting arms shall be fixed to the mounting ring through a rubber or neoprene resilient cushion to reduce the transmission of vibration to the fixing surface.
- (f) The mounting rings shall be constructed of steel pressing and have sufficient flexibility to prevent fracture when fixed to slightly uneven surfaces.
- (g) The fan shall be suitable for both vertical and horizontal mounting.
- (h) The fan shall be supplied for air discharge away from the motor.
- (i) The fan assembly shall be protected with corrosion resistant resin based paints. All bolts and nuts and washers shall be hot dip galvanised. The finishing coat shall be in grey colour unless otherwise specified.
- (j) All exposed metal parts shall be effectively bonded together and connected to a common earthing terminal.
- (k) If screws and nuts are fitted onto the fan blades for balancing purpose, spring washer should be provided to avoid loosening. Other securing mechanism such as welding shall be subject to the approval of the Architect.

C9.9 FUME CUPBOARD EXHAUST FAN

C9.9.1 General Requirements

- (a) The equipment shall be of axial flow design composed of durable materials and quiet in operation.
- (b) Duct connector, cupboard adaptor, clamp ring, Jubilee clips shall be provided. All of them shall be highly resistant to corrosive gases and chemical fumes emitted during chemical reactions as resulted from laboratory experiments and shall be capable of handling gases and fumes of from 0°C to 40°C.

C9.9.2 Performance Requirements

- (a) The fan shall cover the range from 240 to 300 mm in nominal diameter.
- (b) The revolution speed of the fan shall be not less than 2700 rpm.
- (c) The air volume flow rate shall be not less than 0.35 m³/s in static pressure of 100 N/m².
- (d) The noise level of the fan at all operating speeds shall not exceed 58 dBA measured at 1 m from the fan.

C9.9.3 Construction

- (a) Motor
 - (i) The fan shall be driven by a totally enclosed but externally cooled single phase induction motor of metric design to the latest edition of IEC 60034-1, BS 5000: Part 99 or equivalent standards.

- (ii) Insulation shall be not lower than Class E as defined in IEC 60085, BS 2757 or equivalent standards.
 - (iii) The motor shall be rated for continuous running at ambient temperature of up to 40°C.
 - (iv) The motor shall be protected by a sealing coat of polyurethane compound or equivalent material.
- (b) The impellers shall be moulded in phenolic resin or equivalent material.
- (c) Circular fan casing shall be made from rigid PVC or galvanized steel coated with epoxy resin or equivalent material. Ends of the casing shall be spigotted for attachment of duct and fume cupboard connectors respectively.
- (d) Terminal box
 - (i) Terminal box shall be made of the same material as the casing and shall be located outside air stream and affixed to the casing.
 - (ii) Terminal box shall be suitable for reception of a 2 m long, 3-core 1.25 mm² flexible cable to B.S. 6500 or equivalent standards. The cable shall be fitted with the fan.
 - (iii) Duct/cupboard connectors and accessories shall be made from corrosion resistant material such as neoprene, epoxy resin or other approved material.
 - (iv) The fan shall be suitable for mounting vertically, horizontally or at an inclined angle. Normally, the duct/cupboard connectors will support the fan when fitted to the duct work. Extra supporting facilities in the form of two extended ribs shall be provided on the casing and shall be drilled for fixing supporting brackets.

C9.10 1 kW ELECTRIC FIRE, WALL MOUNTED TYPE

C9.10.1 General Requirements

- (a) The electric fire shall comply with IEC-60335-2-30 or equivalent standards.
- (b) The electric fire shall be fitted with a 1.25 mm² 3-core PVC insulated and sheathed flexible cord of approximately 1.5 m in length.

C9.10.2 Performance Requirements

The electric fire shall be fitted with one replaceable infra-red heating element of 1 kW rating.

C9.10.3 Construction

- (a) The electric fire shall be of wall mounted type.
- (b) The electric fire shall be of all metal construction incorporating an attractive chromium plated reflector which can be swivelled for directional adjustment of the reflected heat beam.

- (c) A close mesh chromium plated fire guard shall be provided over the entire length of the heating element and over the major portion of the reflector. The gap of the guard slots shall be not greater than 13 mm.
- (d) The electric fire shall have adequate mechanical strength and stability to withstand rough handling as may be expected in normal use.
- (e) The electric fire shall be fitted with a pull cord 'ON/OFF' switch.

C9.11 2 kW CONVECTOR FIRE

C9.11.1 General Requirements

- (a) The convector fire shall comply with IEC-60335-2-30 standard or equivalent standards.
- (b) The convector fire shall be fitted with a 1.25 mm² 3-core PVC insulated and sheathed flexible cord of approximately 3 m in length; and a suitably fused 13A plug.

C9.11.2 Performance Requirements

The power rating shall range from 2 kW to 2.5 kW.

C9.11.3 Construction

- (a) The convector fire shall be of vertical floor-standing type.
- (b) The convector fire shall be of robust and all steel construction with no sharp edges, non-marking feet if applicable and suitably finished and protected with corrosion and heat resistant paints of approved type.
- (c) The convector fire shall have an on-off switch incorporating an indicating lamp showing that power is available.
- (d) The convector fire shall have an adjustable thermostat for room temperature control.
- (e) The convector fire shall be fitted with a close mesh chromium plated front grille. The gap of the grille slots shall be not greater than 13 mm.

C9.12 2 kW OIL-FILLED ELECTRIC RADIATOR

C9.12.1 General Requirements

- (a) The radiator shall comply with IEC-60335-2-30 or equivalent standards.
- (b) The radiator shall be fitted with a 1.25 mm² 3-core PVC insulated and sheathed flexible cord of approximately 3 m in length; and a suitably fused 13A plug.

C9.12.2 Performance Requirements

The power rating shall range from 2 kW to 2.5 kW.

C9.12.3 Construction

- (a) The radiator shall be of vertical floor-standing type.
- (b) The casing of the radiator shall be constructed of sheet steel, or equivalent. The casing shall be leak-proof and robust in construction and complete with castor wheels.
- (c) The external of casing shall be finished with white or grey stove enamel paints.
- (d) All fins shall be rounded and free from sharp edges.
- (e) The radiator shall have a selector switch providing at least 2 stages of heating.
- (f) The radiator shall have an on-off switch incorporating an indicating lamp showing that power is available.
- (g) The radiator shall have an adjustable thermostat for room temperature control.
- (h) The heating element shall be totally immersed in nonflammable oil.

C9.13 300 mm AND 1200 mm SINGLE TUBULAR HEATER COMPLETE WITH WIRE GUARD

C9.13.1 General Requirements

- (a) The design and the construction of the heater shall comply with IEC 60335-1 and IEC 60335-2-30, other equivalent BS or other equivalent standards.
- (b) The heater shall be designed for use as wardrobe heater.
- (c) The heater shall be of robust construction, durable and maintenance free under normal operating condition.
- (d) The hottest accessible part of the heater shall not exceed 80°C.

C9.13.2 Performance Requirements

The maximum power rating of the heaters shall be:

Size (mm)	Maximum Power Rating (W)
300	60
1200	240

C9.13.3 Construction

- (a) The heating element shall be totally enclosed in an enclosure of such material that must be heat resistant, non-combustible and non-corrosive.

- (b) A built-in automatic on/off thermostat of preset temperature 80°C shall be fitted.
- (c) Wiring terminal shall be made of heat-resistance terminal block, preferably in porcelain, capable of withstanding the design working temperature.
- (d) The heater shall be provided with mounting brackets.
- (e) The heater shall be protected from causing heat-burns to persons.
- (f) The heater shall be free from any potential fire hazards.
- (g) The diameter of the heater enclosure shall not exceed 50 mm.
- (h) The heater shall be fitted with a 0.75 mm² 3-core PVC insulated and sheathed flexible cord of approximately 3 m in length; and a 13A plug fused at 5 A or less.
- (i) The heater shall be effectively bonded to earth through the flexible cord.
- (j) An adhesive label of safety instruction in both English (in letter not less than 3 mm) and Chinese (in letter not less than 5 mm) written as below:
“Do not use without fitting the wire guard. Do not cover.”
- (k) A recommended installation instruction sheet with diagram shall be provided with each heater.
- (l) The galvanised wire guard shall be constructed as detailed in the BSB Standard Drawings No. EE-DAP-100.
- (m) The wire guard shall consist of a frame of 1 mm thick steel sheet or equivalent material to which an 1 mm thick 12 x 12 mm wire mesh is welded.
- (n) The wire guard complete with the end plate and accessories shall be hot-dip galvanised to BS EN ISO 1461 or constructed of equivalent material.
- (o) The clearance between the heater and the wire guard shall be not less than 20 mm.

C9.14 10-Litre OPEN-OUTLET TYPE, ELECTRIC SINK WATER HEATER

C9.14.1 General Requirements

- (a) The hot water capacity shall not be less than 10 litres.
- (b) The sink water heater shall be suitable for installing above the water sink.
- (c) The sink water heater shall be of wall-mounted type.
- (d) The sink water heater shall comply with IEC 60335-2-21 or equivalent standards.

C9.14.2 Performance Requirements

- (a) The sink water heater shall be capable of maintaining water temperature in the container between 55°C and 78°C irrespective of the water inlet temperature and ambient air conditions.

- (b) The water container shall be suitable for connection to a mains water supply having a pressure of not less than 205 kPa. A pressure test certificate shall be provided for each sink water heater quoting the manufacturer's serial number and confirming that a pressure test to 50 kPa has been successfully applied.
- (c) The nominal power rating of the sink water heater shall be 3 kW.

C9.14.3 Construction

- (a) The sink water heater shall be provided with an adjustable thermostat with ample current rating to maintain water temperature from 55°C to 78°C.
- (b) The sink water heater shall be provided with a non-resettable thermal cut-out to protect the water temperature inside the container from exceeding 90°C in order to provide additional safety protection.
- (c) Earthing terminal shall be provided.
- (d) The inner hot water container shall be suitable for local installation.
- (e) The construction material of the inner hot water container shall be designed and chosen by the combined merits on expandability, thermal conductivity, susceptibility to surface fouling, reaction to water acidity and alkalinity on boiler applications, such as tinned copper, or equivalent.
- (f) The outer casing shall be drip-proof and constructed from heavy gauge sheet steel properly treated to prevent corrosion or equivalent material.
- (g) The outer casing shall be in white colour.
- (h) The thermal insulating material shall be of non-combustible and non-CFC type.
- (i) A swivel spout at outlet of 300 mm approx. in radius shall be provided.
- (j) The sink water heater shall be provided with a permanent warning label in English and Chinese characters as follows:
The outlet from the water heater must not be blocked or connected to any form of fitting with an isolating valve.
- (k) The following pipe fittings shall be provided at inlet side:
 - (i) A water control valve
 - (ii) A non-return valve
 - (iii) A water strainer

C9.15 90-Litre AND 135-Litre THERMAL STORAGE ELECTRIC WATER HEATER

C9.15.1 General Requirements

- (a) The water heater shall comply with the relevant requirements of Electrical Products (Safety) Regulation, CAP 406G Laws of Hong Kong.

- (b) The water heater shall comply with the relevant requirements of Waterworks Ordinance CAP 102 of Laws of Hong Kong.
- (c) The water heater shall comply with Code of Practice for the Electricity (Wiring) Regulations issued by the Electrical and Mechanical Services Department, the Government of HKSAR.
- (d) The water heater shall comply with the relevant requirements of Boilers and Pressure Vessels Ordinance, CAP 56 of Laws of Hong Kong.
- (e) The power rating of the product shall range from 2.5 kW to 3 kW.
- (f) All electric component and cabling shall comply with relevant requirements of IEC Standards.
- (g) The water heater shall comply with the latest edition of the following standards, or equivalent standards:
 - (i) For unvented thermal storage type electric water heater
 - IEC 60335-2-21: Particular requirements for storage water heaters, or
 - BS 7206: Specification for unvented hot water storage units and packages, or
 - BS 3456 Part 102.21: Storage water heaters
 - (ii) For thermal cut out
 - BS 3955: Specification for electrical controls for household and similar general purposes
 - (iii) For temperature and pressure relief valve
 - BS 6283: Safety and control devices for use in hot water systems

C9.15.2 Performance Requirements

- (a) The hot water cylinder shall be suitable for a working pressure of 10 bar or below. A test certificate shall be provided for each water heater quoting the manufacturer's serial number and confirming that a pressure test to 1.5 times the working pressure has been successfully applied.
- (b) The hot water storage capacity shall be:

Size of water heater (litres)	Hot Water Storage Capacity (litres)
90	From 90 litres to 100 litres
135	From 135 litres to 155 litres

C9.15.3 Specific Safety Requirements

- (a) The safety standard to which the product conforms and the storage capacity in litres (l) should be clearly and permanently marked on the body of the product in addition to the marking requirements stipulated in the essential safety requirements for electrical products in Electrical Products (Safety) Regulation, CAP 406G of Laws of Hong Kong.

- (b) Manufacturer's installation instructions including recommendations and warnings to users and installers, etc., should also be provided and clearly marked.
- (c) The construction material of the hot water cylinder shall be corrosion resistance, such as copper, stainless steel or other equivalent material. The cylinder shall be capable of withstanding 1.5 times the working pressure.
- (d) The water heater shall be fitted with a thermostat (with a maximum setting temperature of 80°C) to control the heating of the stored water.
- (e) The water heater shall be fitted with a thermal cut-out (complying with BS 3955 and with a temperature setting of 85°C) to cut off the supply of electricity if the stored water is heated above the temperature setting of the thermostat and before the operation of the temperature and pressure relief valve is initiated. The thermal cut-out should be connected in series with the thermostat and should be reset manually after dismantling of the enclosure of the product.
- (f) The water heater shall be fitted with
EITHER
 - (i) a non-resettable temperature relief valve (complying with BS 6283), having a setting of 90°C, and complete with manual test easing gear; AND
a pressure relief valve (complying with BS 6283), having a set pressure of not greater than the maximum design pressure of the water heater or than 10 bar, and complete with manual test easing gear;
 - OR
 - (ii) a non-resettable temperature and pressure relief valve complying with the requirements of BS 6283, having a set temperature of 90°C and a set pressure of the water heater or than 10 bar, and complete with manual test easing gear.

C9.15.4 Construction

- (a) The hot water cylinder shall be suitable for local installation.
- (b) The water heater shall be provided with an anti-vacuum valve complying with BS 6282 to prevent heated water from being syphoned back to supply pipe during water shortage period.
- (c) A draining device shall be provided to discharge water and shall be arranged so as to be clear of all the electrical connections and terminals.
- (d) The outer casing shall be drip-proof and constructed from heavy gauge sheet steel properly treated to prevent corrosion or equivalent material.
- (e) The outer casing shall be in white colour.
- (f) The thermal insulating material shall be of non-combustible and non-CFC type.

- (g) The water heater shall be suitable for vertical floor or wall mounting. It shall be completed with water inlet and outlet suitable for connection to standard water pipe. The inlet and outlet pipes shall be clearly marked on the product and the British Standard Pipe (BSP) sizes shall be clearly stated in installation instructions.
- (h) Material used in the connection to the hot water cylinder shall be of corrosion resistant type, especially on the water side.
- (i) The electric terminal box with cover shall be provided and can be fitted with waterproof metallic flexible conduit.

C9.16 ELECTRIC TEA URN

C9.16.1 General Requirements

- (a) The tea urn shall be suitable for providing boiling water for tea.
- (b) The tea urn shall comply with the standard IEC 60335-2-63 or equivalent standards.
- (c) All electrical components shall comply with the relevant IEC Standards, or of fully equivalent quality and capacity.

C9.16.2 Performance Requirements

- (a) The capacity of the tea urn shall be 14-20 litres.
- (b) The power rating shall range from 2.5 kW to 2.8 kW.

C9.16.3 Construction

- (a) The water container of the tea urn shall be constructed from stainless sheet steel or material of equivalent quality.
- (b) The tea urn shall be of circular table standing model complete with a full size detachable top cover and two heat-insulated handles.
- (c) The tea urn shall be provided with either a simmerstat temperature control or 3 heat rotary switch.
- (d) The tea urn shall be provided with a self-resettable thermal cut-out against failure due to boiling dry.
- (e) The tea urn shall be provided with rapid draw off tap with heat-insulated handle.
- (f) The tea urn shall be fitted with a flexible power supply cable and a suitably fused 13A plug complying with the Electrical Products (Safety) Regulation, CAP 406G of the Laws of Hong Kong. The minimum length of the flexible cable shall be 1.5 m.
- (g) Internal wiring of the tea urn shall be suitable for high temperature operation.

C9.17 ELECTRIC KETTLE 3.5-4.5 Litres

C9.17.1 General Requirements

- (a) The kettle shall comply with the latest edition of IEC 60335-2-15 or equivalent standards.
- (b) The kettle shall be fitted with a 0.75 mm² 3-core PVC insulated and sheathed flexible cord of approximately 1.5 m in length complete with an "appliance connector" and a suitably fused 13A plug.

C9.17.2 Performance Requirements

- (a) The water capacity of the kettle shall be ranged from 3.5 to 4.5 litres.
- (b) The electrical power capacity of the kettle shall range from 2 kW to 2.6 kW.

C9.17.3 Construction

- (a) The kettle shall be designed for providing boiling water for drinking.
- (b) The construction material shall be made from heavy gauge chromium plated copper; or high quality heavy gauge polished aluminium; or stainless steel.
- (c) The kettle shall be fitted with a safety cut-out to keep the kettle from boiling dry.

C9.18 MAINS-SUPPLY DRINKING WATER DISPENSER FOR "COLD" WATER

C9.18.1 General Requirements

- (a) The water dispenser shall be suitable for local installation and must comply with the statutory requirements of the Waterworks Regulation 24, CAP 102A of the Laws of Hong Kong.
- (b) The water dispenser shall comply with the Telecommunication (Control of Interference) Regulations, CAP 106B of the Laws of Hong Kong.
- (c) The water dispenser shall comply with the latest edition of IEC 60335-2-24 or equivalent standards.

C9.18.2 Performance Requirements

The water dispenser shall provide not less than 45.5 litres per hour of chilled drinking water at a temperature of between 10°C and 13°C from a water inlet temperature of 27°C under ambient air conditions of 32°C and 85% relative humidity.

C9.18.3 Construction

- (a) The water dispenser shall be designed to receive water supply from the standard premises water mains and shall be provided with a single 1/2 inch B.S.P. male threaded connection located at the back and protruding by not more than 25 mm.
- (b) The water dispenser shall be designed for heavy duty application.
- (c) The water dispenser shall be provided with an automatic thermostat to control the "cold" water delivery at the above specified temperatures, irrespective of water inlet temperature and ambient air conditions, within the range specified above.
- (d) The cabinet shall be constructed, of brushed finished stainless steel, of minimum 1 mm thickness to ensure complete rigidity and to resist "in-use" denting, or equivalent.
- (e) The drip pan below the tap(s) shall be of a suitable grade of stainless steel to ensure that no rusting will occur during the expected service life of the unit. It shall be connected to a drain pipe terminating at the back of the unit and shall have a 1" B.S.P. male thread for connection to the premises drainage system.
- (f) The cold water reservoir shall be manufactured from a suitable grade of stainless steel or copper, fitted with an external copper pipe refrigerant coil and foamed in place with high efficiency insulation of appropriate thickness.
- (g) The base plate shall be at least 20 mm above the ground level.
- (h) The faucet(s) shall be manufactured from polypropylene or chromium plated steel, and either the push-button or swivel type, self-closing, easy to operate and suitably positioned for filling cups, glasses, etc.
- (i) The refrigeration system shall be of the hermetically sealed type, suitably rated to meet the above specified duty. The condenser shall be air cooled with either natural, or, forced circulation.
- (j) The refrigerant used shall be non-toxic, non-explosive, odourless and non-CFC type.
- (k) The water dispenser shall be fitted with the following devices:
 - (i) A "power ON" indicator light.
 - (ii) An indicator light for the refrigeration unit to indicate its operation.
- (l) The water dispenser shall be fitted with a 3-core PVC insulated and sheathed flexible cable conforming to B.S. 6500: 1990 or equivalent standards, and complete with a suitably fused 13 A plug conforming to the Electrical Products (Safety) Regulation, CAP 406G of the Laws of Hong Kong. The supply cable shall be approx. 2 m long.

C9.19 DOMESTIC ELECTRIC COOKER (TABLE MODEL)

C9.19.1 General Requirements

- (a) The cooker shall be designed for table top use.
- (b) The cooker shall have two radiant rings, grill and oven.

- (c) The cooker shall comply with IEC-60335-2-6 or equivalent standards.
- (d) The overall dimensions of the cooker shall be 390 mm (height) x 470 mm (width) x 420 mm (depth) approximately.

C9.19.2 Performance Requirements

The total electrical loading shall be made up with the components having the ratings as below:

(a) Radiant rings (total)	:	not less than 2 kW
(b) Grill	:	not less than 1 kW
(c) Oven	:	not less than 1 kW

C9.19.3 Construction

- (a) The diameter of the two radiant rings shall be as follows:
 - (i) one radiant ring of diameter 145 mm approximately.
 - (ii) one radiant ring of diameter 170 mm approximately.
- (b) The dimensions of the grill shall be 310 mm (width) x 155 mm (depth) approximately.
- (c) The dimensions of the oven shall be 200 mm (height) x 380 mm (width) x 290 mm (depth) approx. and the volume of the oven shall be 20 litres approximately.
- (d) All radiant rings, grill, and oven shall be simmerstat controlled with power-on and oven indicator lamps.
- (e) All screws, nuts and bolts shall be rust-proof or manufactured from non-ferrous metal.
- (f) The main terminals shall be mounted on the base at the back and accessible for mains connections by removing the exterior back panel.
- (g) The cooker shall have adequate mechanical strength and be so constructed as to withstand such rough usage as may be expected in normal use.
- (h) Radiant rings and oven shall be easily removable to facilitate cleaning.
- (i) The cooker shall be finished in white or cream vitreous enamel paint.
- (j) Internal wiring of the cooker shall be suitable for high temperature operation.
- (k) The cooker shall be fitted with a 3 core, 2 m long approximately power supply cable conformed to BS 6500: 1990 Table 6, or equivalent standards; and controlled by a 20A D.P. switch.
- (l) The cooker shall be fitted with overload protection switch.

C9.20 DOMESTIC ELECTRIC COOKER (FOUR RADIANT PLATES TYPE)

C9.20.1 General Requirements

The cooker shall comply IEC-60335-2-6 or equivalent standards.

C9.20.2 Performance Requirements

The total electrical loading shall be made up with the components having the ratings as below:

(a) Radiant Plates (total)	:	not less than 5.8 kW
(b) Grilling Compartment	:	not less than 2.5 kW
(c) Oven	:	not less than 2.5 kW

C9.20.3 Construction

- (a) The overall dimensions shall be:
 - (i) Total Height : approximately 1300 mm
 - (ii) Height to Hob : approximately 900 mm
 - (iii) Width : approximately 550 mm
 - (iv) Depth : approximately 600 mm
- (b) The capacity shall be :
 - (i) Grilling Compartment
Grilling Usable Area : not less than 850 cm²
 - (ii) Oven Compartment
Oven Volume : not less than 55 litres
- (c) The cooker shall consist of four radiant plates on the hob, an oven compartment and an individual grill compartment.
- (d) The cooker shall be constructed basically from mild steel or material of equivalent strength and quality, and shall be finished externally white with vitreous enamel paint.
- (e) The oven components shall be removable to facilitate cleaning. All screws, nuts and bolts in the oven compartment and grilling compartment shall be rust-proof or manufactured from non-ferrous metal.
- (f) Each radiant plate and the grilling compartment shall be equipped with an adjustable control to obtain variable heat output.
- (g) The radiant plate shall not be of the sealed plate type.
- (h) The hob could be lifted up for replacement of the radiant plates and cleaning purpose. When the hob is raised, a supporting device shall be provided to prevent the falling down of the hob.
- (i) The temperature inside the oven compartment shall be thermostatically controlled with adjusting knobs on the front panel.
- (j) The heater of the oven shall be suitably guarded off so as to protect the user from heat burn.
- (k) The oven door shall be of glass pull out type hinged at the bottom.
- (l) The oven shall be provided with an interior light.
- (m) Internal wiring of the cooker shall be suitable for high temperature operation.

- (n) The supply cable of the cooker shall conform to BS 6500 or other equivalent standards and the cooker shall be controlled by a 60A D.P. cooker control unit.

C9.21 ELECTRIC HOT PLATE

C9.21.1 General Requirements

The hot plate shall comply with IEC 60335-2-6 or equivalent standards.

C9.21.2 Performance Requirements

The capacity shall range from 2 kW to 2.6 kW.

C9.21.3 Construction

- (a) The hot plate shall be designed for use on the table top.
- (b) The heating element shall be metal sheathed.
- (c) The diameter of the heating surface shall range from 180mm to 200 mm approximately.
- (d) The top plate shall be constructed of steel plate of minimum thickness 3 mm, or equivalent material.
- (e) The top plate shall be protected with heat resisting coating to prevent thermal oxidation of the steel plate during operation.
- (f) The level of top plate shall range from 120 to 130 mm above the table top.
- (g) The casing/stand of the hot plate shall be constructed of chrome plated sheet or stoved with heat resisting enamel.
- (h) The hot plate shall have integral power and temperature control switch which shall have at least 3 temperature settings.
- (i) All bare metal conductors except the top plate shall properly be heat-insulated.
- (j) Internal wiring of the hot plate shall be suitable for high temperature operation.
- (k) The hot plate shall be provided with a 3-core flexible power supply cable of approximately 1.5 m in length complete with a suitably fused 13A plug.

C9.22 10-PERSONS AND 15-PERSONS ELECTRIC RICE COOKER

C9.22.1 General Requirements

- (a) The rice cooker shall comply with IEC-60335-2-15 or equivalent standards.
- (b) The rice cooker shall be provided with a detachable 0.75 mm² 3-core circular cotton braided, rubber sheathed or PVC insulated and sheathed flexible cord of approximately 1 m in length and complete with an "appliance connector" and a suitably fused 13A plug.

C9.22.2 Performance Requirements

The capacities of the rice cookers shall be:

Size (Persons)	Capacity (Persons)
10	From 7 to 10 persons
15	From 11 to 16 persons

C9.22.3 Construction

- (a) The rice cooker shall be finished with heat resisting paint in white or a manufacturer's standard colour approved by the Architect.
- (b) The rice cooker shall be fitted with automatic heat preservation mechanism and overheating protection.
- (c) Internal wiring of the rice cooker shall be suitable for high temperature operation.

C9.23 2 kW ELECTRIC TOASTER

C9.23.1 General Requirements

The toaster shall comply with IEC 60335-2-9 or equivalent standards.

C9.23.2 Performance Requirements

The total power rating of the heating elements shall not exceed 2 kW.

C9.23.3 Construction

- (a) The toaster shall have two separate chambers for toasting two slices of bread simultaneously.
- (b) The toaster shall have an automatic pop-up mechanism that shall be controlled by a damper to eliminate excessive shock and vibration during operation of the mechanism.
- (c) A selector switch shall be provided for selection of the degree of toasting.
- (d) The casing shall be constructed of stainless steel or chromium plated steel.
- (e) The toaster shall be designed for easy operation and maintenance.
- (f) The supply cable shall conform to B.S. 6500: 1990 Table 6 or equivalent standards and complete with a suitably fused 13 Amp. plug conforming to the Electrical Products (Safety) Regulation, CAP 406G of Laws of Hong Kong. The length of the supply cable shall be not less than 1.5 m.

C9.24 ELECTRIC HAND DRYER

C9.24.1 General Requirements

- (a) The hand dryer shall comply with IEC 60335-2-23 or equivalent standards.
- (b) The hand dryer shall be designed of wall-mounting type.
- (c) The hand dryer shall be provided with a detachable 1.25 mm² 3-core PVC insulated and sheathed flexible cord of approximately 1 m in length.

C9.24.2 Performance Requirements

- (a) The front cover shall withstand a static force of not less than 111N for 1 minute and an impact of not less than 6.8 J for 1 minute.
- (b) The power rating of the heating element shall not be less than 2kW.

C9.24.3 Construction

- (a) The front cover shall be manufactured from a fully developing one piece metal or approved high strength plastic.
- (b) The thickness of the front cover shall be not less than 3 mm.
- (c) The starting method of the hand dryer shall be any of the following as specified in the Particular Specification:
 - (i) capacitive touch switch,
 - (ii) insulated metal push button, or
 - (iii) automatic sensing device
- (d) Metallic covers shall be finished with acid resistant porcelain enamel or equivalent.
- (e) The front cover shall be firmly secured to the base of product by recessed Allen head or similar type bolts.
- (f) The base shall be designed so that it can be secured to the wall by at least three mounting bolts.
- (g) The air inlet shall be at the bottom and protected by a suitably sized, protective vaned grill.
- (h) The air outlet shall be similarly protected by metal vanes inside the nozzle.
- (i) All metal parts shall be made of corrosion resistant materials such as stainless steel or equivalent.
- (j) The hand dryer shall be suitable for back and side cable entry with an insulated bushing.
- (k) The hand dryer shall be completed with internal electrical overload protection for the fan motor and thermal cut-out protection for the heater unit.
- (l) The hand dryer shall be marked with the symbol for drip-proof or splash-proof construction.

C9.25 WALL CLOCK BATTERY-OPERATED

C9.25.1 General Requirements

The clock shall be accompanied with the necessary battery adequate for operating the clock for at least 1 month.

C9.25.2 Performance Requirements

- (a) The clock shall be tropicalised and dust-proof.
- (b) The accuracy of timekeeping shall not exceed ± 20 sec/month at room temperature (25°C).

C9.25.3 Construction

- (a) The clock-face shall either be round or square in shape as specified in the Particular Specification.
- (b) For round clock-face clock, the nominal clock-face diameter shall range between 300 mm and 350 mm.
- (c) For square clock-face clock, the nominal clock-face side length shall range between 300 mm and 350 mm.
- (d) The clock shall be flush mounted design on the wall and is to be free of any projections on the rear surface.
- (e) The clock dial shall be white with large Arabic Numerals in black and graduated in minutes. Alternative colour and design shall be subject to the approval of the Architect.
- (f) The hour, minute and second full sweep hands shall be of distinct colour.
- (g) The clock shall be completed with a clear glass or plastic front cover.
- (h) The voltage rating of the battery powering the product shall not exceed 1.5 V.

C9.26 ELECTRIC DRY IRON

C9.26.1 General Requirements

- (a) The dry iron shall be designed for household and domestic application.
- (b) The dry iron shall comply with IEC-60335-2-3 or equivalent standards.
- (c) The dry iron shall have adequate mechanical strength and stability to withstand rough handling as may be expected in normal use.
- (d) The dry iron shall be fitted with a 1.25 mm² 3-core PVC insulated and sheathed flexible cord of approximately 2 m in length and a suitably fused 13A plug.

C9.26.2 Performance Requirements

The rated input power of the dry iron shall be 1000 W.

C9.26.3 Construction

- (a) The dry iron shall have an adjustable, self-resetting thermostat control complete with indication lamp for power ON/OFF indication.
- (b) The power cord shall be connected to the iron body in such a manner that no part of the power cord or any accessories associated thereto shall be in contact with the hand of the operator during the normal ironing operation.
- (c) The non-stick coated sole plate of the dry iron shall be constructed of chromium plated or heat resistant aluminium alloy.
- (d) The dry iron shall have the appropriate degree of protection against moisture.

C9.27 VACUUM CLEANER

C9.27.1 General Requirements

- (a) The vacuum cleaner shall comply with IEC 60335-2-2 or equivalent standards.
- (b) The vacuum cleaner shall be suppressed against radio interference in compliance with the Telecommunication (Control of Interference) Regulations, CAP 106B of the Laws of Hong Kong.
- (c) The vacuum cleaner shall be designed of domestic type and for dry load.
- (d) The vacuum cleaner shall be fitted with a 1.25 mm² 3-core PVC insulated and sheathed flexible cord of approximately 5 m in length; and a suitably fused 13A plug.

C9.27.2 Performance Requirements

- (a) The minimum dust capacity shall be 3.4 litres.
- (b) The suction capacity shall be not less than 13.7 kPa.
- (c) The minimum air flow rate shall be 1.8 m³/min.
- (d) The operating noise level shall not exceed 80 dBA measured at one (1) m from the vacuum cleaner under a background noise level of 55 dBA.

C9.27.3 Construction

- (a) The vacuum cleaner shall be a double insulated product (Class II appliance) and shall have the symbol for Class II construction marked on its body.
- (b) The following accessories shall be supplied with the vacuum cleaner as standard fittings:
 - (i) Joint pipe,
 - (ii) Flexible hose,
 - (iii) Curved joint pipe,
 - (iv) Extension pipes,
 - (v) Combination rug and floor tool,

- (vi) Crevice nozzle,
- (vii) Dusting brush,
- (viii) Fabric nozzle.

C9.28 FLOOR POLISHER

C9.28.1 General Requirements

- (a) The floor polisher shall comply with IEC 60335-2-40 or equivalent standards.
- (b) The floor polisher shall be suppressed against radio interference in compliance with the Telecommunication (Control of Interference) Regulations, CAP 106B of the Laws of Hong Kong.
- (c) The floor polisher shall be fitted with a 1.25 mm² 3-core PVC insulated and sheathed flexible cord of approximately 6 m in length; and a suitably fused 13A plug.

C9.28.2 Performance Requirements

- (a) The power rating shall not be less than 400 watts.
- (b) The dust bag volume shall not be less than 2.7 litres.

C9.28.3 Construction

- (a) The floor polisher shall be a double insulated product (Class II appliance) and shall have the symbol for Class II construction marked on its body.
- (b) The floor polisher shall be of the suction type with interchangeable three sets of brush of three pieces each, comprising 3 hard texture brushes, 3 soft brushes and 3 felt pads, suitable for household and similar purposes.

C9.29 7-Litres AND 9-Litres DEHUMIDIFIER

C9.29.1 General Requirements

- (a) The dehumidifier shall comply with IEC 60335-2-40 or equivalent standards.
- (b) The dehumidifier shall be fitted with a 1.25 mm² 3-core PVC insulated and sheathed flexible cord of approximately 2 m in length; and a suitably fused 13A plug.

C9.29.2 Performance Requirements

- (a) The moisture removal capacity, when measured under the operating conditions at 27°C, 60% R.H. shall be as follows:

Size (litres)	Minimum Moisture Removal Capacity
7	7 litres per 24 hours
9	9 litres per 24 hours

- (b) The power factor of the dehumidifier shall be not less than 0.85.
(c) The noise level generated whilst in operation shall not exceed 60 dBA measured at 1.5m from the product under a background noise level of not exceeding 50 dBA.

C9.29.3 Construction

- (a) No "Controlled Refrigerant", as defined under the Ozone Layer Protection (Controlled Refrigerants) Regulation, CAP 403B of Laws of Hong Kong, shall be used.
(b) A humidistat shall be fitted in the dehumidifier for controlling the humidity level.

C9.30 ROOM COOLER

C9.30.1 Type of Room Cooler

- (a) 12 types of room cooler are under this specification, their Schedule of References are:

Schedule Reference	
'C' Type	'R' Type
C26	R26
C29	R29
C32	R32
C40	R40
C49	R49
C58	R58

- (b) The Schedule Reference composes of three characters.
- (i) The first character is an alphabet of either "C" or "R", where:
- C = Room cooler provides cooling air only
R = Room cooler provides cooling with reversed cycle heating

- (ii) The last two characters are numerals indicate the cooling capacity of the room cooler with details shown below:

Last Two Characters	Cooling Capacity	
	Watt	Btu/hr
26	2638 - 2931	9000 – 9999
29	2931 - 3224	10000 – 10999
32	3224 - 3517	11000 – 11999
40	4103 - 4396	14000 – 14999
49	4982 - 5275	17000 – 17999
58	5861 - 6154	20000 – 20999

C9.30.2 General Requirements

- (a) The room air cooler supplied shall conform to the safety standard IEC 60335-2-40 or equivalent standards, in accordance with Electrical Products (Safety) Regulation, CAP 406G of Laws of Hong Kong.
- (b) The room cooler shall be supplied with appropriate radio interference suppression device to meet the requirements prescribed in Telecommunications (Control of Interference) Regulations of the Telecommunications Ordinance (CAP 106)
- (c) The room cooler shall have obtained Energy Label Grade 1 or 2 of the Energy Efficiency Labelling Scheme (EELS) for Room Coolers of Energy Efficiency Office (EEO) of Electrical and Mechanical Services Department.
- (d) The room cooler shall be fitted with a 1.25 mm² 3-core PVC insulated and sheathed flexible cord of approximately 2 m in length which shall be connected to an insulated terminal block and controlled by a D.P. switch with pilot light, both with current capacity of not less than the rated value of the room cooler.

C9.30.3 Performance Requirements

- (a) All room coolers shall have a power factor of not less than 0.85 at full load.
- (b) All room coolers shall achieve the ratings as stated above.
- (c) The capacity of rating shall be proved by the production of printed manufacturer's rating sheets showing also the test condition.
- (d) All the ratings quoted shall conform to ISO 5151 or equivalent standard.
- (e) The maximum noise level generated by the room coolers operating at high cool and high fan setting shall be in accordance with the table below. The noise level shall be measured at a distance of 1.5 m from the cool air discharge and at 1.2 m above the ground under a background noise level of less than 50 dBA.

Schedule Reference		Noise Level
C26, C29, C32, C40,	R26, R29, R32, R40.	Not exceeding 60 dBA
C49, C58,	R49, R58.	Not exceeding 65 dBA

C9.30.4 Construction

- (a) The refrigerant used in the room coolers shall be of non CFC type.
- (b) An adjustable thermostat control shall be provided for each room cooler. The thermostat shall be built into the case of the unit and not fixed on the outside. Only the adjusting knob or dial is to protrude.

C9.31 REFRIGERATOR

C9.31.1 Type of Refrigerator

6 types of refrigerator are under this specification, they are:

Type	Description
1	170 litres
2	170 litres, not exceeding 1600 mm in height
3	270 litres
4	270 litres, not exceeding 1600 mm in height
5	345 litres
6	345 litres, not exceeding 1600 mm in height

C9.31.2 General Requirements

- (a) The refrigerators shall comply with the safety standard IEC 60335-2-24 "Particular requirements for refrigerators and food freezers" or equivalent standards.
- (b) All the ratings quoted, characteristics and test methods shall conform to ISO 8187 or equivalent standards.

- (c) The overall dimensions of the refrigerators shall comply with the following requirements:

Type	Maximum depth (mm)	Maximum width (mm)	Maximum height (mm)
1	660	620	N/A
2	660	620	1600
3	720	700	N/A
4	720	700	1600
5	750	750	N/A
6	750	750	1600

- (d) The corresponding food storage capacities shall be:

Type	Minimum Total Storage Capacity (litres)	Storage Capacity of Frozen Food Storage Compartment (litres)
1	170	35 to 70
2		
3	270	50 to 85
4		
5	345	70 to 110
6		

- (e) The refrigerator shall at least comprise two separate compartments, i.e. Fresh Food Storage Compartment and Frozen Food Storage Compartment.
- (f) For Types 3 to 6, the Fresh Food Storage Compartment shall have a chiller compartment (chilled room) with transparent front opening door.
- (g) The refrigerator shall be of the 'Frost-free' or 'Automatic defrost' type.
- (h) The refrigerator shall be fitted with a 0.75 mm² 3-core PVC insulated and sheathed flexible cord of approximately 2 m in length; and a suitably fused 13A plug.

C9.31.3 Performance Requirements

- (a) The refrigerator shall be completely suitable for operation under sub-tropical climate class. The range of ambient temperatures in which the equipment are intended to be used, and for which the required storage temperatures shall be fulfilled is between 18°C to 38°C. No condensation shall be present on the exterior of the refrigerator at all times.

- (b) The Fresh Food Storage Compartment and Frozen Food Storage Compartment shall be equipped with separate temperature control.
 - (i) Fresh Food Storage Compartment
The refrigeration system shall be designed to maintain the temperature between 0°C to 10°C and the mean temperature shall be 5°C within the compartment at all operating conditions.
 - (ii) Frozen Food Storage Compartment
The storage temperature of the Frozen Food Storage Compartment shall be maintained at a temperature not warmer than -18°C at all operating conditions. The Compartment shall be labelled with a "****" mark as defined in ISO 8187 or equivalent standards.

C9.31.4 Construction

- (a) The cabinet shall be of all steel construction designed for maximum rigidity and robustness to form an assembly sufficiently rigid to prevent distortion during handling, transportation, etc. In addition, concealed adjustable feet shall be fitted to ensure that the cabinet will stand firm on uneven floor. High quality steel panel work treated with a suitable rust preventive primer and anti-corrosion undercoat and finished with white hard finish material giving maximum resistance to abrasion and corrosion.
- (b) Doors:
 - (i) The refrigerator shall be fitted with flush-fitting door(s). The door shall be fitted with chromium plated/matching coloured fasteners and semi-concealed door hinges. The interior of the door shall be complete with bottle racks, cheese and butter storage section.
 - (ii) The design and construction of the door shall withstand heavy usage and suitably braced or otherwise constructed to prevent distortion in usage.
 - (iii) The plastic door liner must be of uniform thickness (gauge) throughout particularly in relation to all inner radiused corners and be sufficiently rigid to prevent sagging when fully loaded with bottles, etc. The bottle retainer strips shall be robustly constructed and secured.
 - (iv) If the refrigerator is designed with only one door, the Fresh Food Storage Compartment and the Frozen Food Storage Compartment shall be separated well according to appropriate temperatures.
- (c) Insulation Material:
No "Controlled Product", as defined under the Ozone Layer Protection (Products Containing Scheduled Substances) (Import Banning) Regulation, CAP 403C of Laws of Hong Kong, shall be used as insulation material in the refrigerator.

- (d) Internal Lighting:
The Fresh Food Storage Compartment of the refrigerators shall be supplied with an interior light of sufficient capacity to illuminate the entire interior. This light complete with air-tight flame retardant lamp guard shall be activated by a door operated switch. The light and switch shall be protected from condensate drip.
- (e) Refrigeration Unit:
- (i) The refrigeration unit shall be hermetically sealed in a steel housing and fitted with an automatic self-resetting motor overload device.
 - (ii) The refrigeration unit shall be designed to be free from radio or TV reception interference or if necessary shall be fitted with an appropriate suppression system as laid down in the Telecommunication (Control of Interference) Regulations, CAP 106B of the Laws of Hong Kong.
- (f) Door Gasket:
- (i) The door gasket shall be robust and manufactured from a rubber base material.
 - (ii) It shall contain a fungoid inhibitor to prevent fungoid growth and discolouration.
 - (iii) In the case of a magnetic gasket, the magnetic ceramic insert must be full length on all sides so fitted, with absence of gaps at the corners.
- (g) Shelves and Internal Fittings:
- (i) The shelves made of either wire or bar shall be adequately protected against rusting and corrosion and must be sufficiently rigid to prevent distortion under full load conditions. The mesh of the wires shall be closely enough to prevent small based containers from toppling and spilling their contents.
 - (ii) Shelves shall preferably be supported from full height adjustable supports, all must be of ample strength, easily adjustable and designed to prevent the accidental tilting or release, of one end of a shelf.
- (h) Refrigerant:
No "Controlled Refrigerant", as defined under the Ozone Layer Protection (Controlled Refrigerants) Regulation, CAP 403B of Laws of Hong Kong, shall be used.
- (i) Accessories:
The refrigerator shall be supplied with all manufacturer's standard accessories which shall include the following:

Description of Accessories	Quantity (No.)
Shelves in refrigerator compartment	3
Large full-width egg racks	1
<u>or</u> half-width egg racks	2
Ice cube trays	2
Butter tray plastic crisper with see through plastic cover	1

- (j) Energy Efficiency:
The refrigerator shall have obtained Energy Label Grade 1 or 2 of the Energy Efficiency Labelling Scheme (EELS) for Household Refrigeration Appliances of Energy Efficiency Office (EEO) of the Electrical and Mechanical Services Department, the Government of the HKSAR.
- (k) Labelling:
The refrigerator shall bear a label showing serial number, power consumption, voltage, amperes and frequency. The label shall be fixed rigidly at a conspicuous position on the equipment.

SECTION D1

INSPECTION AND TESTING

D1.1 GENERAL

Inspection and testing shall be carried out on all new installations and alterations to an existing installation in accordance with the requirements of this Section. IEC 60364 and Code of Practice for the Electricity (Wiring) Regulations shall be referred and adopted where appropriate.

D1.2 VISUAL INSPECTION

A visual inspection shall be carried out in accordance with Code 21A of the C.O.P. before testing of the installation in order to verify the following:

- (a) The installation has been carried out in compliance with regulations and/or C.O.P.,
- (b) The correctness of the designation of the installation; and
- (c) There is no visual damage to the installation.

D1.3 TESTING

Where relevant, the following tests shall be carried out in the sequence indicated. In the event of any test indicating failure to comply, that test and those preceding, the results of which may have been influenced by the fault indicated, shall be repeated after the fault has been rectified.

D1.3.1 Continuity of Ring Final Circuit Conductors

The continuity of all conductors, including the circuit protective conductor of every ring final circuit, shall be verified.

D1.3.2 Continuity of Protective Conductors

Every protective conductor shall be tested to verify that it is electrically sound and correctly connected. The resistance of every protective conductor shall be measured with a testing voltage not exceeding 50V a.c. at 50 Hz. The testing current shall be 1.5 times the design current of the circuit subject to the maximum of 25A.

D1.3.3 Earth Electrode Resistance

The resistance of every earth electrode shall be measured to ensure that the earth resistance of the earth electrode will fulfil the purpose for which it has been installed. Testing method shall be in accordance with Code 21B of the C.O.P.

D1.3.4 Insulation Resistance

The insulation resistance of the installation shall be tested in accordance with the C.O.P. and IEC Regulations. The resistance measured shall not be less than the following minimum values:

(a)	Insulation resistance to earth	1 MΩ
(b)	Insulation resistance between poles or phase	1 MΩ
(c)	Insulation resistance of equipment	

As required by the appropriate requirement or 0.5MΩ if there is no appropriate requirement.

D1.3.5 Insulation to Site Built Assembly

The insulation applied to the live parts of Site Built Assemblies for protection against direct contact shall be tested with an applied voltage equivalent to that specified in the appropriate Regulation / C.O.P. for similar factory-built equipment.

The supplementary insulation of Site Built Assemblies for protection against indirect contact shall be tested for degree of protection not less than IP 2X, and the insulation enclosure shall be tested with an applied voltage equivalent to that specified in the appropriate Regulation / C.O.P. for similar factory-built equipment.

D1.3.6 Electrical Separation of Circuits

Electrical separation required for circuits of safety extra-low voltage equipment, or required for protection against indirect contact, shall be inspected and tested with a testing voltage of 500V d.c. for one minute. The insulation resistance value shall not be less than 5MΩ.

D1.3.7 Protection by Barriers and Enclosure

Barriers and enclosure provided during erection to afford protection against direct contact shall be tested for compliance with IEC 60529.

D1.3.8 Verification of Polarity

A test of polarity shall be carried out to all fuses, single pole control devices, centre contact bayonet and Edison-type screw lampholders, socket outlets, etc. by using proper test probes and a test lamp where main supply is available or using a continuity tester where main supply is not available. Neon indicators shall not be used for this purpose.

D1.3.9 Earth Fault Loop Impedance

A test shall be carried out to verify the effectiveness of the earthing by means of a phase-earth loop tester. The value of impedance for each loop shall not exceed the requirement of Code 11 of C.O.P..

D1.3.10 RCCB and RCBO

Every residual current-operated circuit breaker shall be tested for proper and satisfactory operation. The test shall be made by applying a.c. voltage not exceeding 50V r.m.s. across the neutral and earth terminals.

Alternatively, tests may be carried out in accordance with the standard methods recommended by the device manufacturer.

D1.3.11 Lightning Protection System

Every lightning protection system shall be tested in accordance with Section B7.

D1.3.12 Equipment Testing

Testing on electrical equipment and appliances supplied within the electrical installation contract, e.g. switchboard, generator, busway, pumps, exhaust fans, etc. shall be carried out in accordance with manufacturer's recommended procedures.

D1.3.13 Charger and Battery Set

(a) Factory Test

The battery charger unit including the printed circuit board shall be factory assembled and tested prior to delivery on site according to the manufacturer's testing manual. The delivery of charger to site must be accompanied by the original factory test certificate. A statement or certificate shall be produced by the charger and battery set manufacturer for the proof of the life expectancy of the power supply unit supplied. The Contractor shall be responsible for warranty, maintenance and free of charge replacement of any faulty charger and battery set during a one year period from the date of acceptance by the Architect.

(b) Site Test

The following tests shall be carried out after completion of the installation of the respective system and the connection of the permanent supply cable by the Contractor according to the manufacturer's instruction in the presence of the Architect's inspectorate staffs:

- (i) Inspection of the charger is connected to the mains supply through a suitable rated fuse.
- (ii) Inspection of the batteries connections have been done properly.
- (iii) Inspection of instruments, indicating lamps, fuses, relays and labels on battery charger have been carried out.
- (iv) For initial set-up, charge the batteries at the manual highest rate until the charging current remains constant. Record the starting and finishing time. Check the capacity of charger is capable of recharging the batteries from fully discharged to fully charged within the specified duration.
- (v) Measure charger output on load with batteries disconnected, this should be between 110% and 115% of the normal batteries voltage and within the operating voltage limits of all connected devices.
- (vi) Measure charger current on load with battery disconnected, this should be less than the maximum recommended continuous charge current for the batteries.
- (vii) Interrupt mains input to the charger and check that proper operation of connected devices continues on standby batteries. In the case of switch tripping in Switchboard, interrupt mains input to check whether the capacity of the batteries is adequate to trip the associated air circuit breaker consecutively at least 20 times or up to twenty air circuit breakers simultaneously, whichever the greater. In the case of fire protection system or burglar alarm and security system, interrupt mains input for 24 hours of normal operation and thereafter actuate the system to alarm mode operation for the specified duration to check whether the capacity of batteries is sufficient.
- (viii) Confirm correct function of charger fail/mains fail/battery disconnected/boost charge/trickle charge indications as specified.
- (ix) Restore mains supply and check that charger fail/mains fail indications are off and that mains on indication is restored.

D1.4 FUNCTIONAL TESTING

In addition to the above individual testing, the testing shall be extended to include the functional testing of the electrical system when the fixed electrical system is energized.

Functional test of the fixed electrical installation shall be conducted to produce evidence and verification of the electrical installation which is capable in performing the designated function encapsulated in the original electrical installation design.

All circuits shall be verified through switching operation to ensure that the circuits are installed in accordance with the designated circuit. The test shall include but not be limited to the following:

- (a) On/Off switching of the lighting circuit to ensure that the lighting circuit is installed corresponding to the lighting switch, protective device and labelling.
- (b) Switching of the general power circuit to ensure that the circuit corresponds to the protective device such as RCD, RCBO and MCB, and that the protective device performs in accordance with the designated duty.
- (c) Switching of the main switch / isolator to ensure the corresponding circuit is properly controlled by the main switch / isolator.
- (d) Switching of all sub-main and main distribution circuits, e.g. busducts, cable feeders, underground cables, etc. to ensure the correct isolation of the connected circuit.
- (e) Switching of all changeover switches to ensure the changing over sequence corresponds to the design criteria.
- (f) Ensuring all the protective devices perform properly against the designated circuit.

D1.5 TESTING OF EMERGENCY LIGHTING, EXIT SIGN AND EMERGENCY GENERATOR INSTALLATIONS

Where there are emergency lighting, exit sign and emergency generator installations included in the Contract under the Electrical Installation, the Contractor shall be responsible for the following duties:

- (a) Confirmation to the Fire Service Contractor on the completion and readiness of these installations for fire service inspection by FSD.
- (b) Provision of drawings and necessary information to the Fire Service Contractor for inclusion in the submission to FSD for comment and inspection.
- (c) Co-ordination with the Fire Service Contractor to inspect and witness the final tests of these installations and rectification of any works found not complying with the fire service requirements of the FSD.
- (d) Co-ordination with the Fire Service Contractor to carry out the final functional test and performance test.

ANNEX A

LOW VOLTAGE CUBICLE SWITCHBOARD INSTALLATION

A.1 GENERAL

This Sub-section covers the design, supply and installation of type-tested switchgear and controlgear assembly (TTA) of Low Voltage Cubicle Switchboard (hereafter called the “Switchboard”).

A.2 DESIGN REQUIREMENTS

Unless otherwise specified, the scope of work shall include the design of the Switchboard and selection of equipment and components including the matching with other components of the Electrical and other Installations to ensure that the Switchboard conforms to the specified performance requirements.

All design works including relevant information, data and calculations shall be submitted to the Architect for approval.

A.3 PERFORMANCE REQUIREMENTS

The “Switchboard” shall comply with IEC 60439-1 with latest version and all subsequent amendments issued prior to the date of tendering.

All materials and workmanship shall comply, where applicable, with all relevant IEC, B.S. or EN Standards and all relevant sections of this Specification.

The “Switchboard” shall comply with the electromagnetic compatibility requirement of IEC 60439-1. Immunity and emission tests shall be carried out for the switchboard assemblies in accordance with the testing requirements in IEC 60439-1.

The Works shall be carried out in a manner consistent with good practice in Hong Kong.

The “Switchboard” shall be of multi-cubicle type assembled from compartments housing the busbars, switches, etc. as shown on the Drawings, suitable for service conditions detailed in Sub-section A.6 of this part below and complying where relevant, to the appropriate Standards and Codes of Practice listed in this Specification. Where an alternative standard is proposed, the tenderer shall prove by means of adequate supporting documents that the alternative standard meets the requirements of the relevant Standard.

The “Switchboard” comprising a combination of one or more low-voltage switching devices together with associated control, measuring, signalling, protective, regulating equipment, etc., shall be completely assembled with all the internal electrical and mechanical interconnection and structural parts. The “Switchboard” shall conform to an established type without deviations likely to significantly influence the performance from the typical “Switchboard” verified to

be in accordance with IEC 60439-1 by a competent and independent internationally recognised testing authority. Appropriate technical information and literature in English language and copies of type-test certificate and drawings must be available for examination.

A.4 CONSTRUCTION AND FINISH

The “Switchboard ” shall be constructed from steel, self supporting, so formed as to give a rigid and robust construction without cross-struts, and shall be structurally, mechanically and electrically sound, with cubicle top, panels and doors of sheet steel or the equivalent metal, not less than 2.00 mm. Alternatively, if the “Switchboard” thickness is less than 2.00 mm, the design and the whole construction shall satisfy all the following structural requirements as type tested and certified by a competent and independent internationally recognized testing authority:

Test	Standard	Severity
Shock	IEC 60068-2-27	Equivalent peak acceleration of 15 g for a duration of 11 ms.
Bump	IEC 60068-2-29	Equivalent acceleration of 10 g for a duration of 16 ms, and 1000 Nos. of bump in each mutually perpendicular direction.
Random Vibration	IEC 60068-2-36	Total r.m.s. acceleration of 0.26 g for a frequency range from 10 Hz to 150 Hz

Appropriate technical information and literature in English language and copies of the type test certificate and drawings must be available for examination.

The “Switchboard” shall have clear accessibility to all internal components within it. Steel work shall be treated to prevent corrosion before being painted. Steel parts, normally left bright, shall be cadmium plated.

The bottom of the “Switchboard” shall be closed and made to vermin-proof by means of non-magnetic, fire-proof barrier plates cut away where required to suit the cables as specified. In general, the “Switchboard” shall be suitable for indoor use to IP 31 as specified in IEC 60529. In the event that top entry cabling facilities are required, the top of the “Switchboard” shall also be constructed in like manner.

Detachable panels at the back of the “Switchboard” shall each be provided with a pair of handles for easy fixing/removal of the panels.

The “Switchboard” shall be of uniform height and uniform depth front-to-back, throughout its length and shall present a neat and tidy appearance.

Unless otherwise specified, the “Switchboard” shall be constructed generally to Form 3b of IEC 60439-1.

The switch/control units in each cubicle shall be arranged to form a multi-tier arrangement.

The compartment for housing the incoming/outgoing terminals for external conductors shall be of ample dimensions for accommodating the external conductors, including space for spreading of the cores. Suitable mounting brackets or cable supports shall be provided to prevent the terminals or cables being subjected to stresses which may reduce their normal life or performance.

All switches shall be provided with mechanical interlocks so that their doors, covers, and the like can only be opened when the switches are in the off position and it shall not be possible to close the switches while the doors, covers and the like are opened, except by overriding the interlock or using a tool. The interlock shall automatically be restored on reclosing the doors, covers and the like.

The exterior of each “Switchboard” shall be finished to a light grey or the manufacturer’s nearest standard colour. The end plates and heads of any external fixing bolts or set screws shall be of non-corrosive type and finished to match with the colour of the switchboard.

The "space" provision for future outgoing circuits shall comprise blank panels, undrilled, and provision for accommodating fuseswitches and/or circuit breakers. Busbars shall be extended as necessary and drilled for future connection of conductors. The spaces scheduled or shown on the Drawings are indicative of minimum requirements and may be varied to suit the arrangement offered, subject to approval.

Insulators, including busbar supports, shall be non-hygroscopic and non-deteriorating. The use of fibrous materials, linseed oil, varnish, etc. is prohibited.

The “Switchboard” shall be provided with one or more plates, marked in a durable manner and located in a place such that they are visible and legible when the “Switchboard” is installed. The following information shall be given on the nameplates:

- (a) The manufacturer’s name or trade mark
- (b) Type designation or identification number or other means of identification making it possible to obtain relevant information from the manufacturer
- (c) IEC 60439-1
- (d) Type of current
- (e) Rated operation voltage (and frequency in case of a.c.)
- (f) Rated insulation voltage
- (g) Short-circuit withstand strength
- (h) Degree of protection
- (i) Rating of main busbars

Other information as required under Clause 5.1 of IEC 60439-1 shall be provided in the relevant documents, the circuit diagrams or in the manufacturer’s list or catalogues.

A.5 ELECTRICITY CHARACTERISTICS OF THE “SWITCHBOARD”

The electrical characteristics of the “Switchboard” shall be as follows unless otherwise specified:

- (a) Rated operational voltage : 380/220V $\pm$ 6%, 3-phase, 4-wire, 50 Hz., $\pm$ 2%, a.c.
- (b) Neutral earthing : Solid at transformer
- (c) Rated short-time : 50 kA for 1 second withstanding current
- (d) Power factor : Incoming 0.25 lagging

A.6 SERVICE CONDITIONS

The Site will have the following conditions of service:

- (a) Climate : Hong Kong (tropical)
- (b) Temperature range : peak - 5°C to 40°C
average 0°C to 35°C
(over 24 hours)
- (c) Relative humidity : 99% maximum

The “Switchboard” shall only be provided with the built-in natural cooling facilities as furnished in accordance with the recommendations endorsed by the licenser to suit the service conditions specified.

A.7 BUSBARS, WIRING AND EARTHING

The busbar chamber shall contain triple phase and neutral busbars of equal cross-sectional areas rated as shown on the Drawings or specified elsewhere. The configuration of the busbar assembly contained in the “Switchboard” shall be the same as shown on the type test drawings. Any change in the configuration will require separate type test certificates.

The whole busbars, including the conductors connecting the busbars to each outgoing circuit, shall be arranged to withstand short circuit at any point. All conductors between the main busbars/droppers and the outgoing protective devices not short-circuit type tested to a fault current of 50 kA for 1 second at 0.25 lagging power factor shall be insulated by approved means to comply with the requirement that "an internal short-circuit between phases and/or between phases and earth is only a remote possibility" as stipulated in Clause 7.5.5.1.2 of IEC 60439-1.

All busbars shall be made of hard drawn high conductivity copper to BS 1433 and shall be electro-tinned. Construction, marking and arrangement of the busbars, connections and auxiliary wiring shall be to IEC 60439-1.

External busbars for connection to the “Switchboard” shall be fully insulated and arranged in such a manner that they will not obstruct access to other equipment.

All neutral conductors shall have cross-sectional areas not less than that of the respective phase conductors and shall be distinguished by the colour black or by the initial letter N.

Whenever a vertical section of the “Switchboard” contains more than one outgoing circuit, busbar risers or droppers to which the outgoing circuits are connected shall be provided and shall be arranged in such manner that an internal short-circuit is not to be expected under normal operating conditions.

Busbars shall also be provided for all circuits which have a current rating of 400A and above.

All auxiliary circuit wiring shall be PVC-insulated with designated conductor temperature of 90⁰C to BS 6231. They shall, wherever possible, be grouped and placed together in a neat manner. Different insulant colours shall be provided to distinguish the various circuits. All wires shall also have at both ends a coded ferrule of insulating materials permanently marked with suitable characters and codes. Each connection shall terminate at an approved type of terminal block, which shall also be suitably labelled.

Cable for auxiliary circuits shall be run inside cable compartments or special cable ways designed to provide adequate protection against mechanical damage. They shall also be bunched neatly and be identifiable throughout their length of run.

Wiring from the fixed part of the “Switchboard” to the movable part, such as hinged door, shall be enclosed by a flexible PVC tubing. If apparatus with a voltage exceeding the limits of extra-low voltage are attached to lid, door, etc., the continuity of the protective circuits shall be ensured in accordance with Clause 7.4.3.1.5 of IEC 60439-1.

Connectors or soldered joints are not permitted in the auxiliary circuit wiring.

Exposed live terminals shall be suitably shrouded or covered.

A continuous tinned copper earthing bar of adequate rating to be not less than that shown in Table 3 of IEC 60439-1 shall be fixed at the rear interior, bottom portion throughout the length of the switchboard, bonding the framework of all modular sections. An earthing terminal shall be provided at the bottom inside portion of the “Switchboard” suitable for the connection of 25 x 3 mm copper tape.

A.8 CIRCUIT BREAKERS, FUSES, SWITCHES AND AUTOMATIC CHANGEOVER SWITCHES

Unless otherwise specified, circuit breakers (including ACB, MCCB), fuseswitches (including switchfuses), and automatic changeover switches shall comply with the requirements stipulated in Section C4 of this Specification.

MCCBs shall have the breaking capacity to withstand the prospective fault level at the switchboard.

A.9 METERING, PROTECTIVE RELAYS AND INDICATING LAMPS

For every incoming circuit, facilities shall be provided to measure or indicate the following:

- (a) current
- (b) voltage
- (c) power factor
- (d) supply healthy

Wiring from the measuring devices shall be brought out and be terminated in approved type of rail-mounted termination/feed through blocks housed inside separate compartments accessible from the front. Test plugs shall also be provided at each termination points to measure the voltages and/or currents flowing in that particular measuring circuit by external testing instruments.

Instruments, meters and relays shall be of the flush mounted pattern, with bezels black finished, positioned on the front of the "Switchboard". All terminals shall be suitably insulated and potential circuits shall be suitably fused, using H.R.C. fuses.

Indicating instruments shall be to IEC 60051, of moving iron spring controlled type or moving coil with transducer type with 100 mm diameter, 240° scale dials and external zero adjustment. Integrating meters shall be to BS 5685. The accuracy class shall be "2.5" for indicating instruments and "2" for integrating meters, or better. Selector switches shall be provided such that voltmeters can read voltages between phase and phase and between phase and neutral, and that ammeters can read all phase and neutral currents.

Power factor meters shall be suitable for 3-phase, 4 wire, balanced or unbalanced loads, having a four-quadrant 360° scale to indicate both leading and lagging power factors.

Alternatively, Digital Multifunction Power Meter can also be used. The specification of Digital Multifunction Power Meter shall refer to Part C of this Specification.

Separate current transformers (CT) in compliance with IEC 60044 shall be used for measuring and protection applications. Current transformers shall have accuracy Class of "3" or better for use with ammeters, "1" or better for use with Watt-hour meters and "10P" or better for protection applications. The product of rated accuracy limit factor and rated output of the protection CT shall not be less than 10 times the total rated burden of the trip circuit including the relays, connection leads and overcurrent release where applicable.

Current transformers shall be mounted without reduction of area of busbars or connections and be arranged for easy removal.

Protective relays shall be to IEC 60255 and of the type as shown on the Drawings or as specified. Where a protective relay consists of multi-elements, suitable labels shall be provided to indicate the phases to which the corresponding elements are connected.

Indicating lamps shall be of long life, operating on 6V through a built-in transformer.

All air circuit breakers other than those used for controlling the incoming supply and unless specified, shall have overcurrent tripping facilities to give time delay overload current protection and instantaneous short circuit interruption. The time-current characteristics shall be submitted for inspection. Shunt trip coils operated by power supply from the mains shall not be used.

For air circuit breakers controlling the incoming supply to the "Switchboard", the circuit protection shall be provided by the following devices:

(a) Electromechanical Type I.D.M.T. Overcurrent Protection Relay:

This relay shall have triple elements with current setting ranging from 50% to 200% in 25% tapings and with time setting from 0 to 1.3 seconds in variable steps. The relay shall be of draw-out-case type flush mounted on the front panel. The characteristic of the relay shall match with that of the Supply Company.

(b) Electromechanical Type I.D.M.T. Earth Fault Relay:

One single pole earth fault relay with current setting from 10% to 40% in 5% tapings and with time setting from 0 to 1.3 seconds. The relay shall be of draw-out-case type, flush mounted on the front panel. The characteristic of the relay shall match with that of the Supply Company.

(c) Shunt-Trip Release:

It shall be operated by a d.c. supply of 30V++ obtained from the secondary batteries complete with battery charger, etc. of suitable rating.

++ Note : Other voltages may be specified to suit particular project.

Alternatively, Digital Protection Relay can also be used. The specification of Digital Protection Relay shall refer to Part C of this Specification.

Unless otherwise specified, Digital Power Analyzer to be used shall comply with the requirements stipulated in Part C of this Specification.

A.10 SUPPLY COMPANY METERING

Provision shall be made, where specified and/or shown on the Drawings, for the accommodation of the Supply Company's metering equipment upon the Switchboard. The metering equipment will be supplied and mounted by the Supply Company on Site. The metering compartment shall be complete with a hinged glazed door for meter viewing.

The accommodation for the Supply Company's metering equipment shall include a suitable insulating panel for mounting the meters and suitable fuses to protect the voltage coil circuits to each meter. The "mains" side of the fuseholders shall be wired to the incoming supply mains. Fuses shall be of the H.R.C. type rated at 5A, with provision for sealing to prevent unauthorised removal.

The “Switchboard” shall also be provided with suitable provisions of C.T. Chambers for mounting the Supply Company's current transformers (C.T.s) in accessible positions.

Wiring between the current transformers and the meters will be carried out by the Supply Company on Site, but adequate and appropriate cabling facilities for installing the said wiring shall be provided in the Switchboard.

A.11 LABELS

Laminated self-coloured material labels of ample sizes shall be provided for each of the units both at the front and in the cabling compartment on the “Switchboard”, engraved in English and Chinese characters. A means of fixing these labels shall be provided other than by adhesives.

During the progress of manufacture of the “Switchboard”, a schedule of labels shall be submitted for approval before engraving is carried out.

Warning labels shall be affixed to the rear panels and shall be coloured red with white lettering in both English and Chinese characters denoting ‘DANGER- LIVE BUSBARS INSIDE’.

Similar warning labels shall be affixed at the front and in the cabling compartment for each automatic/remote closing or changeover switching denoting “ Beware-automatic closing” in English and Chinese characters.

In addition to automatic screening shutters and barriers, warning labels shall also be provided for all live parts, such as test terminal blocks.

A.12 CABLE ARRANGEMENTS

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

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

A.13 AUTOMATIC INTERLOCKING FACILITY

When automatic interlocking facility is specified or shown on the Drawings, the design shall be that it is safe, reliable and well proven. Unless otherwise approved by the Architect, the mechanical part of the automatic interlocking facility shall be of rod-type design to ensure a safe and reliable interlocking system. For locally assembly switchboard containing automatic interlocking facility, the interlocking design shall be endorsed by the respective licensor.

A.14 ANCILLARY EQUIPMENT

The “Switchboard” shall be supplied complete with one hydraulic operated handling truck in the main switchroom suitable for handling all sizes of air circuit breakers on the “Switchboard”, and one set of portable earthing equipment for each main incoming air circuit breaker. Portable earthing leads will not be accepted as an alternative to the earthing equipment.

The battery charger/batteries systems shall be housed in separate enclosures from the “Switchboard”. The battery charger/batteries enclosure shall be the same type of enclosures as the “Switchboard”. All secondary batteries to be supplied with the “Switchboard” shall be of the nickel-cadmium type, sealed or ventilated, requiring little or no maintenance and having long life. The capacity of the batteries, with charger disconnected, shall be adequate to trip the associated air circuit breaker(s) consecutively at least 20 times. In case there are more than one air circuits breakers being tripped by the same bank of batteries, the batteries shall be capable of tripping at least two air circuit breakers simultaneously.

The battery charger, suitable for 220V 50Hz supply, shall be of automatic trickle charge type, with facilities for manually-operated boost charge, and capable for re-charging the battery from fully discharged to fully charged condition in not more than eight hours. Battery overcurrent protection shall be provided to safeguard the battery from being overcharged. Instruments shall include voltmeter for battery voltage and ammeter for battery current.

The battery charger set shall be manufactured to conform to the current editions of the relevant standards as indicated below:

BS EN 55014	Limits and methods of measurement of radio disturbance characteristics of electrical motor-operated and thermal appliances for household and similar purposes, electric tools and similar electric apparatus.
BS EN 61204	Specification for Performance Characteristics and Safety Requirements of Low-voltage Power Supply Devices, d.c. Output.
IEC 60478	Specification for Stabilized Power Supplies, d.c. Output, Part 1: Terms and Definition Part 2: Rating and Performance Part 3: References Levels and Measurement of Conducted EMI Part 4: Tests other than RFI Part 5: Measurement of the Magnetic Component of the Reactive Near Field
BS EN 60622	Specification for Sealed Nickel-Cadmium Prismatic Rechargeable Single Cells.
BS 7430	Code of Practice for Earthing
BS EN 60950	Specification for Safety of IT Equipment, including Electrical Business Equipment.

The battery shall be sealed, high rate maintenance free nickel-cadmium type and shall have a proven life expectancy of at least 7 years.

The battery charger set shall be designed and manufactured by a reputable manufacturer which has continuously manufactured battery set to work in conjunction with a wide range of applications for at least 5 years and their manufacturing facility shall have a local agent to provide full technical support which includes adequate spare holding and technical expertise in testing, commissioning and trouble-shooting.

The battery chargers unit including the printed circuit board shall be factory assembled and tested prior to delivery on site according to the manufacturer's testing manual. The delivery of chargers to site must be accompanied by the original factory test certificate. A statement or certificate shall be produced by the charger and battery set manufacturer for the proof of the life expectancy of the power supply unit supplied.

The following site tests shall be carried out after completion of the installation of the respective system and the connection of the permanent supply according to the manufacturer's instruction in the presence of the Architect's inspectorate staff:

- (a) Inspection of the charger that it is connected to the mains supply through a suitable rated fuse.
- (b) Inspection of the battery connections has been done properly.
- (c) Inspection of instruments, indicating lamps, fuses, relays and labels on battery charger have been carried out.
- (d) For initial set-up, charge the batteries at the manual highest rate until the charging current remains constant. Record the starting and finishing time. Check the capacity of charger is capable of recharging the batteries from fully discharged to fully charge within the specified duration.
- (e) Measure charger output on load with batteries disconnected, this should be between 110% and 115% of the normal batteries voltage and within the operating voltage limits of all connected devices.
- (f) Measure charger current on load with battery disconnected, this should be less than the maximum recommended continuous charge current for the batteries.
- (g) Interrupt mains input to the charger and check that proper operation of connected devices continues on standby batteries. In the case of switch tripping in Switchboard, interrupt mains input to check whether the capacity of the batteries is adequate to trip the associated air circuit breaker consecutively at least 20 times or up to twenty air circuit breakers simultaneously, whichever the greater.
- (h) Confirm correct function of charger fail/mains fail/ battery disconnected/ charge indications as specified.
- (i) Restore mains supply and check that charger fail/mains fail indications are off and that mains on indication is restored.

The "Switchboard" shall be supplied complete with all operating handles, jigs, etc. required for the normal charging, closing, opening, racking in and out operations of all circuit breakers of the "Switchboard" and shall be properly fixed in a neat manner on a wooden board with brass hooks inside the main switch room where the "Switchboard" is installed.

The “Switchboard” shall be provided with two rubber mats of ribbed surface, complying with BS 921, laid in front of and at the rear of the “Switchboard”. The rubber mats shall be continuous sheets of minimum thickness of 10 mm, each of same length as the “Switchboard” and minimum width of not less than 1000 mm or the width of the space between the front or back of the “Switchboard” to the adjacent wall.

The “Switchboard” shall be provided with one complete spare set of fuses equal in number for each rating of fuses in all switch-fuses and fuse-switches and fitted in a conveniently accessible position on wooden board(s) in the relevant Main Switchroom.

A.15 OPERATION INSTRUCTION/DRAWING AT THE MAIN SWITCH ROOM

For each “Switchboard” a schematic wiring diagram contained in a framed, transparent perspex at a conspicuous position adjacent to the “Switchboard” shall be provided. In case that the “Switchboard” has more than one incoming air circuit breakers with interlocking facility, a brief operation instruction listing out all the relevant switching steps and interlocks for commissioning/decommissioning of part or whole of the “Switchboard” shall also be provided in a similar manner to the schematic diagram.

A.16 INSPECTION AND TESTING FOR LOW VOLTAGE CUBICLE SWITCHBOARD INSTALLATION

(a) Testing before Connection of Power Supply

These tests shall be carried out after completion of installation of the “Switchboard” and before the connection of the incoming supply cable.

(i)	Dielectric Test	This shall be carried out at power frequency as defined in IEC 60439-1.
(ii)	Insulation Test	This shall be carried out by means of a 1000V "Megger" tester or similar instrument.
(iii)	Secondary Injection Test	This shall be carried out using a.c. and shall check (approximately) that protection relays or devices function in accordance with their performance curves by a test at the lowest setting and two further tests of current and timing.
(iv)	Primary Injection Test	This shall be carried out to prove the correct operation of protective devices or system when set at the agreed setting.
(v)	Polarity Check for CT	This shall be carried out to ensure that all CTs are correctly connected.
(vi)	Functional Test	This shall be carried out to ensure that all devices operate properly as intended.

(vii) Contact Resistance Test	This shall be carried out by means of "Ductor" tester or similar instrument to ensure that contacts and joints for switchgears, cables, busbars as well as the contacts and joints for outgoing cables and busbars are maintained in good condition.
(viii) Temperature Rise Limits Test	This shall be carried out as defined in IEC 60439-1.

Note: Tests (i) to (vii) must be carried out on site and test (viii) can be carried out in factory.

(b) Testing after Connection of Supply

The following tests shall be carried out after the incoming supply cables are connected and the "Switchboard" successfully commissioned on no load:

- (i) Phase-to-phase voltage test
- (ii) Phase-to-neutral voltage test
- (iii) Phase-to-earth voltage test
- (iv) Neutral-to-earth voltage test
- (v) Phase sequence test on each and every outgoing circuit

All tests shall be witnessed by and carried out to the satisfaction of the Architect and all test results must be submitted in quadruplicate to the Architect for record purposes.

A.17 REQUIRMENTS DURING MAINTENANCE PERIOD

- (a) The following tests shall be carried out for every six months during Maintenance Period and for each time a test report shall be submitted to the Architect for record:

(i) Insulation Test	This shall be carried out by means of a 1000V "Megger" tester or similar instrument.
(ii) Contact Resistance Test	This shall be carried out by means of "Ductor" tester or similar instrument to ensure that contacts and joints for switchgears, cables, busbars as well as the contacts and joints for outgoing cables and busbars are maintained in good condition.
(iii) Functional Test	This shall be carried out to ensure that all devices operate properly as intended.
(iv) Temperature Rise Measurement	This shall be carried out to ensure the temperature rise limits of each device and switchgear are not exceeded as defined in IEC 60439-1.

- (b) At the end of the Maintenance Period, an Inspection and Test Report shall be submitted to the Architect within two weeks before the completion of the Maintenance Period. Such Inspection and Test Report shall, in addition to those required in Sub-section A.17(a) of this part also state clearly the following:
 - (i) The “Switchboard” is operated in good condition.
 - (ii) The work carried out and any adjustments made during Maintenance Period.
 - (iii) Any recommendation on the necessary improvement or rectification on the “Switchboard”.
- (c) The test and inspection shall be carried out with the prior approval of the Architect if such would require shut-down of the “Switchboard”. Where dictates, the work will be carried out at any time outside normal hours as required by the Architect.

ANNEX B
DIESEL GENERATING SET INSTALLATION

B.1 REQUIREMENTS OF DIESEL GENERATING SETS

B.1.1 Generating Set Rating

Each diesel generating set shall be of 3 phase, 4 wire output and rated at 50 Hz, 380V, 0.8 power factor lagging.

Each generating set shall comply with ISO 8528 and shall be of Prime Power (PRP) rating for the transient as well as the steady state power requirements of the connected essential loads. Offers based on standby rating will not be considered. The actual rating of each generating set shall be clearly indicated on the name plate fixed on the generating set.

B.1.2 General Requirements of Diesel Engine

- (a) The engine shall be a fresh water-cooled, four stroke, direct injection, naturally aspirated or pressure charged, diesel engine of industrial type complying with the requirements of all parts of ISO 8528 and continuously rated to meet the load requirements under site conditions at a crank shaft speed not exceeding 1500 r.p.m., and suitable for running on "light" diesel fuel.
- (b) The engine shall be complete with the following equipment:
 - (i) Engine mounted instrument panel, incorporating lubrication oil pressure gauge, lubrication oil temperature gauge, cooling water outlet temperature gauge, tachometer and hour-meter. The tachometer shall sense the actual engine speed. Frequency sensing type is not acceptable. Ammeter and voltmeter indicating the charging rate of the engine driven dynamo and the battery status shall also be provided.
 - (ii) Protective screens for flywheel, and coupling (if exposed) and other exposed moving parts.
 - (iii) Engine cooling system incorporating engine driven water circulating pump, thermostatically controlled water temperature regulating device, and engine driven tropicalized radiator with mechanically driven fan.
 - (iv) Air cleaner of the dry type or 'oil bath' type incorporating replaceable element.
 - (v) Lubricating oil system (full flow, replaceable element type filter).
 - (vi) Fuel oil system comprising filter, fuel transfer pump, injection pump and injectors.

- (vii) Governor with manual adjustment of $\pm 5\%$ of normal speed. The governing accuracy shall comply with performance Class G3 in ISO 8528-2 "Specification for Reciprocating Internal Combustion Engines, Performance - Speed governing". Governor shall sense the actual engine rotation. Governor designed for sensing the frequency of generator output voltage is not acceptable.
- (viii) Tubular exhaust silencer (acoustic type) with standard accessories and extensions to reduce the sound pressure level to a figure within the limit set by the Environmental Protection Department.
- (ix) Fuel control solenoid (electrically operated) together with an emergency fuel shut off valve (manually operated).
- (x) Two stage engine protective devices for high cooling water temperature and low lubricating oil pressure. Engine protective device for engine over-speed shall also be provided, the engine over-speed sensor shall sense the actual engine rotating speed and shall be free from harmonic interference.
- (xi) All wiring of the control and protection systems, carried out in suitable heat and oil resisting cable, shall be wired out to a suitable cable termination block.
- (xii) One common earth terminal clearly labelled with the earthing symbol for bonding the generator set package to the independent earthing system.
- (c) In accordance with ISO 8528, an additional engine power of 10% of the rated power of the generating set shall be provided for governing purpose only (e.g. transient load conditions and suddenly applied loads).
- (d) The difference in height between the generator set and the daily service tank shall not exceed the maximum value recommended by the generator set manufacturer.

The equipment and accessories to be installed and the details of the fuel oil supply system shall be subject to the approval of the Architect.

- (e) If an underground fuel oil storage-tank is installed, the associated piping, fittings and accessories shall be installed as required to complete the fuel oil system of the generator set. The underground fuel oil storage tank shall be complete with float control and other necessary accessories. A solenoid control valve energised by the starting circuit shall be installed in the fuel oil pipe from the daily service tank to the storage tank.

B.1.3 General Requirements of Alternator

- (a) The alternator shall be of self-exciting, self regulating and brushless type, complete with permanent magnet exciter and shall comply generally with the requirements of ISO 8528-3.

- (b) The voltage regulation of the alternator apart from satisfying the requirements of the electrical loads as specified in terms of steady state and transient conditions shall be of three phase sensing type.

The steady state and transient behaviour shall comply with performance Class G3 in ISO 8528-5. The maximum percentage of voltage dip shall not exceed 20% of the rated value under all loading conditions including step load application. In case that electronic equipment and computers form a substantial amount of supply loads, the maximum voltage dip shall not exceed 10%.

- (c) The machine shall be constructed with the type of enclosure to IP 22 as specified in IEC 60529. Anti-condensation heating elements bounded to the winding of the alternator and suitable for connection to the mains electricity supply (220V) shall be fitted to the alternator. The anti-condensation heaters should be thermostatically controlled and arranged to cut off when the alternator is in operation. They shall be easily accessible for maintenance and replacement.
- (d) A termination box shall be provided suitable for accommodating and terminating cables or busbar trunking entering from the bottom, sides or top. If busbar trunking is used for power-feeder between the alternator and switchboard, special provision shall be made to prevent the vibration of the diesel generating set affecting the tightness of the terminations. Due to site condition, cable termination may only be made at a particular side of the alternator.
- (e) The rating assigned to the alternator by the manufacturer shall be of maximum continuous rating 'MCR'.
- (f) The insulation of the alternator shall be minimum of Class H rated as Class F.

B.1.4 Starting System

Electrical battery starting system for each diesel generating set with a set of 24V electric starting equipment comprising starter motor, battery charger, starting battery and all necessary wiring and switchgear shall be provided. The battery shall be of the nickel cadmium type, with clear plastic cases complete with a hardwood floor stand with hardwood cover suitable for installation adjacent to the starter motor. The battery shall be rated to give six engine cranking cycles each of six seconds within a 60-second period. The battery shall also be capable of providing adequate power to supply the control circuit and to trip the main MCCB/ACB. Separate batteries shall be provided for engine starting and the shunt trip coil if their operating voltages are different. The connection bars of the batteries shall be protected with corrosion resistant petroleum jelly. A suitable double pole switch should be provided to isolate the supply from the battery to the engine starter unit.

The battery charger shall be of 2 rate charging and of constant voltage type installed in the control cubicle, and arranged to maintain the batteries in fully charged condition. In addition, when the engine is running, the batteries shall be charged by an engine driven dynamo controlled by an AVR and cut out.

The battery charger shall be capable of charging up to 75% battery capacity specified in the previous paragraph in 6 hours. Current limiting device shall be provided to limit the charging current with the limit recommended by the battery manufacturer.

B.1.5 Electrical Loads

The electrical loads to be connected to the diesel generating set will be of continuous duty-type. Motor loads will be designated as S1 in accordance with IEC 60034-1 “Rotating electrical machines, rating and performance”.

Thyristor controlled lifts and other thyristor loading such as uninterrupted power supply (UPS), variable voltage variable frequency speed controller (VVVF), etc. will be connected to some of the generators. High current harmonics are generated by these thyristor loading which could have adverse effects on the diesel generating sets on voltage distortion, system instability, overheating of buffer windings, etc. The generator design shall take necessary precautions (including the provision of engine overspeed sensing device free from harmonic interference, etc.) to guard against the occurrence of the above adverse effects caused by the harmonics.

In addition, the generator sets shall be able to tolerate a reasonable amount of lift regenerative power. The generator set shall be suitably sized to cater for the possible regenerative power. Appropriate dummy loads and associated accessories shall be provided, if necessary, for the absorption of the excessive regenerative power.

B.1.6 Suitability for Cold Starting and Step Load Acceptance

The generating set shall be suitable for cold starting and for the acceptance of step loads immediately after attaining normal voltage and frequency.

B.1.7 Radio Interference Suppression

The alternator shall be fully equipped for radio interference suppression to BS EN 55014.

B.1.8 Painting

All exposed ferrous metal surfaces of the machines, under-frame and auxiliary equipment shall, where applicable, be treated with rust-inhibiting primer paint, undercoat and finishing coat. Hot face parts shall be coated with heat resisting paint work which can tolerate high temperature up to 650°C without deterioration.

B.1.9 Baseframe Assembly

The generating set shall comprise a diesel engine directly coupled to an alternator and mounted in line on a steel section baseframe. This diesel alternator baseframe shall be provided with anti-vibration mountings complete with holding down of adequate strength bolts and nuts for installation onto a concrete plinth. The complete assembly shall be equipped with four lifting eyes to facilitate lifting and transporting.

Grouting shall not be carried out until the final agreement from the Architect. Grout shall be composed of equal parts of cement and fine granular sand mixed with fresh water.

B.1.10 Welding

All welding shall be carried out only by welders of the recognized proficiency. The welding electrodes, equipment and process shall also be in accordance with EN 1011 or BS 1821/2640 for arc welding or oxy-acetylene welding respectively.

Welding shall not be carried out under unfavorable conditions. All welded surfaces shall be clean and dry before any welding is to be done.

B.1.11 Structural Steel

Structural steel used shall comply with BS 7668 Grade S345J0WPH. All forms of steel used shall be of standard section with dimensions, tolerances and properties complying with BS 4. Supplier of structural steel work shall provide certificates of the material.

All exposed edges shall be ground to produce a chamfer not less than 2 mm in width to ensure proper adherence of paint.

B.2 CONSTRUCTION OF CONTROL CUBICLE

B.2.1 The control cubicle shall be of totally enclosed type and meet the requirements of IP 44 as specified in IEC 60529 enclosures. The cubicle shall be painted against corrosion after completion of all drilling and operation.

B.2.2 All control cubicles shall have labels made from laminated self-coloured materials and engraved with descriptions in both English and Chinese to be agreed by Architect's Representative. Fixing of labels shall be by mechanical means.

B.2.3 The contactors, switch fuses, relays and all other necessary items shall be housed in the appropriate control panel which shall be arranged with front access for maintenance. It shall also be lockable to prevent unauthorised access and malicious damage to the equipment inside.

B.2.4 Each relay shall be labelled appropriately to its service either by function or by code, in which case a code index shall be securely attached to the panel for easy and positive identification.

B.2.5 A control cubicle shall be installed for each diesel generating set.

B.2.6 All circuits shall be accommodated in accordance with IEC 60439-1 with the latest version and all subsequent amendments.

B.2.7 The cubicle shall be equipped with anti-condensation heater which shall be thermostatically controlled.

B.2.8 The cubicle shall have adequate space mountings for cable terminal box or boxes suitable for armoured cables or busbar entering and leaving both at the top and the bottom of the control cubicle, for connection of mains feeders.

- B.2.9 Terminal blocks and provision for conduit termination shall be provided for small outgoing wiring. All small wiring shall be appropriately ferruled and coded for identification.
- B.2.10 The cubicle shall be so partitioned to allow maintenance of the panel in a safe manner without interrupting the power supply from the mains to the external loads.
- B.2.11 The cubicle shall be constructed to Form 3b of IEC 60439-1.
- B.2.12 The cubicle shall be provided with two rubber mats of ribbed surface, complying to BS 921 or other technically equivalent national or international standards, laid in front of and at the rear of the cubicle. The rubber mats shall be continuous sheets of minimum thickness of 10 mm, each of same length as the cubicle and minimum width of not less than 1000 mm or the width of the space between the front or back of the cubicle to the adjacent wall.

B.3 OPERATION REQUIREMENT

B.3.1 Automatic Operation

Unless otherwise specified, the generating set shall be arranged for automatic start, automatic full load transfer and automatic stop. All automatic operations shall be provided with manual override facilities.

- (a) Failure of one or more phases of the mains supply, or a reduction in voltage to less than 80% normal, shall initiate a timing device adjustable in the range of 0 to 5 seconds. If the failure persists at the expiry of this pre-set time delay, the engine start sequence shall be initiated.
- (b) On receipt of the start signal, the set shall run up to speed and accept the essential loads automatically as soon as possible and within a maximum period of 10 seconds. The automatic load transfer shall be by means of the change-over switch or remote opening/closing of A.C.B. at the main L.V. switchboard.
- (c) On restoration of the mains supply the set will continue to run and supply essential loads for an adjustable period of 0 to 10 minutes. Thereafter automatic transfer of essential load to mains supply shall take place as soon as the adjusted period expired.
- (d) At the end of the adjustable period in (c) the set shall continue to run on no load for an adjustable period of 0-15 minutes.
- (e) If the mains power fails again for a duration exceeding 0.5 second during the adjustable period specified in (c), the control timer setting of the adjustable period (0-10 minutes) shall be cancelled and when the mains power is restored again, the operating sequence will start again from (c).
- (f) If the mains fails again during the adjustable period specified in (d) the essential loads will be connected immediately and automatically back to the set and the operating sequence will continue as if the connection had been made in the manner as described in (b).

- (g) In the event of failure of the engine to start the set shall, after a pre-determined time delay, make a second attempt to start. A third attempt may be initiated. Eventually, if it fails to start, the starting circuits shall be lock-out, and a visible and audible alarm given which shall remain until reset.
- (h) Both electrical and mechanical interlocking devices shall be provided to prevent starting engagement when the engine is in motion.
- (i) In the event of electrical failure such as over-current, short circuits or earth fault during the operation of the generator set, the ACB/MCCB connecting the generating set and the L.V. Switchboard shall be tripped, the engine shall be shut down and both visual and audible warning signal shall be given.
- (j) Provision shall be made for manual control of the set for testing purpose, including one "auto-off-manual" selector switch, "start" and "stop" push-buttons, and a "simulate mains failure" key switch.
- (k) Restoration of normal mains supply during the starting period shall not interrupt the starting sequence but shall prevent the load transfer to the alternator. Therefore the operating sequence will follow the mode as described in (d).
- (l) As ACB is used for the protection/ isolation of the generator, ACB lifting truck shall be provided.

B.3.2 Protection

Protective devices shall be provided to guard against the following mechanical and electrical failures where any continuous running may result in severe damage of the generating set.

- (a) Over-speed, high coolant temperatures, low lubrication oil pressure of engine.
- (b) Electrical short circuit, overload, earth fault of the stator and rotor winding, over/under-voltage, over/under-frequency, loss of excitation, under-speed and rotation failure of the alternator.

In the event of a fault, the protective device shall shut down the engine and initiate both audible and visual alarms. The audible alarm shall be cancelled by an acknowledge push button. The settings for each of the systems being monitored shall be specified by the engine manufacturer and alternator manufacturer respectively.

B.4 CONTROL REQUIREMENT

B.4.1 Instruments and Functions for Control Cubicle

- (a) Voltmeter and selector switch and fuse 0-500V range.
- (b) Ammeter, current transformers and selector switch.
- (c) Frequency meter in 45 to 55 Hz range.
- (d) Watt-meter.
- (e) 4 Poles withdrawable air circuit breaker or 4 Poles MCCB complete with d.c. shunt trip facility and protection against overload and short circuit and earth fault by means of over-current and earth fault protection relay.
- (f) 3-phase mains voltage sensing unit.
- (g) Auto/off/manual selector switch.
- (h) "Start", "Stop" push buttons for manual operation.
- (i) "Simulate main failure" key switch.
- (j) Diesel generating set anti-condensation element "On-off" switch.
- (k) Automatic 2-rate battery charging equipment complete with voltmeter and charging rate ammeter.
- (l) Automatic voltage regulation unit and excitation controls.
- (m) "Engine Fault" automatic shut-down indication lamps, alarm, and reset buttons.
- (n) "Failure to start" indicating lamp, alarm and reset button.
- (o) "Diesel generating set Supply Available" indication lamp.
- (p) "Mains Available" indication lamp.
- (q) "Diesel generating set on Load" indication lamp.
- (r) "Mains on Load" indication lamp.
- (s) Diesel generating set output under-voltage and over-voltage protection device. The devices shall be capable of monitoring the three phase supply and with an adjustable range.
- (t) Lamp test push button.
- (u) Any other function controls to meet the requirements of Section B.3 "Operation Requirements".

- (v) Cable terminal box or boxes suitable for armoured cables or busbar trunking entering from the bottom or top of the control cubicle as appropriate for each site, for connection of mains cables.
- (w) Clean contacts shall be provided in the Control Cubicle for the following alarms/indications to enable them to be connected for remote indications:

	<u>Alarms/Indications</u>	<u>Location</u>
(i)	Generator on load	Fire control main panel
(ii)	Generator fails to start	- ditto -
(iii)	Auto/off/manual selector switch in manual position	- ditto -
(iv)	Generator Engine Fault	- ditto -
(v)	Generator running	- ditto -
(vi)	Essential Power Supply ON/OFF	Lift Machine Room
(vii)	Essential Power Supply NORMAL/TRIP	- ditto -

- (x) The fuel oil tank shall be fitted with two stages fuel capacity limiting control to alert building management and shut down non-FSI essential services when the remaining fuel capacity falls to 7 hours and 6.5 hours continuous running of the emergency generator respectively.
- (y) Contacts shall be provided for controlling each of the generator room air supply and exhaust fans, remote radiator fans, cooling water booster pump, etc. which shall be ON automatically when the diesel generating set is started. All indication lamps shall be operated at a voltage not greater than 50V.

B.4.2 Interfacing with CCMS System

- (a) All necessary contactors, relays, microswitches, transducers, transformers, signal and control cables, conduits and other necessary accessories to facilitate the monitoring by the Central Control and Monitoring System (CCMS) or the Direct Digital Control (DDC) System shall be provided. These provisions shall include termination works at dedicated terminal strips in individual control panels of equipment for connection to an interfacing panel in the Emergency Generator room of the Building.
- (b) The parameters of diesel generating sets system such as engine oil pressure, coolant temperature, engine r.p.m., system d.c. volts, engine running hours, generator a.c. volts, generator a.c. amps, generator frequency, low oil pressure, high coolant temperature, over-speed, over-crane, emergency stop, fault shutdown, fuel oil pump fault and Underground tank/Daily services oil tank low level alarms shall be all repeated and can be retrieved in the CCMS for remote monitoring and recording.
- (c) The interfacing panel shall be constructed from 1.6 mm thick stainless steel, with front lockable hinged door.

B.5 INSTALLATION OF DIESEL GENERATING SETS

B.5.1 Position

Special attention shall be paid for the construction dimensions and location of the air intake/outlet louvers and shall ensure that the capacity of the radiator fan is sufficient for the air requirements of the generator set. Air discharge restriction of the radiator fan and the air intake restriction of the generator set shall be selected with appropriate noise attenuators.

The diesel generating sets shall be properly erected and aligned onto the concrete plinth and the vibration generated by the set shall be isolated from the generator room.

B.5.2 Guards and Insulations

All moving parts, bare exhaust manifolds, pipes and pressure charger (if any) shall be properly and completely guarded and or insulated in accordance with the relevant regulations. The guards shall be of such design that will guard against the serviceman from coming into contact with any part which is likely to cause injury to personnel. All guards shall be detachable.

B.5.3 Air-ducts

An exhaust air duct from the radiator to the louvers mounted in the wall shall be of 1 mm galvanised M.S. sheet and shall be properly supported near the radiator end. It shall then be connected to the radiator flanges through a flexible joint to isolate the vibrations generated by the diesel generating set. An inspection panel shall be provided for the ease of future maintenance.

B.5.4 Engine Exhaust System

- (a) The engine exhaust system shall comprise silencer, bellows, hangers, piping, clamps, flange couplings, heat resisting jointing. All installation works shall be carried out to suit actual site requirements.
- (b) The silencer shall be capable to attenuate the noise generated from the exhaust air to a level to cope with the Environment Protection Department's requirement.
- (c) The complete exhaust from the exhaust manifold to the end of the exhaust pipe including the silencers, flexible joint and pressure charger (if any) shall be coated with heat resisting paint, lagged with non-combustible insulating material and enclosed with aluminium cladding. Asbestos shall not be used for insulation. The exposed portion of exhaust pipe outside the generator room shall be of stainless steel, Grade 316.
- (d) The exhaust system shall not create a back-pressure exceeding the amount recommended by the engine manufacturer, and shall be sufficiently flexibly installed in order to allow for reasonable amount of expansion and contraction.
- (e) The engine exhaust pipe hangers shall incorporate anti-vibration spring mechanism.

- (f) Suitable water draining device shall be provided for the exhaust system so that no fluid could enter to the diesel generating set through the exhaust outlet.
- (g) The installation of the exhaust outlet shall comply with all requirements of the Environment Protection Department.

B.5.5 Electrical Works

- (a)
 - (i) Independent earthing system shall be provided for each of the neutral connection and earthing of the diesel generating set. The installation of diesel generating set shall be solidly and effectively earthed in accordance with the latest edition of the Code of Practice for the Electricity (Wiring) Regulations.
 - (ii) An earth fault protection relay and the necessary accessories shall be provided to complete the earth protection system.
 - (iii) Joints in copper earth bar shall be brazed together using pan head riveted and sweated.
 - (iv) When the plant is subject to vibration, or where circumstances necessitate, the earthing connections shall be made of flexible copper conductor having PVC sheath.
 - (v) The exposed conductive part of all equipment shall be earthed into separate earthing terminal.
- (b) Sufficient of clean contacts shall be provided in the control cubicle for each Air Circuit Breaker of the L.V. Main switchboard for the remote open/close operation of the respective Air Circuit Breaker.
- (c) The control cubicle shall have clean contacts and related transducers for indications of alarms and status at the Central Control and Monitoring System (CCMS).

B.6 ENGINE COOLING SYSTEM USING REMOTE RADIATOR

B.6.1 General

If remote radiator cooling is required, the following specification in this session shall be complied with.

B.6.2 Remote Radiators

- (a) The remote radiator shall be suitable for outdoor installation with ample capacity to comply with the cooling requirement of the diesel engine. The radiator shall be a forced draft design with cooling core and fans.

- (b) The core shall be encased in a galvanised steel frame and covered with a removal guard of zinc plated or galvanised steel wire. The core shall be bolted to a heavy gauge galvanised steel structure which supports it all points and is capable of withstanding wind loads to 45 metre/sec. Core shall consist of the non-ferrous cooling coil tube mechanically expanded into aluminium plate fins for a permanent bond. Vents and drains shall be provided in the core.
- (c) The fan shall be of the propeller type with aluminium blades. The fan motor shall be of totally enclosed type, Class B insulated. Zinc plated, close mesh steel wire fan guard shall be provided. Weatherproof push lock turn reset emergency stop switch shall be provided to stop the fan in case of emergency.
- (d) The radiator shall be designed so that the overall sound pressure level shall not exceed the value specified by the Environmental Protection Department.

B.6.3 Heat Exchangers

- (a) Heat exchanger shall be of the horizontal shell and tube pattern with the coolant from engine flowing inside the tubes which shall be straight.
- (b) The shell shall consist of either a seamless steel or brass pipe or a fusion welded steel cylinder with the necessary parts and flange welded in place.
- (c) The tubes may be externally finned or grooved to increase exchange surface and shall be expanded into grooved holes in the tube plates and the ends belled. Welding of the tubes to the tube plate shall not be accepted.
- (d) The tubes shall be made of either copper or brass. The tube plates and supports shall be of stainless steel.

B.6.4 Water Circulating Pumps

- (a) Two water circulating pumps (one duty and 1 standby) shall be provided for each diesel generating set. The two pumps shall work automatically and alternatively as duty and standby or controlled manually by a selector switch on the control panel.
- (b) The pump shall be centrifugal type and direct driven through flexible coupling by electric motor fixed on a common bed plate.
- (c) The pumps shall be constructed to meet the following requirement:

Pump casing	:	Cast Iron
Impeller	:	Leaded Gunmetal
Shaft	:	Stainless Steel Grade 316
Bearing	:	Ball or Ball and Roller
Seals	:	Mechanical
Bolt and Nuts	:	Stainless Steel

- (d) The pump motor shall be Class B insulation suitable for 380V 50 Hz 3 phase supply. The speed of the motor shall not exceed 1500 r.p.m..

B.6.5 Expansion Tank

- (a) An expansion tank of suitably capacity for each water circulating system with ballcock, valve, overflow, drain and all necessary accessories shall be provided to meet the local regulations and the operational requirement.
- (b) The tank shall be fabricated from mild steel plates of 3mm thickness welded onto a mild steel frame. To stiffen the tank, mild steel flat bars are to be intermittently welded on the inside of the tank.
- (c) All steel work, mild steel angle stand including the surfaces of the tank shall be painted with one coat of best quality primer and two coats of best quality paint. Colour of the tank shall be directed by the Architect or his Representative.

B.6.6 Pipework and Valve

All pipework shall be R250 copper pipe to BS EN 1057. Jointing method for pipe size 65 mm and above shall be of the flanged brazing or bronze welded type.

All pipes shall be properly pitched and supported with strong hangers, brackets and saddles. The support system shall be designed to take into account the size of the pipelines, their content and materials of construction, the vibration isolation components, the amount and direction of movement, the location of the pipeline in relation to the building fabric and other services and the need for access. Adequate provision shall be provided for free expansion and contraction of the pipeline.

Gate valves shall be flanged cast iron body with bronze trim, cast iron wedge, bronze rising stem. Globe valves shall be flanged cast iron body, renewable bronze disc and seat, outside screw and bronze rising stem.

Disconnecting flanges shall be installed at valves and at suitable locations for cleaning and removal of piping. Where pipes pass through walls or slabs, pipe sleeves shall be provided.

Pipes and valves shall be painted in colours with directional arrow indication.

B.6.7 Hydraulic Test

- (a) Water system and circuits shall be hydraulically tested.
- (b) Test pressure for water circuits and components shall be 2 times working pressure, or 1.5 working pressure plus 3.5 bar whichever is lower.

B.6.8 Power Supply and Control System

- (a) Power supply to the remote radiator and the pump shall be fed from the control cubicle. All cables shall be PVC insulated to IEC 60189 and run in steel conduits or PVC armoured cable as appropriate.
- (b) Control panel housing fuseswitch, the starter and control circuit for the remote radiator and the water pump shall be provided. They shall be automatically started and stopped in line with the operation of the diesel generating set.

B.7 FUEL SUPPLY SYSTEM

B.7.1 Underground Horizontal Fuel Storage Tank

(a) Construction

- (i) The construction of the underground fuel storage tank shall comply with BS 2594 or other technically equivalent national or international standards.
- (ii) All joints in the tank shell and dished ends shall comply with EN 1011-1 and EN 499.
- (iii) Tank shells shall be made of rings and each ring shall be formed from a single plate or from not more than two plates welded together, rolled into a true circle. No longitudinal weld in any ring shall lie within the bottom third of the tank circumference in accordance with BS 2594 or other technically equivalent national or international standards. Longitudinal seam welds in adjoining rings of plate shall be staggered from one another by a minimum of 45 degrees. Joints or seams shall not be placed in the positions of the cradles. All openings in the tank shall be located clear of the welding seams.
- (iv) An end plate is made up from two smaller plates the welded joint between them shall be horizontal, and above, the centre of the tank end.
- (v) The inside surfaces of the tank shall be smooth and free from any obstruction apart from essential pipe connections. No internal bracing or gusset plates will be permitted inside the tanks.
- (vi) Tank-hole covers and all flanges and pads associated with each manhole cover shall be provided and complete with bolts, washers and joint rings as shown on the Drawings.
- (vii) After the construction has been completed, the tank shall be thoroughly cleaned and all loose debris removed. It shall then be tested hydraulically at a pressure of 70 kPa, measured at the top of the tank. The pressure shall be maintained for a period of 2 hours to ensure that the tank is sound and shows no leaks or undue distortion. The test shall be carried out in the presence of and to the satisfaction of the Architect or his Representative.

The pressure gauge employed for the test shall be tested and calibrated by approved laboratory before use. Pressure gauge with full-scale deflection readings more than 3 times the test pressure shall not be used.

- (viii) Immediately after hydraulic test of the tank, the tank shall be drained and dried out it and a thick coat of linseed oil shall be applied on the interior surfaces of the tank to prevent rusting.

(b) Protection of Tank

All parts of the exterior surfaces of the tank shall be thoroughly cleaned by mechanical means to remove all rust, mill scale, grease and other foreign matters to achieve a bright, rust free and dry surface. The painting procedures shall comply with ISO 12944.

(c) Calibration

- (i) The tank shall be calibrated after it has been installed in the tank chamber, by dipstick. The measuring device shall be calibrated.
- (ii) The dipstick shall be made from 20 mm diameter brass pipe. When the tank has been calibrated, the dipstick shall be marked on all faces by clearly scribed lines of 100-litre intervals for the tanks up to 10000 litres in capacity and of 250-litre interval for those above 10000 litres, and have the volume figures stamped on two opposite faces at interval of 1000 litres.
- (iii) After calibration, the tank shall be thoroughly dried out and applied with a thick coat of linseed oil on the interior surface to prevent rusting.
- (iv) The results of calibration shall be tabulated and submitted for record purpose.

B.7.2 Daily Service Fuel Tank

(a) Construction of the Daily Service Fuel Tank

The daily service tank shall be fabricated from mild steel plates welded onto a mild steel frame. To stiffen the tank, mild steel flat bars are to be intermittently welded on the inside of the tank.

(b) Accessories of Daily Service Fuel Tank

The tank shall be fitted with the following standard accessories:

- (i) A tapped filling socket connection on top of the tank complete with all the necessary fittings and union coupling for connection to the filling pipe.
- (ii) A tapped overflow socket connection close to the top and on the side of the tank complete with all the necessary fittings and union coupling for connection to the overflow pipe or plugged with a brass screw cap if it is not used.
- (iii) A tapped outlet socket connection close to the bottom and on the side of strainers, and union coupling for connection to the delivery pipe strainer must be submitted for approval before installation.
- (iv) A tapped drain socket connection at the bottom of the tank complete with all the necessary fittings connection to and including the 20 mm gate valve.

- (v) A tapped return socket connection on the top of tank complete with all the necessary fittings and union coupling for the connection to the return pipe; or plugged with a brass screw cap if it is not used.
 - (vi) A tapped vent socket connection on the top of tank complete with all the necessary fittings and union coupling for the connection to the vent pipe.
 - (vii) One quick closing valve installed on the delivery pipe complete with all necessary linkage for operation from outside the building. If steel linkage for operation from outside the building. If steel wire and pulleys are used, the wire must be properly adjusted in length and protected; and the pulleys securely anchored.
 - (viii) The tank shall be fitted with an approved content gauge unit. Provide an accurate measuring device for the calibration of the content gauge and a supporting stand which shall be fabricated from angle iron complete with strut and tie members as may be deemed necessary. They shall be designed in such a way that it will be possible to remove the tank without first lifting it. A mild steel oil drip tray welded to the angle bracket or stand shall also be included. Exact height of the frame shall be determined to suit site requirement.
- (c) Painting of the Daily Service Fuel Tank

All parts of the exterior surfaces of the tank shall be thoroughly cleaned by mechanical means to remove all rust, mill scale, grease and other foreign matters to achieve a bright, rust free and dry surface and then painted with one coat of zinc rich primer, one coat of epoxy based under coat and two finishing coats of approved paint.

The interior surface of the tank shall be thoroughly dried out and applied with a thick coat of linseed oil to prevent rusting.

B.7.3 Fuel Transfer Pumping System

(a) Electrical Fuel Transfer Pumps

Rotary fuel transfer pumps complete with all necessary accessories including strainers, check valves, gate valves, etc. shall be provided.

- (i) The pumps shall be positive displacement type, with high quality cast iron body, high tensile steel shafts and built in internal relief valve.
- (ii) Each pump shall be capable of delivering 'light' diesel fuel oil at 300 kPa 950 rpm maximum with capacity. For each pair of pumps a manual switch shall be provided to select the pump running mode as "duty" or "standby" respectively.

- (iii) The coupling motor shall be flame proof 3 phase, 50 Hz, 380V with no volt release and overload protection. It shall have a manual/auto/off switch with connections for remote start/stop operation by the level switch at the daily service tank. The duty pump shall be actuated when the fuel level in the daily service tank fall below 30% of the tank capacity, cut off automatically when the tank is 90% full. The pumps shall also be inoperative when the fuel level in the underground storage tank falls below a pre-set level.
- (iv) Audible alarm shall be given off under the following conditions:
 - underground storage tank fuel level low
 - pump fail to start
- (v) A composite pump control cubicle in the pump room incorporating the starters, safety and protection devices, all necessary wiring work, relays, fuel level control and alarm, push button and indication lights shall be provided. The cubicle shall be of wall-mounted type, type of protection EEx d flameproof enclosures for operation in Zone 1 hazardous area as classified Institute of Petroleum Code of Great British (IPMCSP) and IP 65 enclosure to IEC 60529. The drawings and the official certificate issued by British Approvals Services for Electrical Equipment in Flame Atmosphere (BASEEFA) of the cubicle shall be submitted.

(b) Control Equipment

The following controls and indicator lights shall be incorporated on the control cubicle:

- (i) A suitably rated main supply door-interlocked isolator with "Supply On" indicator light.
- (ii) An "Automatic/Off/Manual" selector switch.
- (iii) Push button manual "start/stop" of each of the pump set, and the corresponding indicator lights.
- (iv) Indicator lights showing "pump running".
- (v) Selector switch to select duty pump.
- (vi) Clean contacts for connection to CCMS for the status monitoring of the pumps.
- (vii) Engraved labels in both English and Chinese for all control operations shall be incorporated on the composite control cubicle.
- (viii) Indicator lights showing the remaining fuel capacity falls to 7 hours and 6.5 hours continuous running of the emergency generator respectively.

(c) Hand Pump

A semi-rotary double acting hand pump shall be provided for each daily service tank and consist of 25 mm diameter inlet and outlet and a 25 mm diameter flexible oil resistant inlet pipe of adequate length to suit site condition.

B.7.4 Pipeworks and Fittings

(a) General

- (i) Supply and install all necessary fittings and pipework of approved design as required by the emergency generating plants and as generally shown on the Drawings. However exact dimension of piping shall be determined on site and any modification of pipe route indicated on Drawings requires prior approval from the Architect.
- (ii) All pipes up to 80 mm diameter shall conform with ISO 65 heavy quality and pipes 80 mm diameter and above with BS 1600 Part 2 Schedule 40 or other technically equivalent national or international standards.
- (iii) Flanges shall be slip-on-welding type in accordance with ISO 7005 Class 150. Screwed fittings shall be made of malleable iron and threads shall comply with ISO 7-1.
- (iv) All screwed joints shall be cleaned, threaded and pulled up tightly. All jointing materials shall be diesel resistant. Gaskets made of rubber or compressed asbestos fibre shall not be used.
- (v) Particular care shall be taken to ensure that all pipes and fittings are carefully reamed to ensure that the full bore of the pipe is maintained and where necessary cleaned out before erection.
- (vi) Square elbows shall not be used, where practicable, long sweep bends shall be used in preference to round elbows.
- (vii) Valves shall be of 'fully way' type to allow free flow of fuel. A sample valve shall be submitted to the Architect for approval before installation. Valves shall be made of bronze.
- (viii) Round piping supports and anchors as necessary to be suitably placed to the instruction of the Architect, in order to provide rigidity to reduce stresses due to unstable ground.
- (ix) Jointing materials shall be diesel resistant.
- (x) A return diesel pipe shall also be provided from the generator back to the daily service tank.

(b) Protection of Buried Pipe

The procedures for protection of the buried pipes shall be as follows:

- (i) Clean the outer surface of the pipe to remove all rust, mill scale, grease and other foreign matters to achieve a rust free and dry surface;
- (ii) apply one layer of primary protection paste as approved by the Architect as primer to give a thin continuous coating over the area to be protected;
- (iii) apply self-amalgamating tape or other wrapping materials as approved by the Architect on the pipe with minimum 55% overlap. Care should be taken to ensure the tape is in contact with the underlying surface of the pipe and to smooth out any wrinkles or air pockets;
- (iv) apply overcoat self-amalgamating tape or other wrapping materials as approved by the Architect on the pipe with minimum 55% overlap as an outerwrap.

(c) Painting of Pipeworks

All pipeworks, other than the buried pipes, shall be painted with one coat of zinc rich primer before installation and painted immediately after installation with one coat of epoxy based under coat and two finishing coats of best quality paint.

B.7.5 Diesel Fuel Level Switches

(a) General

- (i) The level switches shall be manufactured to
 - IEC 60079 Electrical Apparatus for Explosive Gas Atmospheres; and
 - IP Model Code of Safe Practice (Electrical) of IPMCSP.

(b) Classification

- (i) The level switch shall be of Group IIA and Temperature Class T1 in accordance with IEC 60079-0.
- (ii) The electrical components of the level switch installed in the vapour space above fuel and inside the fuel tank(s) shall be of the type of protection of EEx ia which is suitable for installation in Zone 0 Hazardous Area as classified in IPMCSP.

(iii) The electrical components of the level switch installed outside of the fuel tank shall be of the type of protection of

- EEx ib or
- EEx d or
- EEx P which are all suitable for installation in Zone 1 Hazardous Area as classified in IPMCSP.

(c) Performance Requirements

Unless otherwise stated, the level switch (in general accompanied with a controller) shall be capable to control on/off operation of a remote system when a preset level of the diesel fuel in the storage tank is reached. Details of the operation and the exact control level settings shall be as stated in the Specification. The level switch shall be suitable for on-site calibration of the level settings.

Sufficient of level settings are required for fuel capacity limiting control to alert building management and shut down non-FSI essential services when the remaining fuel capacity falls to 7 hours and 6.5 hours continuous running of the emergency generator respectively.

(d) General Construction

- (i) The level switch shall consist of two major components - a level sensor and a switch unit, both of which shall meet the classification as specified in Sub-section 7.5.2. Where applicable, the level switch shall be accompanied with a controller to perform the function as stated in Sub-section 7.5.3.
- (ii) The level sensing element shall be installed in a tube of stainless steel and places inside the fuel storage tank. It shall be mounted horizontally or vertically depending on the principle of operation.
- (iii) The switch unit shall be mounted on the tank and with the level sensor to form an integral set. The unit shall be housed inside a casing made of cast iron or aluminium alloy. It shall be capable of detecting the signal from the sensor and transmitting it (in general through a controller) to control the on/off operation of a remote system.

(e) Certification

A copy of certificate to prove the apparatus rating shall be submitted. Certificate issued by authorities other than BASEEFA shall be furnished with details of relevant standard.

(f) Technical Information

A full descriptive technical brochure giving details of the equipment offered, including construction, dimensions, method of installation, etc. shall be submitted.

B.8 ACOUSTIC TREATMENT INSTALLATION

B.8.1 Performance Requirements

- (a) The acoustic treatment package shall be designed to ensure that when the generator set is running under full load the generated noise complies with the "Noise from Places other than Domestic Premises, Public Places or Construction Sites" under the Noise Control Ordinance.
- (b) For Testing and Commissioning purposes, the proposed points at which measurements have to be carried out according to the method set out in the "Technical Memorandum for The Assessment Of Noise From Places Other Than Domestic Premises, Public Places or Construction Sites".

B.8.2 Scope of work

The scope of work shall include but not limit to the followings:

- (a) Pipework acoustic sleeving.
- (b) Duct Silencer for all air passage including air inlet louvre, air discharge outlet louvres, ventilation fan and coupled radiator.
- (c) Mufflers/silencer for the engine exhaust air system including exhaust flues.
- (d) Acoustic wall and ceiling lining inside Generator Room.
- (e) Acoustic enclosures including silencer and acoustic lining for the remote radiator, if required.
- (f) Other acoustic treatments required.
- (g) Measurement of Noise level at the specified point.

All vibration and noise suppression equipment shall be new, sound workmanship and robust design and shall be supplied by manufacturers experienced in the design and construction of similar equipment and who have made equipment and materials for similar duties for at least five years.

B.8.3 Installation of the Acoustic Treatment System

- (a) Pipework Acoustic Sleeving

Wherever necessary to maintain acoustic integrity of the system acoustic seal sleeving to all pipes penetrating the building structure shall be provided.

Pipework sleeves shall consist of an inner pipe lined with mineral wool and clamping end plates with neoprene seals. Pipe in situ shall be fitted with split clamping rings. Pipe temperatures above 115°C shall have silicon fibre seals.

Pipes shall be resiliently supported on either side of the penetration by resilient hangers.

Seals shall comply with FSD requirements wherever appropriate.

(b) Duct Silencers for All Air Passage

The duct silencers shall consist of an outer casing fabricated from galvanised steel sheet not less than 1.6 mm thick and a number of splitters made from 0.8 mm perforated galvanised steel sheets which divide the silencer into separate longitudinal airways. Sound shall be attenuated by the sound absorptive fill in the splitter as air passes through those airways.

The sound absorbent material shall be non-combustible inorganic glassfibre or mineral wool or other approved and equivalent material and shall have a glass fibre mat facing. The material shall be fitted in the splitters with at least 10% compactness. The material shall also be non-hygroscopic, resistant to attack by moulds and insects. The material should be supported so that it does not shake down but remains intact during the life of the plant. Bird screen made of galvanized wire mesh shall be provided with all intake silencers.

The acoustic fill shall be suitable for continuous exposure up to 260°C with the galvanised steel sheet having a temperature limit of 400°C. A polyester membrane shall be used to line up the silencer to prevent ingress of dust and/or water into the sound absorptive fill. The absorptive fill in the splitters shall be firmly secured as to be free from erosion for channel velocity up to 30 m/s.

The shape of the splitters shall be designed for maximum possible sound attenuation with the minimum possible resistance to air flow. Maximum allowance pressure drop is 50 Pa. The minimum sound insertion loss (dB) of the silencer, tested in accordance with BS 4718 or other technically equivalent national or international standards, shall be as follows:

Octave Band Centre Frequency (Hz)

Frequency (Hz)	63	125	250	500	1k	2k	4k
Minimum Insertion Loss (dB)	8	18	24	40	45	46	41

The silencer shall have fully welded seams or duct sealer to ensure air tightness. All weld affected parts shall be touched up with an aluminium rich paint and all exposed ferrous parts including the frame shall be protected from corrosion by applying rust-inhibiting primer paint, an undercoat and finishing coat of colour as determined by the Architect on Site. All such primer and paint shall be resistant to heat up to the working temperature of 260°C.

(c) Mufflers for Engine Exhaust

Exhaust gas muffler (or mufflers) of low noise level type shall be provided for each engine such that the noise level standard/ requirement can be achieved.

In case that the above standard cannot be achieved with the installation of exhaust gas mufflers, suitable acoustic enclosure shall be provided at the engine exhaust pipe outlet to attenuate the noise before the hot exhaust air is discharged. The acoustic enclosure shall be capable to withstand the hot engine exhaust air which may be up to 650°C.

(d) Acoustic Wall/Ceiling Lining Inside Generator Room

Acoustic treatment to the generator room walls, doors and ceiling wherever else necessary in order to reduce the room reverberant noise level and time is required.

Acoustic wall/ceiling lining shall be fabricated from sound absorptive material firmly hold in position by G.I. channels and protected by perforated galvanised sheet steel.

The material shall be in form of the high density rigid section fibreglass or rock-wood slabs or other similar approved material having a minimum thickness of 50 mm and a density around 48 kg/m³. The acoustic fills shall be of Class 1 or 2 rate of surface flame spread as laid down in BS 476 Part 7 or other technically equivalent national or international standards.

The minimum random incidence absorption coefficient of material when fixed as specified shall be as follows:

Frequency (Hz)	125	250	500	1000	2000
Absorption Coefficient	0.26	0.78	1.11	1.10	1.04

Material shall be selected of suitable random incidence absorption coefficient to suit the site condition and equipment offered.

A polyester membrane shall be lined between the glass fibre and perforated sheet for better protection against dust and water.

The fixing GI channels shall be 25 x 50 x 1.0 mm thick and shall be fixed by fastener onto the wall surfaces at an intervals of 600 mm approximately.

The protective perforated steel sheet shall be fabricated from galvanised sheet of not less than 0.8 mm thick and shall be secured by self tapping screws to the G.I. channels. The holes shall be 2.4 mm diameter with 4.8 mm centre to centre distance. The perforated metal sheet shall be removable to enable future maintenance.

The acoustic lining shall not pack down or settle after installation. All metal surfaces shall be undercoated and finished with 2 coats white gloss paint.

Samples and recognised test certificates for the absorption material shall be submitted to the Architect for approval.

(e) Acoustic Enclosure for Remote Radiators if Required

A complete acoustic treatment to the remote radiator shall be provided to achieve the standard specified in the previous section which include the whole remote radiators with opening for air intake and discharge. Duct silencer shall be installed for every air passage. The sound absorptive material for the duct silence shall be capable to withstand high temperature generated from the remote radiator.

The whole acoustic enclosure shall be designed to facilitate easy access to the remote radiator for maintenance.

B.9 EXHAUST FAN FOR EMERGENCY GENERATOR ROOM

B.9.1 General

Ventilation of the generator room is achieved by an axial flow exhaust fan with air duct silencer and other accessories. The air flow capacity of the fan shall have a minimum value of 10 air change/hour.

All material and workmanship shall comply, where applicable, with all relevant sections of the “General Specification for Air-conditioning, Refrigeration, Ventilation and Central Monitoring & Control System Installation in Government Buildings, Hong Kong” publish by Architectural Services Department, the Government of the Special Administrative Region.

B.9.2 Fan General

The fan shall be axial flow aerofoil type and the blades shall be moulded in glass fibre reinforced polyester resin. Service door shall be provided within the fan casing for access to the terminal box of the fan motor. The casing shall be hot dip galvanized.

The fan motor shall be totally enclosed, squirrel cage induction motor suitable for continuous operation within the emergency generator room. The motor shall be suitable for local electricity supply.

Fan unit mounting and fixing details shall include details and dimensions of equipment bases, fixing bolts, flexible connections, vibration isolators and any special Building Work requirement.

Fan characteristic shall be plotted over the entire range from shut-off to free delivery as static pressure in Pa, total efficiency in percentages and operating kW, against the air flow in m³/s at the specified speed and shall clearly indicate the operating point of the fan.

The fan shall have non-overloading characteristics over the entire operating range and the characteristic curves must be such that the fan operating point falls below the point of no flow static pressure, to the right of the point corresponding to that of maximum mechanical efficiency. All allowance, including mechanical and

electrical, to adjust either the static pressure or air volume by $\pm 15\%$ over those specified values shall be made. If necessary, this shall be accomplished by modifying the width of the fan wheel and/or by providing inlet vanes to change the characteristic curve.

Sound power rating curves shall be certified accurately by the manufacturer for the complete fan and drive assemblies and tested in accordance with ISO 8136.

All characteristic curves shall be certified accurately by the manufacturer for the complete fan and drive assemblies.

Fan shall be selected with speeds and outlet velocities in order to keep the noise level to within the specified values. Nevertheless, outlet velocities shall not exceed 13m/s.

The fan with nominal fan brake power rating above 5kW shall have a minimum efficiency of 75% and for up to 5 kW shall have minimum efficiency of 65%.

The complete fan unit including motor and drive shall be supplied from a single manufacturer and all guarantees, test certificates, etc., shall be deemed to apply to the entire assembly.

All fan, drive and accessories shall be of the highest commercial standard and shall be designed, constructed, rated and tested in accordance with the recommendations standards of the U.S.A., or alternatively, shall comply with ISO 5810.

The motor shall have drive gear contained in wire guard enclosure for safety and compliance with Labour Department requirements.

The fan shall be supplied by manufacturers experienced in the design and construction of similar equipment for at least five years.

B.9.3 Axial Fan

Casings shall be of heavy galvanized sheet construction adequately stiffened and braced and shall be entirely free from vibration or drumming during normal operation. All surfaces of fan casings shall be galvanized after manufacture.

The fan casing shall be provided with drain sockets or holes with copper drain-pipes brought out to an accessible point, valved and plugged.

Fan casings shall be fitted with flanges on the outlet connection suitable for connection of discharge ductwork and flexible connections, as shown on the Drawings.

Where the suction side of the fan is connected to ductwork, then matching flanges shall also be provided.

Terminal boxes welded to the casing shall be provided for electrical connection to fan motor.

Fan impellers shall be diecast in aluminium alloy and examined by X-ray to ensure flawless castings. Impeller and shaft shall be statically and dynamically balanced and tested for overspeed.

Except for sealed bearings, all lubrication shall have sight glasses and oil pipes shall be provided to bring the lubricators to any easily accessible position.

B.9.4 Duct Work

All metal air ducts and plenums including all necessary supports for the whole ventilation system shall be provided. Ductwork shall be made from hot-dip galvanized sheet to BS EN 10143 Grade E2, coating type, or equivalent.

Flexible joints shall be provided and fixed between the air ducts and the ventilation fan. The flexible joint shall be of non-combustible materials covered by 25 mm thick aluminium faced fibre glass external insulation or equivalent and approved fire proof material.

The minimum sheet thickness shall be according to that recommended by the latest edition of DW/144 Specification for sheet metal ductwork.

Stiffeners shall be applied so that the true rectangular cross-section of the duct is maintained. Supports shall be arranged and spaced so that ductwork does not distort, sag or twist under weight of the ductwork. Ductwork should be supported at the joints whenever practicable and be fastened so that it does not slip.

All ductwork and fittings delivered to site shall be new and shall be clearly and indelibly stamped to identify different grades, materials and manufacturers.

Test holes shall be 25 mm diameter and fitted with an effective removable seal. Test points shall be provided to enable fan duties and items to be assessed and the system to be commissioned.

All ductwork and materials including linings, adhesives, flexible ducts, flexible connections, gaskets, sealants, fibreglass boards, etc. shall fully comply with all requirement of the FSD and shall satisfy BS 476 Part 7 in respect of resistance to penetration of fire and spread of flame and smoke.

Jointing for flanged cross joints shall be formed by a gasket of approved material to thickness not less than 4mm.

B.9.5 Silencers

The insertion loss shall be calculated according to the specified noise level requirements and the diesel generating sets and fan selected so that the noise control requirements can be met.

The silencers shall comply with FSD requirements. The materials shall be inert, non-hygroscopic, verium and moisture proof and shall not support growth of bacteria.

B.10 LIFTING HOIST

- B.10.1 One manual lifting hoist complete with trolley shall be supplied and installed for each diesel generating set. The hoist shall be chain driven for maintenance and relocation purposes.
- B.10.2 The load chain shall be of malleable quality, electrically welded, pitched and of calibrated steel complying with ISO 1834-1836, 3075-3077 and proof tested to twice the safe working load specified for the hoist and trolley.
- B.10.3 The hooks shall comply fully with BS 2903 or other technically equivalent national or international standards. They shall be able to rotate upon ball or roller bearings for ease of swivelling, and provided with a catch to prevent displacement of wire rope from the hook.
- B.10.4 All moving parts of the hoist and trolley shall be greased or oiled after installation. Ball or roller bearings shall be packed with appropriate grease.
- B.10.5 Standard I-beam completed with end stopper shall be provided and ensure that the construction of the stoppers of the I-beams is suitable to stop the trolley motion outside the working range.
- B.10.6 A qualified surveyor to carry out the formal test under load conditions is required. The hoist with trolley shall be tested to a proof load of at least 125% of safe working load on site. Original surveyor certificate and copy of completed forms for Labour Department shall be submitted.

B.11 WARNING SIGN

A warning sign of reasonable size stating "Attention - Engine starts automatically without warning. Do not come close." in lettering not less than 10 mm high with Chinese translation shall be provided and fixed at a prominent position in the generator room.

The warning sign board shall be made from laminated self-coloured materials and engraved with the description as mentioned in the pervious paragraph. The font for English lettering shall be in Bold type.

B.12 SCHEMATIC DIAGRAMS

The electrical and control schematic diagrams for the diesel generating set shall be fixed in wooden frame with transparent pane of suitable size. These schematic diagrams shall be placed at a prominent position in the generator room.

B.13 TESTING

B.13.1 Testing of Diesel Generating Set Installation

- (a) The complete and fully assembled diesel generating set shall also be tested at the manufacturer's works before despatch, including full operating tests as well as tests on control, protections such as over-voltage protection, under-voltage protection, engine over-speed protection and protection device overload trip, alarms, governor trials and fuel consumption tests, and tests showing the step load acceptance capability, in accordance with the relevant British Standard Specification.
- (b) The performance tests for all equipment and systems installed shall be tested in accordance with "Building Services Branch, Testing and Commissioning Procedure No. 11 for Emergency Generator Installation in Government Buildings, Hong Kong" published by the Architectural Services Department, the Government of the HKSAR. This shall include the necessary adjustment and setting of all controls, checking the operation of all overload protection and safety devices and the commissioning of the completed installation.
- (c) All apparatus, fuels, tools and instruments necessary for testing the installation shall be available. Test methods and measurements shall be in accordance with ISO 8528-6. All readings given by the measuring instrument shall be in S.I. units.
- (d) Diesel fuel, water, lubricants, etc. shall be provided for all tests including dummy load test, actual load test and other fire services test. Sufficient quantities of these consumables shall be topped up before carrying out such tests. Two additional fire service tests shall be allowed following satisfactory completion of dummy load tests.
- (e) Four copies of certified results of the tests are required to show that the installation of diesel generating set has been tested and commissioned in accordance with the "Building Services Branch, Testing and Commissioning Procedure No. 11 for Emergency Generator Installation in Government Buildings, Hong Kong" published by the Architectural Services Department, the Government of the HKSAR.
- (f) Sound pressure level measurement, with octave band frequency analysis shall be conducted.

B.13.2 Testing of Control Cubicle

- (a) Performance tests for Control Cubicle shall be conducted in accordance with "Building Services Branch, Testing and Commissioning Procedure No. 2 for Electrical Installation in Government Buildings, Hong Kong" published by the Architectural Services Department, the Government of the HKSAR.

- (b) Electrical resistance test (Ductor Test) and temperature rise test for the control cubicle shall be carried out before the cubicle is accepted and energised. The test shall include the measurement of electrical resistance for all joints, connections and internal resistance of protective devices e.g. ACB, MCCB, F/SW, etc. All instruments used inclusive of make, serial number shall be recorded and the results of the measurements shall be properly documented.

B.13.3 Testing of Daily Service Tank, Fuel Storage Tank and Pipework

- (a) The daily service tank, fuel storage tank and the completed pipework shall be hydraulically tested for a period of time not less than 2 hours without undue deformation and leaking. The following test pressure shall be used:
 - (i) 70 kPa for the daily service tank and the fuel storage tank.
 - (ii) 700 kPa for the completed pipework, valves and fittings.
- (b) Pressure gauges with full scale deflection readings more than 3 times the test pressures shall not be used. The pressure gauges employed in test shall be tested and calibrated by approved laboratory before use.
- (c) Immediately after the hydraulic testing, the daily service tank and fuel storage tank must be drained and dried out and a thick coat of linseed oil or equivalent coating shall be applied on the interior surfaces of the tank to prevent rusting. All pipework, fittings and valves after tests shall be drained, dried and flushed out with linseed oil to remove all traces of water to prevent rusting.
- (d) The following information shall be permanently and clearly marked on a nameplate to be attached to daily service tank and fuel storage tank in an agreed position:
 - (i) Contractor's name
 - (ii) Gross capacity in litres
 - (iii) Date of hydraulic test

B.13.4 Testing of Noise Control System

After the completion of the acoustic installation, a sound pressure level measurement, with octave band frequency analysis, at the agreed points shall be conducted.

The method of measurement shall generally be in accordance with BS 4142 or other technically equivalent national or international standards. Measurement shall be taken by an industrial grades sound level meter to IEC 60651.

B.13.5 Testing of Exhaust Fan

The testing of Exhaust Fan and all accessories shall comply with the testing requirement in accordance with the “Building Services Branch, Testing and Commissioning Procedure No. 1 for Air-conditioning, Refrigeration, Ventilation and Central Monitoring & Control Systems in Government Buildings, Hong Kong” published by the Architectural Services Department, the Government of the HKSAR.

B.14 SUBMISSION TO THE AUTHORITIES

4 weeks after the award of the contract, the Contractor shall provide all necessary information for the submission to the Authorities for the Diesel Generator Installation for the compliance of various Statutory Regulations, including but not limit to the Fire Service Regulations, the Dangerous Goods Regulations and the Air Pollution Control Regulations. The Information shall include drawings, equipment catalogues, data sheets, calculations and other information as required by the relevant Authority.

ANNEX C

LIST OF INTERNATIONAL STANDARDS

USED IN THE ELECTRICAL GENERAL SPECIFICATION

Part and Clause Nos.	Standard Used		Relevant Known BS/BS EN Standard	
	No.	Title	No.	Title
PART A				
A2.1, A2.3, A3.6, B1.1.10, B1.1.12, B1.2.4, B1.3.9, B1.4.5(m), B2.3, B2.7.11, B3.1.4, B6.1, B6.7.4, B6.10.1, B6.10.2, D1.1	IEC 60364	Electrical installations in buildings.	BS 7671	Requirements for electrical installations. IEE Wiring Regulations, 16th Edition.
A2.2	IEC 60364-7- 704	Construction and Demolition Site Installations.	BS 7671: Section 604	Construction Site Installations.
A3.5	IEC 60454-3-1	Specification for pressure sensitive adhesive tapes for electrical purposes.	BS 3924	Specification for pressure-sensitive adhesive tapes for electrical insulating purpose.
A3.6, B1.1.21	BS 1710	Specification for identification of pipelines and services.	-	-
A3.6, B1.1.21	BS 4800	Schedule of paint colours for building purposes.	-	-
A3.9	ISO/R 885	General purpose bolts and screws – Metric Series – Radii under the head.	BS 4183	Specification for machine screws and machine screw nuts. Metric series.
A3.9	BS EN 24016	Hexagon head bolts. Product grades A and B.	-	-
A3.9	BS EN 24018	Hexagon head screws. Product grade C.	-	-

Part and Clause Nos.	Standard Used		Relevant Known BS/BS EN Standard	
	No.	Title	No.	Title
A3.9	BS EN 24034	Hexagon nuts. Product grade C.	-	-
A3.9	BS 1210	Specification for wood screws.	-	-
A3.11	ISO 683/13	Heat-treatable steels, alloy steels and free-cutting steels. Part 13: Wrought stainless steels.	BS 1449: Pt 2	Steel plate, sheet and strip. Part 2: Specification for stainless and heat-resisting steel plate, sheet and strip.
A4.3.1	ISO 5457	Technical drawings - Sizes and layout of drawing sheets.	BS 3429	Specification for sizes of drawing sheets.

Part and Clause Nos.	Standard Used		Relevant Known BS/BS EN Standard	
	No.	Title	No.	Title
PART B				
A2.1, A2.3, A3.6, B1.1.10, B1.1.12, B1.2.4, B1.3.9, B1.4.5(m), B2.3, B2.7.11, B3.1.4, B6.1, B6.7.4, B6.10.1, B6.10.2, D1.1	IEC 60364	Electrical installations in buildings.	BS 7671	Requirements for electrical installations. IEE Wiring Regulations, 16th Edition.
A3.6, B1.1.21	BS 1710	Specification for identification of pipelines and services.	-	-
A3.6, B1.1.21	BS 4800	Schedule of paint colours for building purposes.	-	-
B2.6	IEC 60502 IEC 60811	Extruded solid dielectric insulated power cables for rated voltages from 1 kV up to 30kV. Common test methods for insulating and sheathing materials of electric cables.	BS 5467	Spec. for cables with thermosetting insulation for electricity supply for rated voltages of $\leq 600/1000\text{V}$ and $\leq 1900/3300\text{V}$.
B2.6	IEC 60189 IEC 60227	Low-frequency cables and wires with PVC insulation and PVC sheath. Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V.	BS 6346	Specification for PVC-insulated cables for electricity supply.
B2.6, C2.2	IEC 60055-1 IEC 60055-2	Paper-insulated metal-sheathed cables for rated voltages up to 18/30 kV. 60055-1: Tests. 60055-2: General and construction requirements.	BS 6480	Specification for impregnated paper-insulated cables of rated voltages up to and including 33000V.

Part and Clause Nos.	Standard Used		Relevant Known BS/BS EN Standard	
	No.	Title	No.	Title
B2.6	BS 6724	Specification for armoured cables for electricity supply having thermosetting insulation with low emission of smoke and corrosive gases when affected by fire.	-	-
B2.7.1	IEC 61238	Compression and mechanical connectors for power cables with copper or aluminum conductors.	BS 4579	Specification for performance of mechanical and compression joints in electric cable and wire connections.
B2.8.5	IEC 60702-2	Mineral insulated cables and their terminations with a rated voltage not exceeding 750 V. 60702-2: Terminations.	BS 6207: Pt. 2	Specification for mineral-insulated copper-sheathed cables with copper conductors. Pt. 2: Terminations.
B2.8.5, C2.3	IEC 60228 IEC 60228A	Conductors for insulated cables. First supplement: Guide to the dimensional limits of circular conductors.	BS 6360	Specification for conductors in insulated cables and cords.
B2.9.1	BS 1494: Pt. 1	Specification for fixing accessories for building purposes. Pt. 1: Fixings for sheet, roof and wall coverings.	-	-
B3.4.3	IEC 60309-3	Plugs, socket-outlets and couplers for industrial purposes. Particular requirements for plugs, socket-outlets, connectors and appliances inlets for use in explosive gas atmospheres.	BS 4343	Plugs, socket-outlets and couplers for industrial purposes. Dimensional interchangeability requirements for pin and contact-tube accessories of harmonised configurations.
B3.4.6, B7.2.5	BS EN 60742	Isolating transformers and safety isolating transformers requirements.	BS 3535	Isolating transformers and safety isolating transformers.
B4.1.1	IEC 60127	Miniature fuses.	BS EN 60127	Miniature fuses.
B4.1.1, B6.10.1	IEC 60189 IEC 60227	Low-frequency cables and wires with PVC insulation and PVC sheath. Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V.	BS 6004	Specification for PVC-insulated cables (non-armoured) for electric power and lighting.

Part and Clause Nos.	Standard Used		Relevant Known BS/BS EN Standard	
	No.	Title	No.	Title
B4.1.1	IEC 60245	Rubber insulated cables of rated voltages up to and including 450/750 V.	BS 6007	Rubber-insulated cables for electric power and lighting.
B4.1.4	BS 2754	Memorandum. Construction of electric equipment for protection against electric shock.	-	-
B4.2.1, C1.2.3, C1.3.1	IEC 61035	Specification for conduit fitting for electrical insulations.	BS 4568: Pt. 2	Specification for steel conduit and fittings with metric threads of ISO form for electrical insulations. Part 2: Fitting and components.
B4.2.1, B4.2.3, B4.6.1, B4.8, B6.6.4, B7.1.3, B7.1.4, B7.1.5, B7.2.7, B7.2.9	IEC 60670	General requirements for enclosures for accessories for household and similar fixed electrical installations.	BS 4662	Specification for boxes for the enclosure of electrical accessories.
B5.10	IEC 60439-2	Low-voltage switchgear and control gear assemblies. 60439-2: Particular requirements for busbar trunking system (busways).	BS 5486: Pt. 2 BS EN 60439: Pt 2	Factory building assemblies of switchgear and control gear for voltages up to and including 1000V a.c. and 1200V d.c. Part 2: Particular requirements for busbar trunking systems (busways). Specification for low-voltage switchgear and control gear assemblies. Part 2: Particular requirements for busbar trunking systems (busways).
B6.12.1	IEC 60755 IEC 61008-2	General requirements for residual current operated protective devices. Residual current monitors for household and similar uses. 61008-2: Applicability of the general rules to RCCBs functionally independent of line voltage.	BS 4293	Specification for residual current-operated circuit-breakers.

Part and Clause Nos.	Standard Used		Relevant Known BS/BS EN Standard	
	No.	Title	No.	Title
B7.4.1, B7.4.2(c), B7.4.4, B7.4.6	IEC 60079 IEC 60079-12	Electrical apparatus for explosive gas atmospheres. Part 12: Classification of mixtures of gases of vapours with air according to their maximum experimental safe gaps and minimum lighting currents.	BS 5345 BS 4683	Code of practice for the selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres. Specification for electrical apparatus for explosive atmospheres.
B7.4.2(c), C6.4.3(a), C6.4.4(a)	IEC 60079-0 IEC 60079-1 IEC 60079-10 IEC 60079-12	Electrical apparatus for explosive gas atmospheres. Part 0 General requirements. Part 1: Flameproof enclosures "d". Part 10 Classification of hazardous areas. Part 12 Classification of mixtures of gases or vapours with air according to their maximum experimental safe gaps and minimum lighting currents.	BS 5345: Pt. 1 BS EN 50014	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) Part 1: General recommendations. Electrical apparatus for potentially explosive atmospheres - general requirements.
B7.4.5	BS 2470	Specification for hexagon socket screws and wrench keys. Inch series.	-	-
B7.4.5	BS 2558	Specification for tubular box spanners.	-	-
B7.4.6	BS 4683	Specification for electrical apparatus for explosive atmospheres.	-	-
B7.4.8	BS 476: Part 4	Fire tests on building materials and structures. Non-combustibility test for materials.	-	-
B7.5.4	BS EN ISO 1461	Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods.	-	-
B7.5.8	IEC 60502	Extruded solid dielectric insulated power cables for rated voltages from 1 kV up to 30 kV.	BS 6346	Specification for PVC-insulated cables for electricity supply.

Part and Clause Nos.	Standard Used		Relevant Known BS/BS EN Standard	
	No.	Title	No.	Title
B7.6.2, B7.6.10	BS 6651	Code of practice for protection of structures against lightning.	-	-

Part and Clause Nos.	Standard Used		Relevant Known BS/BS EN Standard	
	No.	Title	No.	Title
PART C				
C1.1.2, C1.1.4	IEC 60227-3 IEC 60227-4 IEC 60227-5	Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V. 60227-3 Non-sheathed cables for fixed wiring. 60227-4 Sheathed cables for fixed wiring. 60227-5 Flexible cables (cords).	BS 6004	Specification for PVC-insulated cables (non-armoured) for electric power and lighting.
C1.1.2, C1.1.4	IEC 60245-3 IEC 60245-4 IEC 60245-7	Rubber insulated cables of rated voltages up to and including 450/750 V. 60245-3 Heat resistant silicone insulated cables. 60245-4 Cords and flexible cables. 60245-7 Heat resistant ethylene-vinyl acetate rubber insulated cables.	BS 6007	Rubber-insulated cables for electric power and lighting.
C1.1.3, C2.2	IEC 60502-1	Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV) - Part 1: Cables for rated voltages of 1 kV (Um = 1,2 kV) and 3 kV (Um = 3,6 kV).	BS 6346	Specification for PVC-insulated cables for electricity supply.
C1.1.2, C1.1.3	BS 7211	Specification for thermosetting insulated cables (non-armoured) for electric power and lighting with low emission of smoke and corrosive gases when affected by fire.	-	-
C1.1.3	BS 6004	Specification for PVC-insulated cables (non-armoured) for electric power and lighting.	-	-

Part and Clause Nos.	Standard Used		Relevant Known BS/BS EN Standard	
	No.	Title	No.	Title
C1.1.3	BS 7629-1	Specification for 300/500 V fire resistant electric cables having low emission of smoke and corrosive gases when affected by fire. Multicore cables.	-	-
C1.1.4	BS 6007	Rubber-insulated cables for electric power and lighting.	-	-
C1.1.4	BS 7919	Electric cables. Flexible cables rated up to 450/750V, for use with appliances and equipment intended for industrial and similar environments.	-	-
C1.1.4, C9.1.2	BS 6500	Specification for insulated flexible cords and cables.	-	-
C1.2.1, C1.2.5	IEC 60614-1 IEC 60614-2-1	Conduits for electrical installations 60614-1: General requirements. 60614-2-1: Metal conduits.	BS 4568: Pt. 1 Pt. 2 BS EN 50086-1 50086-2	Specification for steel conduit and fittings with metric threads of ISO form for electrical insulations. Part 1: Steel conduit, bends and couplers. Part 2: Fitting and components. Specification for conduit systems for electrical installations. 50086-1: General requirements. 50086-2-1: Rigid conduit systems. 50086-2-2: Pliable conduit systems.

Part and Clause Nos.	Standard Used		Relevant Known BS/BS EN Standard	
	No.	Title	No.	Title
C1.2.2	IEC 60614-2-5	Conduits for electrical installations 60614-2-5: Flexible conduits.	BS 731: Pt. 1 BS EN 50086-1 50086-2	Flexible steel conduit for cable protection and flexible steel tubing to enclose flexible drives. Part 1: Flexible steel conduit and adapters for the protection of electric cable. Specification for conduit systems for electrical installations. 50086-1: General requirements. 50086-2-1: Rigid conduit systems. 50086-2-2: Pliable conduit systems.
C1.2.3, C1.3.1, B4.2.1	IEC 61035	Specification for conduit fittings for electrical installations.	BS 4568: Pt. 2	Specification for steel conduit and fittings with metric threads of ISO form for electrical installations. Part 2: Fitting and components.
C1.2.3, C1.2.4, C3.1, C6.6.2	BS 5733 IEC 60670	Specification for general requirements for electrical accessories. General requirements for enclosures for accessories for household and similar fixed electrical installations.	- BS 4662	- Specification for boxes for the enclosure of electrical accessories.
C1.2.3, C1.2.4, C1.2.5, C1.3.1 C1.3.3, C6.6.2	IEC 60670	General requirements for enclosures for accessories for household and similar fixed electrical installations.	BS 4568: Pt. 2	Specification for steel conduit and fittings with metric threads of ISO form for electrical insulations. Part 2: Fitting and components.
C1.2.4, C1.2.5, C1.3.3	BS 4662	Specification for boxes for the enclosure of electrical accessories.	-	-
C1.2.6, C1.4.7	BS 3382: Pt. 2	Specification for electroplated coatings on threaded components. Parts 1 and 2: Cadmium on steel components. Zinc on steel components.	-	-

Part and Clause Nos.	Standard Used		Relevant Known BS/BS EN Standard	
	No.	Title	No.	Title
C1.3.4	IEC 61035-1	Specification for conduit fittings for electrical installations. 61035-1: General requirements.	BS EN 50086-1 BS 4607:5	Specification for conduit fittings for electrical installations. 50086-1: General requirement. Non-metallic conduits and fittings for electrical installations. Part 5: Specification for rigid conduits, fittings and components of insulating material.
C1.3.1	IEC 60614-2-3	Specification for conduits for electrical installations. Part 2: Particular specifications for conduits. Section Three: Pliable conduits of insulating material		
C1.3.1	IEC 60614-2-2	Conduits for electrical installations 60614-2-2: Rigid plain conduits of insulating materials.	BS 6099: Section 2.2	Conduits for electrical installations Part 2: Particular Specification Section 2.2: Specification for rigid plain conduits of insulating material.
C1.3.2	BS EN 50086-1	Specification for conduit systems for electrical installations 50086-1: General requirements	-	-
C1.4.1, C1.5	IEC 61084-1	Cable trunking and ducting systems for electrical installations. Part 1: General requirement.	BS 4678: Pt. 1 Pt. 2 Pt. 4	Cables trunking. Part 1: Steel surface trunking. Part 2: Steel underfloor (duct) trunking. Part 4: Specification for cable trunking made of insulating material.
C1.4.2	BS 4678: Pt. 1	Cables Trunking. Part 1: Steel surface trunking.	-	-
C1.4.2	BS2989	Specification for Continuously hot-dip zinc coated and iron-zinc alloy coated steel of structural qualities: wide strip, sheet/plate and slit wide strip.	-	-

Part and Clause Nos.	Standard Used		Relevant Known BS/BS EN Standard	
	No.	Title	No.	Title
C2.2, C2.5	BS 6724	Specification for armoured cables for electricity supply having thermosetting insulation with low emission of smoke and corrosive gases when affected by fire.	-	-
B2.6, C2.2	IEC 60055-1 IEC 60055-2	Paper-insulated metal-sheathed cables for rated voltages up to 18/30 kV. 60055-1: Tests. 60055-2: General and construction requirements.	BS 6480	Specification for impregnated paper-insulated cables of rated voltages up to and including 33000V.
C2.2	IEC 60702-1 IEC 60702-2	Mineral insulated cables and their terminations with a rated voltage not exceeding 750 V. 60702-1: Cables. 60702-2: Terminations.	BS 6207	Specification for mineral-insulated copper-sheathed cables with copper conductors.
C2.2	BS 7846	Electric cables. 600/1000 V armoured fire-resistant cables having thermosetting insulation and low emission of smoke and corrosive gases when affected by fire	-	-
B2.8.5, C2.3	IEC 60228 IEC 60228A	Conductors for insulated cables. First supplement: Guide to the dimensional limits of circular conductors.	BS 6360	Specification for conductors in insulated cables and cords.
C2.5, C2.7.1	IEC 60754 IEC 60754-1	Test on gases evolved during combustion of materials from cables 60754-1: Determination of the amount of halogen acid gas.	BS 6425 BS 6425: Pt. 1 Pt. 2	Test on gases evolved during the combustion of material from cables. Part 1: Method for determination of amount of halogen acid gas evolved during the combustion of polymeric material taken from cables. Part 2: Determination of degree of acidity (corrosivity) of gases by measuring pH and conductivity.

Part and Clause Nos.	Standard Used		Relevant Known BS/BS EN Standard	
	No.	Title	No.	Title
C2.5	BS 2782	Methods of testing plastics.	-	-
C2.6	BS 3858	Specification for building and identification sleeves for use on electric cables and wire.	-	-
C2.9.1, C2.10.1	ISO 1459 ISO 1460 ISO 1461	Metallic coatings - Protection against corrosion by hot dip galvanizing - Guiding principles. Metallic coatings - Hot dip galvanized coatings on ferrous materials - Gravimetric determination of the mass per unit area. Metallic coatings - Hot dip galvanized coatings on fabricated ferrous products - Requirements.	BS 729	Specification for hot dip galvanized coatings on iron and steel articles.
C2.9.1, C2.10.1	BS 1449: Pt. 1	Steel plate, sheet and strip. Part 1: Carbon and carbon-manganese plate, sheet and strip.	-	-
C2.10.1	ISO 683/13	Heat-treatable steels alloy steels and free-cutting steels Part 13: Wrought stainless steels.	BS 1449: Pt. 2	Steel plate, sheet and strip. Part 2: Specification for stainless and heat resisting steel plate, sheet and strip.
C3.2.1	IEC 60669-1	Switches for household and similar fixed electrical installations. Part 1: General requirement.	BS 3676	Switches for household and similar fixed electrical installations.
C3.2.5, C3.2.1, C3.3.1, C3.7.6, C7.4.1	BS EN 60529	Specification for degrees of protection provided by enclosures (IP code).	BS 5490	Specification for classification of degrees of protection provided by enclosures. (withdrawn)

Part and Clause Nos.	Standard Used		Relevant Known BS/BS EN Standard	
	No.	Title	No.	Title
C3.3.1, C9.1.2	BS 546 BS 1363 IEC 60309-2	Specification. Two-pole and earthing-pin plugs, socket outlets and socket outlet adapters. Specification for 13A fused plugs and switched and unswitch socket-outlets. Plugs, socket-outlets and couplers for industrial purposes 60309-2: Dimensional interchangeability requirements for pin and contact-tube accessories.	BS 4343	Plugs, socket-outlets and couplers for industrial purposes. Dimensional interchangeability requirements for pin and contact-tube accessories of harmonised configurations.
C3.3.2	BS EN 60742 BS 3535	Isolating transformers and safety isolating transformers. Isolating transformers and safety isolating transformers	BS 3052	Specification for electric shaver supply units. (withdrawn)
C3.3.3, C3.4.2	IEC 60269-1	Low-voltage fuse 60269-1: General requirements.	BS 1362	Specification for general purpose fuse links for domestic and similar purposes (primarily for use in plugs).
C3.4.1	BS 646	Specification for cartridge fuse (rated up to 5 Amp) for a.c. and d.c. services.	-	-
C3.4.2	BS 5733	Specification for general requirements for electrical accessories.	-	-
C3.6.2	BS 667	Specification for portable photoelectric photometers.	-	-
C3.6.3	BS 67	Specification for ceiling roses.	-	-

Part and Clause Nos.	Standard Used		Relevant Known BS/BS EN Standard	
	No.	Title	No.	Title
C3.6.4	BS EN 61184 BS EN 60061-1 BS EN 60061-3	Bayonet Lampholders Specification for lamp caps and holders together with gauges for the control of interchangeability and safety. 60061-1: Lamp caps. 60061-3: Gauges.	BS 52 BS 1875	Specification for bayonet lamp-caps lampholders and B.C. adaptors (lampholder plugs). (withdrawn) Specification for bi-bin lamp-holders for tubular fluorescent lamps for use in circuits the declared voltage of which does not exceed 250 volts.
C3.7.2	IEC 60051 IEC 60051-1 IEC 60051-9	IEC 60051: Directacting indicating analogue electrical-measuring instruments and their accessories. Definitions and general requirements common to all parts. Recommended test methods.	BS 89	Direct acting indicating electrical measuring instruments and their accessories
C3.7.3	BS EN 60044-1 EN 60044-1	Current transformers Current transformers	-	-
C3.7.3	IEC 60185	Current transformers.	BS 3938	Specification for steel current transformers.
C4.1.1, C4.1.7, C4.2.2, C4.2.5, C4.4.1, C4.4.2, C4.5.1, C4.5.3, C4.14.1, C4.14.2, C4.14.3, C4.14.5, C4.15, C4.22.2, C5.6	IEC 60947 IEC 60947-1 IEC 60947-2 IEC 60947-3 IEC 60947-4-1	Low voltage switchgear and control gear 60947-1: General rules. 60947-2: Circuit-breakers. 60947-3: Switches, disconnectors, switch disconnectors and fuse combination units. 60947-4: Contactors and motor starters 60947-4-1: Electromechanical contactors and motor-starters.	BS EN 60947 60947-1 60947-2 60947-3 60947-4-1	Low voltage switchgear and control gear 60947-1: General rules. 60947-2: Circuit-breakers. 60947-3: Switches, disconnectors, switch disconnectors and fuse combination units. 60947-4: Contactors and motor starters. 60947-4-1: Electromechanical contactors and motor-starters.
C4.6.1, C4.6.2, C4.6.3,	IEC 60898	Circuit breakers for overcurrent protection for household and similar installations.	BS EN 60898	Specification for circuit breakers for overcurrent protection for household and similar use.

Part and Clause Nos.	Standard Used		Relevant Known BS/BS EN Standard	
	No.	Title	No.	Title
C4.1.5, C4.13.3, C4.21.3, C5.2, C6.3.2, C6.4.2, C6.4.3(a), C6.4.4(a), C7.4.1	IEC 60529	Degree of protection of enclosures.	BS EN 60529 BS 5490	Specification for degree of protection provided by enclosures (IP code). Specification for classification of degree of protection provided by enclosures. (withdrawn)
C4.1.1, C4.9.1, C4.9.4, C4.10.5, C4.10.7, C4.11.1, C4.17, C5.1, C5.2, C5.3, C5.4, C5.10.2, C5.10.6, C5.11.5	IEC 60439-1 IEC 60439-2	Low-voltage switchgear and control gear assemblies. 60439-1: Type tested and partially type tested assemblies. 60439-2: Particular requirements for busbar trunking systems (busways)	BS EN 60439-1 60439-2 BS 5486: Pt. 1 Pt. 2	Specification for low-voltage switchgear and control gear assemblies. 60439-1: Specification for type-tested and partially type-tested assemblies. 60439-2: Particular requirements for busbar trucking systems (busways). Factory building assemblies of switchgear and control gear for voltages up to and including 1000V a.c. and 1200V d.c. Part 1: Requirements for type-tested and partially type-tested assemblies. (withdrawn) Part 2: Particular requirements for busbar trunking systems (busways)

Part and Clause Nos.	Standard Used		Relevant Known BS/BS EN Standard	
	No.	Title	No.	Title
C4.6.3, C4.8.2, C4.8.5, C4.13.1 C4.14.1, C5.6, C5.10.6, C5.11.5	IEC 60269 IEC 60269-2-1	Low-voltage fuses. 60269-2-1: Examples of types of standardised fuses for use by authorised persons.	BS EN 60269 BS 88 BS 88: Pt. 1 Pt. 2: Section 2.1 Section 2.2 BS 1361	Low-voltage fuses. Cartridge fuse for voltages up to and including 1000 V ac and 1500 V dc Part 1: Specification for general requirement. Part 2: Specification for fuse for use by authorised persons. Section 2.1: Supplementary requirements. Section 2.2: Additional requirements for fuses with fuse-links for bolted connections. Specification for cartridge fuses for ac circuits in domestic and similar premises.
C4.7.1, C4.7.2	BS EN 61008 IEC 61008	Specification for residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs). Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs).	BS 4293	Specification for residual current-operated circuit-breakers.
C4.8.2	BS 3036	Specification. Semi-enclosed electric fuses (ratings up to 100 amperes and 240 volts to earth).	-	-
C4.12.1	IEC 60439-3	Low-voltage switchgear and controlgear assemblies. Part 3: Particular requirements for low- voltage switchgear and controlgear assemblies intended to be installed in places where unskilled persons have access for their use - Distribution boards.	-	-

Part and Clause Nos.	Standard Used		Relevant Known BS/BS EN Standard	
	No.	Title	No.	Title
C4.13.1	BS EN 60439-3	Low-voltage switchgear and control gear assemblies. Part 3: Particular requirement for low-voltage switchgear and controlgear assemblies intended to be installed in places where unskilled persons have access for their use - Distribution boards.	-	-
C4.16.1	IEC 61000	Electromagnetic compatibility (EMC).	-	-
C4.17.1	IEC 61024-1	Protection of Structures against lightning.	-	-
C4.18.1, C4.19.1, C4.19.2	BS EN 60068-2-6 BS EN 60068-2-27 BS EN 61000-4-3 BS EN 50081	Environmental testing – Part 2: Tests - Test Fc: Vibration (sinusoidal). Part 2: Tests. Test Ea and guidance: Shock. Electromagnetic compatibility (EMC). Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test. Electromagnetic compatibility. Generic emission standard.	-	-
C4.21.1	BS EN 61204 BS 5654	Low-voltage power supply devices, d.c. output - Performance characteristics and safety requirements. Specification for stabilized power supplies, d.c. 110 output.	-	-
C4.21.1	BS EN 60622 BS 7430 IEC 60950	Sealed nickel-cadmium prismatic rechargeable single cells. Code of practice for earthing. Information technology equipment - Safety - Part 1: General requirements.	-	-

Part and Clause Nos.	Standard Used		Relevant Known BS/BS EN Standard	
	No.	Title	No.	Title
C4.22.2, C5.6	IEC 60831 IEC 60269	Shunt power capacitors of the self-healing type for a.c. systems having a rated voltage up to and including 1000 V. Low-voltage fuses.	-	-
C4.23.1	IEC 60255	Electrical relays. All or nothing electrical relays.	-	-
C4.23.1, C4.24.1	IEC 61000-4-2 IEC 61000-4-3	IEC 61000: Electromagnetic compatibility (EMC). Electrostatic discharge immunity test. Radiated, radio-frequency, electromagnetic field immunity test.	-	-
C4.23.1, C4.24.1	IEC 61000-3-2 IEC 61000-4-4 IEC 61000-4-5 IEC 60255-25 IEC 60255-21-1 IEC 60255-21-2	IEC 61000: Electromagnetic compatibility (EMC). Limits for harmonic current emissions. Electrical fast transient/burst immunity test. Surge immunity test. IEC 60255: Electrical Relays. Electromagnetic emission tests for measuring relays and protection equipment. Vibration tests (sinusoidal). Shock and bump tests.	-	-
C5.4	BS 1432	Specification for copper for electrical purposes: high conductivity copper rectangular conductors with drawn or rolled edges.	-	-
C5.4	BS 1433	Specification for copper for electrical purposes. Rod and bar.	-	-

Part and Clause Nos.	Standard Used		Relevant Known BS/BS EN Standard	
	No.	Title	No.	Title
C5.10.2	IEC 60667	Specification for vulcanised fibre for electrical purposes.	BS 5102 BS 2572	Specification for phenolic resin bonded paper laminated sheets for electrical applications. (withdrawn) Replaced by BS 2572. Specification for phenolic laminated sheet and epoxy cotton fabric laminated sheet.
C5.10.2, C5.10.6, C5.11.5	IEC 60439-1	Low-voltage switchgear and controlgear assemblies - Part 1: Type-tested and partially type-tested assemblies.	-	-
C5.10.6	IEC 60439-2	Low-voltage switchgear and controlgear assemblies - Part 2: Particular requirements for busbar trunking systems (busways).	-	-
C6.1.2	ISO 9000	Quality assurance.	BS 5750	Quality system.
C6.1.2	IEC 60155	Starters for tubular fluorescent lamps.	BS 3772 BS EN 60155	Specification for starters for fluorescent lamps. (withdrawn) Glow-starters for fluorescent lamps.
C6.1.2	IEC 60926 IEC 60927	Starting devices (other than glow starters) - General and safety requirements. Starting devices (other than glow starters) - Performance requirement.	-	-
C6.1.2	IEC 60400	Lampholders for tubular fluorescent lamps and starterholders.	-	-
C6.1.2, C6.3.2, C6.4.3(a), C6.5.2	IEC 60598 IEC 60598-1 IEC 60598-2 IEC 60598-2-22	Luminaires. Luminaires - Part 1: General requirements and tests. Luminaires - Part 2: Particular requirements. 60598-2-22: Luminaires for emergency lighting.	BS 4533 Part 101 Pt. 102 Section 102.22 BS EN 60598 60598-2-22	Luminaires. Part 101: Specification for general requirements and tests. Part 102: Particular requirement Section 102.22: Specification for luminaires for emergency lighting. Luminaires. Particular requirements.

Part and Clause Nos.	Standard Used		Relevant Known BS/BS EN Standard	
	No.	Title	No.	Title
C6.1.2	IEC 60920	Ballasts for tubular fluorescent lamps - general and safety requirements.	BS EN 60920	Specification for ballasts for tubular fluorescent lamps. General and safety requirements.
	IEC 60921	Ballasts for tubular fluorescent lamps - Performance requirements.	BS EN 60921	Specification for ballasts for tubular fluorescent lamps. Performance requirements.
	IEC 60928	AC supplied electronic ballasts for tubular fluorescent lamps. General and safety requirements.		
	IEC 60929	AC supplied electronic ballasts for tubular fluorescent lamps.		
C6.1.2	IEC 61048	Capacitors for use in tubular fluorescent and other discharge lamp circuits. General and safety requirements.	BS 4017	Specification for capacitors for use in tubular fluorescent, high pressure mercury and low pressure sodium vapour discharge lamp circuits. (withdrawn)
	IEC 61049	Capacitors for use in tubular fluorescent and other discharge lamp circuits. Performance requirements.	BS EN 61048	Specification for capacitors for use in tubular fluorescent and other discharge lamp circuits - general and safety requirements.
			BS EN 61049	Specification for capacitors for use in tubular fluorescent and other discharge lamp circuits - performance requirements.
C6.1.2, C6.6.3	IEC 60081 IEC 60901	Tubular fluorescent lamps. Compact fluorescent lamps.	BS 1853 BS EN 60081	Fluorescent lamps for general lighting services Part 1: Specification for internationally specified lamps. (withdrawn) Part 2: Specification for lamps used in the United Kingdom not included in BS EN 60081, BS EN 60901, BS EN 61195, BS EN 61199. Specification for tubular fluorescent lamps for general lighting service.

Part and Clause Nos.	Standard Used		Relevant Known BS/BS EN Standard	
	No.	Title	No.	Title
C6.1.2	IEC 60245-7	Rubber insulated cables of rated voltages up to and including 450/750 V. Part 7: Heat resistant ethylene-vinyl acetate rubber insulated cables.	BS 6231	Specification for PVC-insulated cables for switchgear and controlgear wiring.
C6.4.2	BS 4533: Pt. 101 BS EN 60598-1	Luminaries. Part 101: Specification for general requirements and tests. Luminaries. 60598-1: General requirements and tests.	-	-
B7.4.2(c), C6.4.3(a), C6.4.4(a)	IEC 60079-0 IEC 60079-1 IEC 60079-10 IEC 60079-12	IEC 60079: Electrical apparatus for explosive gas atmospheres. Part 0: General requirements. Part 1: Flameproof enclosures "d" Part 10: Classification of hazardous areas. Part 12: Classification of mixtures of gases or vapours with air according to their maximum experimental safe gaps and minimum lighting currents.	BS 5345: Pt. 1 BS EN 50014	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) Part 1: General recommendations. Electrical apparatus for potentially explosive atmospheres - general requirements.
C6.4.4(a)	IEC 60079-1	Electrical apparatus for explosive gas atmospheres. Part 1: Construction and verification test of flameproof enclosure of electrical apparatus.	BS 4683: Pt. 2 BS 5501: Pt. 5 BS EN 50018	Specification for electrical apparatus for explosive atmospheres. Part 2: The construction and testing of flameproof enclosures of electrical apparatus. Electrical apparatus for potentially explosive atmospheres Part 5: Flameproof enclosure 'd'. See BS 5501: Part 5.
C6.4.4(b)	ISO 3522	Cast aluminum alloys - chemical composition and mechanical properties.	-	-

Part and Clause Nos.	Standard Used		Relevant Known BS/BS EN Standard	
	No.	Title	No.	Title
C6.4.4(b)	BS 1490	Specification for aluminum and aluminum alloy ingot and castings for general engineering purposes.	-	-
C6.5.2	IEC 60924	DC supplied electronic ballasts for tubular fluorescent lamps.	BS EN 60924	Specification for general and safety requirements for DC supplied electronic ballasts for tubular fluorescent lamps.
C6.5.2	IEC 60742	Isolating transformers and safety isolating transformers.	BS 3535 EN 60742	Isolating transformers and safety isolating transformers. Isolating transformers and safety isolating transformers.
C6.5.3	BS EN 61436 BE EN 61951-2	Secondary cells and batteries containing alkaline or other non-acidic electrolytes. Sealed nickel-metal hydride rechargeable single cells. Secondary cells and batteries containing alkaline or other non-acidic electrolytes. Portable sealed rechargeable single cells – Nickel-metal hydride.		
C6.6.1	BS EN 60742	Isolating transformers and safety isolating transformers. Requirements.	-	-
C6.6.2	IEC 60670	General requirements for enclosures for accessories for household and similar fixed electrical installations.	-	-
C6.8.1	IEC 60928	AC supplied electronic ballasts for tubular fluorescent lamps – General & safety requirements.	-	-
C6.8.1	IEC 60929	AC supplied electronic ballasts for tubular fluorescent lamps – Performance requirements.	-	-

Part and Clause Nos.	Standard Used		Relevant Known BS/BS EN Standard	
	No.	Title	No.	Title
C6.8.1, C4.24.1	IEC 61000-3-2	Limits for harmonic current emission (equipment input current = 16A per phase).	-	-
C6.8.1	EN 55015	Limit and method of measurement of radio disturbance characteristics of lighting and similar equipment.	-	-
C6.8.1	EN 61547	Equipment for general lighting purposes – EMC immunity requirements.	-	-
C6.8.1	EN 60928 EN 60929	Auxiliaries for lamps. a.c. supplied electronic ballasts for tubular fluorescent lamps. General and safety requirements Specification for a.c. supplied electronic ballasts for tubular fluorescent lamps. Performance requirements.	-	-
C7.2	BS EN 60662	Specification for high-pressure sodium vapour lamps.	-	-
C7.2	BS 6193	Specification for high-pressure sodium vapour lamps. (withdrawn)	-	-
C7.2, C7.3, C7.4.1	BS EN ISO 9000-4	Quality management and quality assurance standards.	BS 5750	Quality system.
C7.2, C7.3, C7.4.1	BS 5750	Quality system.	-	-
C7.3	BS EN 60188	See BS 3677.	BS 3677	Specification for high-pressure mercury vapour lamps.
C7.3	BS 3677	Specification for high-pressure mercury vapour lamps.	-	-
C7.4.1	BS EN 60598	Luminaires.	BS 4533	Luminaires.
C7.4.1	BS 4533	Luminaires.	-	-

Part and Clause Nos.	Standard Used		Relevant Known BS/BS EN Standard	
	No.	Title	No.	Title
C8.1	BS EN 60423	Conduits for electrical purposes. Outside diameters of conduits for electrical installations and threads for conduits and fittings.	BS 6053	Specification for outside diameters of conduits for electrical installations and threads for conduits and fittings.
C8.1	ISO 9000 Series	Quality assurance.	BS 5750	Quality system.
C8.2	EN 60357	See BS 1075.	BS 1075	Specification for tungsten halogen lamps (non vehicle).
C8.3.2	IEC 60555-2	Disturbances in supply systems caused by household appliances and similar electrical equipment. 60555-2: Harmonics.	BS EN 60921	Specification for ballasts for tubular fluorescent lamps. Performance requirements.
C8.3.2	IEC 61046	DC or ac supplied electronic step-down convertors for filament lamps. General and safety requirements.	BS EN 61046	Specification for d.c. or a.c. supplied electronic step down convertors for filament lamps. General and safety requirements.
C8.3.2	IEC 61047	Electronic step-down convertors for filament lamps.	-	-
C8.3.2	BS EN 55015/A1	Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment.	BS 5394	Specification for limits and methods of measurement of radio interference characteristics of fluorescent lamps and luminaires.
C9.2.1	BS 5060	Specification for performance and construction of electric circulating fans and regulators.	-	-
C9.2.1	IEC60879	Performance and construction of electric circulating fans and regulators.	BS 5060	Specification for performance and construction of electric circulating fans and regulators

Part and Clause Nos.	Standard Used		Relevant Known BS/BS EN Standard	
	No.	Title	No.	Title
C9.3.1, C9.4.1, C9.5.1, C9.6.1, C9.7.1	IEC 60335-2-80	Safety of household and similar electrical appliances - Part 2: Particular requirements for fans.	-	-
C9.8.1, C9.9.3	IEC 60085	Thermal evaluation and classification of electrical insulation.	-	-
C9.9.3	BS 5000	Rotating electrical machines of particular types or for particular applications.	-	-
C9.9.3	BS 2757 IEC 60034-1	Method for determining the thermal classification of electrical insulation. Rotating electrical machines - Part 1: Rating and performance.	-	-
C9.10.1, C9.11.1, C9.12.1, C9.13.1, C9.13.3	IEC 60335-2-30	Safety of household and similar electrical appliances - Part 2: Particular requirements for room heaters.	-	-
C9.13.3	BS EN ISO 1461	Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods.	-	-
C9.14.1, C9.15.1	IEC 60335-2-21	Household and similar electrical appliances - Safety - Part 2-21: Particular requirements for storage water heaters.	-	-
C9.15.1	BS 7206 BS 3456 Part 102.21	Specification for unvented hot water storage units and packages. Specification for safety of household and similar electrical appliances – storage water heaters.	-	-

Part and Clause Nos.	Standard Used		Relevant Known BS/BS EN Standard	
	No.	Title	No.	Title
C9.15.3	BS 3955 BS 6283	Specification for electrical control for household and similar general purposes Safety and control devices for use in hot water systems.	-	-
C9.15.4	BS 6282	Devices with moving parts for the prevention of contamination of water by backflow.	-	-
C9.16.1	IEC 60335-2-63	Safety of household and similar electrical appliances - Part 2-63: Particular requirements for commercial electric water boilers and liquid heaters.	-	-
C9.17.1, C9.22.1	IEC 60335-2-15	Household and similar electrical appliances - Safety - Part 2-15: Particular requirements for appliances for heating liquids	-	-
C9.18.1, C9.31.2	IEC 60335-2-24	Safety of household and similar electrical appliances - Part 2-24: Particular requirements for refrigerating appliances, ice-cream appliances and ice-makers.	-	-
C9.19.1, C9.20.1, C9.21.1	IEC 60335-2-6	Household and similar electrical appliances - Safety -Part-2-6: Particular requirements for stationary cooking ranges, hobs, ovens and similar appliances.	-	-
C9.23.1	IEC 60335-2-9	Household and similar electrical appliances - Safety -Part-2-9: Particular requirements for grills, toasters and similar portable cooking appliances.	-	-
C9.26.1	IEC 60335-2-3	Household and similar electrical appliances - Safety -Part-2-3: Particular requirements for electric irons.	-	-

Part and Clause Nos.	Standard Used		Relevant Known BS/BS EN Standard	
	No.	Title	No.	Title
C9.27.1	IEC 60335-2-2	Household and similar electrical appliances - Safety -Part-2-2: Particular requirements for vacuum cleaners and water-suction cleaning appliances.	-	-
C9.28.1, C9.29.1, C9.30.2	IEC 60335-2- 40	Safety of household and similar electrical appliances-Part 2: Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers.	-	-

Part and Clause Nos.	Standard Used		Relevant Known BS/BS EN Standard	
	No.	Title	No.	Title
PART D				
A2.1, A2.3, A3.6, B1.1.10, B1.1.12, B1.2.4, B1.3.9, B1.4.5(m), B2.3, B2.7.11, B3.1.4, B6.1, B6.7.4, B6.10.1, B6.10.2, D1.1	IEC 60364	Electrical installations in buildings.	BS 7671	Requirements for electrical installations. IEE Wiring Regulations, 16th Edition.
D1.3.7	IEC 60529	Degree of protection of enclosures.	BS EN 60529 BS 5490	Specification for degree of protection provided by enclosures (IP code). Specification for classification of degrees of protection provided by enclosures. (withdrawn)